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This issue of Scholarly Review, like each Summer issue, is the culmination of student work masterfully conducted over the past few months, much of it during the throws of college applications and AP exams. The discipline of these young scholars is reflected in the high quality of their scholarship.

Leonard Collomb determines the most accurate text classifier model for predicting whether an online product review originated from a human or computer.

Thea Hwang follows the evolution of the skirt through history, parsing the meaning of this particular fashion choice in modern society.

Renee Jia reviews global oral health and challenges preventing access to oral care across diverse communities, advocating for oral health awareness programs.

Chunyu Li asks if democracy is growing or dying in light of its transformations over the last fifty years, with an emphasis on United Nations regulations.

Jonathan Li presents a holistic approach to enhancing child safety in vehicles, with the aim of significantly reducing the incidence of injuries and fatalities in motor vehicle crashes.

Richard Liao explores the profound philosophy of Santideva, focusing on the concept of emptiness and its implications on human agency.

Angeline Luan highlights the intersection of modernist poetry and Chinese cultural revival during the early 20th century, focusing on the works of Guo Moruo (1892-1978).

Lydia Sun finds the impacts of different types of exercises on the stress levels of people who act as caregivers for people with Alzheimer's Disease.

Emma Tao details the theoretical analysis, implementation, and limitations of Cognitive Behavioral Art Therapy, a newly developed therapeutic method..

Jialin Wang aims to improve the efficiency of bird identification by using a convolutional network to identify bird species based on their visual representations.

Hailey Xi discusses a frontier in vaccine research, laying the groundwork for developing mRNA vaccines targeting Epstein-Barr virus-associated diseases.

Lillian Yeh reveals original survey research on the effects of musical training and listening perceptions on the music listening experience.

Nina Zhang examines Carpaccio's most renowned piece of work, the Cycle of Saint Ursula, to investigate the extent of female power in 1500s Venice.

Hengrui Zhu devises an indicator of the extent to which voters vote based on their ideology, rather than socioeconomic and racial status.

To these emerging scholars, we give tremendous thanks.

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Determining the Most Accurate Text Classifier Model for Predicting Whether Online Product Reviews are Human or Computer Generated

By Leonard Collomb

Abstract

In recent years, fake online product reviews have become an increasingly prevalent issue for e-commerce platforms (McCluskey, 2022). This project attempts to address this issue of pervasive fake reviews negatively impacting e-commerce platforms by focusing on the automated detection of computer-generated reviews. The study evaluates several text classifier algorithms, including Logistic Regression, Support Vector, Decision Tree, K-Nearest Neighbors (KNN), Random Forest, Extra Trees, AdaBoost, Bagging, and Gradient Boosting, and compares their performances in distinguishing computer-generated reviews from genuine reviews. These classifiers are assessed based on their accuracy and F1 scores (the harmonic mean of their precision and recall scores) in distinguishing between human and computer-generated reviews after being trained on a dataset comprising of approximately 20,000 computer-generated and approximately 20,000 human-written reviews, which have been transformed into numerical vectors using TF-IDF vectorization. Results indicate that Logistic Regression consistently outperforms other classifiers, demonstrating robust accuracy and F1 scores across trials. K-Nearest Neighbors classifier shows the poorest performance, likely due to challenges in high-dimensional text data. Ensemble methods, such as Random Forest and Extra Trees, deliver notable success, leveraging multiple decision trees to enhance predictive performance. AdaBoost and Gradient Boosting also demonstrate competitive results, showcasing the capabilities of adaptive boosting. The study concludes that Logistic Regression is the most accurate classifier for detecting computer-generated reviews, offering insights into its simplicity and effectiveness in capturing linear patterns within the data. Further exploration could involve tuning hyperparameters for models with poor performance, and exploration with even more models.

Keywords: Text Classification, TF-IDF Vectorization, Product Reviews, Computer-generated Text, Scikit-learn, Text Classifier, Logistic Regression, Support Vector Machine (SVM), K-Nearest Neighbors Classifier, Decision Tree Classifier, AdaBoost Algorithm, Gradient Boosting Algorithm.

Introduction

In recent years, fake reviews have emerged as a pervasive and concerning issue plaguing e-commerce platforms in the contemporary digital landscape, even influencing "around $152 billion in global spending on lackluster products" in 2021 (McCluskey, 2022). As online shopping continues to gain popularity, the reliance on reviews as a decision-making factor for making online purchases has surged, making them an integral part of the consumer experience. However, the rise of fake reviews has tainted the authenticity and reliability of user-generated content on these platforms. A primary challenge posed by fake reviews is the distortion of product perception. Consumers heavily depend on reviews to gauge the quality, functionality, and overall satisfaction associated with a product, and thus, potential buyers are misled into making decisions based on fabricated positive feedback or negative criticism, resulting in an inaccurate representation of the product ("Emplifi Reveals", 2023).

Furthermore, studies show that people are only about 60-80% accurate in detecting fake reviews (Walther et al., 2023). Human susceptibility to biases, cognitive limitations, and the sheer volume of reviews on online platforms make it challenging for individuals to consistently identify deceptive content. The reliance on human judgment alone leaves the online review ecosystem vulnerable to manipulation and deceit. Recognizing the shortcomings in human review scrutiny emphasizes the critical need for sophisticated technological interventions. Automated systems, equipped with advanced algorithms and machine learning models, can provide a more objective and effective means of detecting computer-generated reviews. To address this issue, there is a dire need for automated solutions aimed at detecting computer-generated reviews. This research project seeks to contribute to ongoing efforts, such as those recently initiated by Amazon (Mehta, 2023), in enhancing the integrity of online reviews by focusing on the type of model used to detect these computer-generated reviews.

Online reviews, often produced at scale by automated systems, pose a unique challenge due to their ability to mimic authentic user feedback (Salminen et al., 2021). The nuances may range from subtle linguistic patterns to context-specific cues that people and traditional classifiers may struggle to discern. Given this complexity, the choice of classifier becomes crucial in addressing this specific issue. Different classifiers exhibit varying degrees of effectiveness in distinguishing between authentic and computer-generated reviews. This project aims to systematically evaluate and compare the performance of various classifiers to ascertain which type is most effective at accurately solving the challenges posed by computer-generated reviews. By identifying the strengths and weaknesses of different classifiers, the research endeavors to provide valuable insights that can guide the development of more robust and versatile automated systems capable of enhancing the integrity of online review platforms.

Methods

Data Cleaning and Acquisition

The original text dataset (Salminen, 2023) utilized for this project consisted of approximately 20,000 computer-generated reviews and an equivalent number of human-written reviews, organized in the format illustrated in figure 1.

Figure 1
First 11 of Approximately 20,000 Rows of Dataset of Computer-generated Reviews (Salminem)

category	rating	label	text_
Home_and_Kitchen_5	5.0	CG	Love this! Well made, sturdy, and very comfortable. I love it!Very pretty
Home_and_Kitchen_5	5.0	CG	love it, a great upgrade from the original. I've had mine for a couple of years
Home_and_Kitchen_5	5.0	CG	This pillow saved my back. I love the look and feel of this pillow.
Home_and_Kitchen_5	1.0	CG	Missing information on how to use it, but it is a great product for the price! I
Home_and_Kitchen_5	5.0	CG	Very nice set. Good quality. We have had the set for two months now and have not been
Home_and_Kitchen_5	3.0	CG	I WANTED DIFFERENT FLAVORS BUT THEY ARE NOT.
Home_and_Kitchen_5	5.0	CG	They are the perfect touch for me and the only thing I wish they had a little more space.
Home_and_Kitchen_5	3.0	CG	These done fit well and look great. I love the smoothness of the edges and the extra
Home_and_Kitchen_5	5.0	CG	Great big numbers & easy to read, the only thing I didn't like is the size of the
Home_and_Kitchen_5	5.0	CG	My son loves this comforter and it is very well made. We also have a baby
Home_and_Kitchen_5	5.0	CG	As advertised. 5th one I've had. The only problem is that it's not really a

Figure 2
Data Organization of Twelve Vectorized Review-text Datapoints

```
(0, 17743)    0.1638616229486196
(0, 22473)    0.1174867182818726
(0, 32880)    0.06866838674685247
(0, 23238)    0.11224381719100973
(0, 4076)     0.08961306159008037
(0, 36467)    0.09255355402985942
(0, 33047)    0.14271786222210697
(0, 32868)    0.2260601741198411
(0, 19729)    0.13425463771390117
(0, 4997)     0.23500621968219912
(0, 8410)     0.2805758439156411
(0, 21620)    0.10236632090062607
```

Note. The content of the data displayed in this figure is not particularly significant– the figure serves to display the format of the post-processing training set.

This process was repeated twice to accommodate for three distinct trials (later labeled as Trial 1, Trial 2, and Trial 3). In each trial, every classifier underwent training and testing on identical datasets to minimize potential areas of variability and enhance comparability. The performance metrics, including accuracy and F1 score, were systematically recorded for each classifier in every trial. Cross-validation was employed in each trial to further ensure robustness, with the dataset being divided into training and testing sets multiple times to validate the model's performance comprehensively. This rigorous approach ensures the reliability and consistency of the results obtained across the three trials.

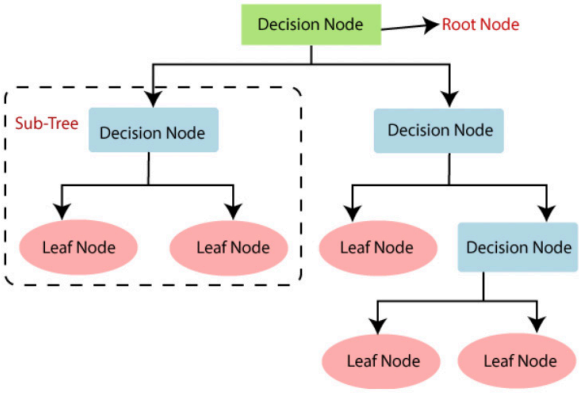
Classifiers Tested

A total of nine distinct text-classification algorithms were tested for their efficacy in the detection of computer-generated product reviews. As mentioned previously, this was done in three different trials, with each trial having the dataset split differently, but consistently between classifiers. Each algorithm that was tested carries a unique set of features and classifying algorithm, allowing us to not only identify the most effective classifiers, but also gain insight about patterns within the training data itself. This section serves as a preliminary exposition of these classifiers, explaining their basic mechanisms and shedding light on their respective strengths and limitations.

Logistic Regression is a classification method that generally models the probability of a binary outcome, and thus is useful in problems like this one. It works by essentially fitting a best-curve dividing line to the data it is trained with, effectively creating a decision boundary and outputting a probability of a certain outcome given an inputs features. This makes it well-suited for problems in which the relationship between features can be clearly delineated by some curve ("Logistic Regression", 2023). Similarly, Support Vector classifiers work by finding a hyperplane in a high-dimensional space that most effectively separates data points with different labels (effectively a higher-dimension equivalent to a two-dimensional decision boundary). In this way, they plot multidimensional decision boundaries, similarly to Logistic Regression, but are more versatile than the latter in many cases (Saini, 2024).

Decision Tree classifiers, on the other hand, function very differently. Instead of creating decision boundaries, Decision Tree classifiers recursively split a labeled dataset based on its features to create a tree-like structure, hence the algorithm's name. Each internal node represents a decision based on a feature, each branch a rule, and each leaf node a class label, as shown in figure 3. This algorithm is very versatile, and can be used in both classification and regression problems ("Decision Tree", 2024). The Random Forest classifier also utilizes this algorithm, essentially functioning as a fusion between a voting classifier and a decision tree classifier, in that it builds multiple decision trees, and then combines their predictions. Because it introduces randomness during both the trees' creations and the resulting voting process, it reduces overfitting and improves its generalization capabilities (Dutta, 2023). The Extra Trees classifier is very similar to both the Decision Tree and Random Forest classifiers, but it introduces even more randomness during the tree-building process by aggregating the results of many decorrelated trees and by utilizing more trees than the Random Forest classifier. This additional randomness enhances the model's robustness, especially in the presence of noisy data (Gupta, 2023).

Figure 3
Visual Representation of Decision Tree Classification Algorithm ("Visual Representation of Decision Tree")



An AdaBoost classifier is an adaptive boosting ensemble algorithm that begins with a weak classifier, then boosts the weak classifier by weighing misclassified data points slightly more heavily, and repeats this process until it arrives at a strong classifier. It then combines all of the classifiers it created in this

way, weighting classifiers by their expected accuracy. It is thus less prone to overfitting and performs well in practice (Saura H., 2023). Similarly to an AdaBoost classifier, Gradient Boosting sequentially builds a series of weak learners, with each subsequent learner correcting the errors of its predecessor by minimizing a cost function using gradient descent, resulting in a strong and accurate predictive model (Nikki, 2023).

Bagging classifiers are another type of voting classifier that involve training multiple instances of the same model on different bootstrap samples of the dataset, and aggregating their predictions. Compared to classic voting classifiers, this ensemble method helps reduce overfitting and improves stability (Dey, 2023). The K-Nearest Neighbors (KNN) classifier classifies data points based on the majority class (and weights) of their K-nearest neighbors in the feature space. While very simple, this algorithm is a non-parametric and instance-based learning algorithm which does not make any assumptions about data distribution, and is thus essential to machine learning (LaViale, 2023).

Results and Discussion

Each text classifier performed differently between trials and from each other in the task of detecting computer-generated reviews. Multiple models, including Logistic Regression, Support Vector Machine (SVM), Decision Tree, K-Nearest Neighbors (KNN), Random Forest, Extra Trees, Adaboost, Bagging, and Gradient Boosting, were subjected to standardized evaluation; each model underwent three trials, during which accuracy and F1 scores were recorded to comprehensively assess their effectivenesses (which are reflected in tables 1-11). Furthermore, these effectiveness scores were analyzed and interpreted in the context of each classifier's typical strengths and weaknesses, and serve as a foundation for proposing potential avenues of improvement for these classifiers.

Logistic Regression consistently exhibited strong performance across all of its trials, as shown in table 1. Several factors contribute to the effectiveness of Logistic Regression in the context of detecting computer-generated reviews– firstly, the simplicity of the model, relying on a linear decision boundary, appears well-suited to capture the underlying patterns in the data. Although this was not initially observed, the results of this model suggest that the relationships between features and the target variable are approximately linear. This simplicity implies that a highly effective model would not require complex transformations or feature engineering to perform well in this task. Furthermore, Logistic Regression's inherent resistance to irrelevant features allows it to focus on the most discriminative aspects of the reviews, potentially filtering out noise in the dataset. Logistic Regression's inherent resistance to overfitting is another aspect of its simplicity, as the model does not attempt to capture complex, nonlinear relationships that might merely represent noise rather than true patterns. The consistency in performance across trials suggests that the linear model successfully generalizes to different subsets of the data, demonstrating its reliability for the binary classification task. This generalizability indicates that the underlying structure of the data is adequately captured by the linear relationships assumed by Logistic Regression, and underscores the advantages of using a simple, interpretable model for the detection of computer-generated reviews (within this context).

Table 1
Accuracy and F1 score performance of Logistic Regression

Logistic Regression	Trial 1	Trial 2	Trial 3	Mean
Accuracy	0.8929145542	0.8995919377	0.8986026957	0.8970363959
F1 score	0.8907117617	0.8979129997	0.8980606663	0.8955618093

The Support Vector Machine (SVM) also exhibited strong yet slightly lower performance compared to Logistic Regression, as seen in table 2. This performance can be attributed to SVM's inherent characteristics and the nuances of the dataset, since SVM's strength lies in its effectiveness in high-dimensional spaces, making it well-suited for text classification tasks with numerous features. However, SVM is known to be sensitive to outliers, and the dataset's handling of outliers might have impacted its performance. Further preprocessing techniques, such as outlier removal or robust feature scaling, could be explored to enhance SVM's robustness. Despite these considerations, SVM's competitive performance underscores its utility for text classification, suggesting that addressing specific characteristics of the dataset may further optimize its effectiveness in detecting computer-generated reviews.

Table 2
Accuracy and F1 score performance of Support Vector Classifier

Support Vector	Trial 1	Trial 2	Trial 3	Mean
Accuracy	0.8800544083	0.8780759243	0.8822802028	0.8801368451
F1 score	0.8784461153	0.8772715957	0.8821490468	0.8792889193

The Decision Tree model displayed comparatively lower performance, as shown in table 3, raising insights into its behavior and potential limitations. In general, Decision Trees are inherently interpretable and capable of capturing non-linear relationships within the data. However, as indicated by Logistic Regression's success, the data was approximately linear, and thus, this functionality was not taken advantage of. Furthermore, Decision Trees' susceptibility to overfitting might have played a role in the observed outcomes, as its ability to create complex decision boundaries comes with a caveat of a higher sensitivity to noise and specifics of the training data, causing it to generalize less effectively to unseen instances. The lower accuracy and F1 scores across trials suggest that the Decision Tree struggled to encapsulate the intricate patterns inherent in distinguishing computer-generated reviews, shortcomings that an ensemble approach, like Random Forest, might be able to account for by exploring to harness the strength of multiple trees for improved predictive performance.

Table 3
Accuracy and F1 score performance of Decision Tree Classifier

Decision Tree	Trial 1	Trial 2	Trial 3	Mean
Accuracy	0.7333992828	0.7270928651	0.7289476938	0.7298132806
F1 score	0.7052228603	0.7009079821	0.706323687	0.7041515098

K-Nearest Neighbors (KNN) demonstrated the lowest performance among the classifiers, as shown in table 4. One primary factor contributing to its suboptimal results may be that the effectiveness of distance-based metrics diminishes as the number of features increases (Thorn, 2021). Given the nature of text classification tasks, which typically involve high-dimensional spaces due to the large number of unique words and features, KNN may have struggled to discern meaningful patterns. Furthermore, the default value of K might not have been optimal for the dataset, and exploring a range of values for K could help identify a more suitable configuration. The over-reliance on local information and the simple lack of inherent ability to capture global patterns might have further contributed to the K-Nearest Neighbors classifier's performance challenges.

Table 4
Accuracy and F1 score performance of K-Nearest Neighbors Classifier

K-Nearest Neighbors	Trial 1	Trial 2	Trial 3	Mean
Accuracy	0.5542228268	0.5555830345	0.5620131075	0.5572729896
F1 score	0.6867124359	0.6872062663	0.692961165	0.6889599558

Unlike Decision Tree, Random Forest, a robust ensemble method, demonstrated notable success across trials, which can be seen in table 5. The ensemble nature of Random Forest, comprised multiple decision trees, played a pivotal role in its comparative effectiveness; this approach allowed the model to mitigate overfitting by aggregating predictions from diverse trees, each trained on a different subset of the data. Random Forest excels in capturing complex relationships within the dataset, leveraging the collective wisdom of individual trees. It is able to assign importance to features and thereby focuses on the most discriminative aspects of the reviews, contributing to its strong predictive performance. Its capacity to handle intricate patterns make it a compelling choice for text classification tasks, and further exploration might involve investigating the impact of the number of trees or other hyperparameter adjustments for potential optimizations.

Table 5
Accuracy and F1 score performance of Random Forest Classifier

Random Forest	Trial 1	Trial 2	Trial 3	Mean
Accuracy	0.8815382713	0.8725114381	0.8832694448	0.8791063847
F1 score	0.8844390832	0.8759475394	0.8875387181	0.8826417803

Like Random Forest, the Extra Trees classifier consistently exhibits robust and competitive performance, as one can see in table 6. This makes intuitive sense– The Extra Trees classifier is essentially just a Random Forest classifier that introduces even more randomness. The model's inherent strength, stemming from its ensemble of decision trees and their randomized nature, allows for it to capture

complex relationships within the dataset, leveraging the collective wisdom of individual trees of the model. Its approach of being comprised multiple decision trees allowed the model to mitigate overfitting by aggregating predictions from many different trees, each trained on a different subset of the dataset. Further exploration might involve investigating hyperparameter tuning and other potential optimizations to fully leverage the model's capabilities.

Table 6
Accuracy and F1 score performance of Extra Trees Classifier

Extra Trees	Trial 1	Trial 2	Trial 3	Mean
Accuracy	0.8924199332	0.8936564857	0.893780141	0.89328552
F1 score	0.8952564411	0.8959341723	0.8976528059	0.8962811398

Adaboost, another ensemble method, demonstrated moderately competitive performance in the task of detecting computer-generated reviews, as shown in table 7. The model's adaptive boosting strategy, focusing on correcting misclassifications from previous weak learners, may have contributed to its success. Adaboost's consistent accuracy and F1 scores across trials indicate its ability to learn and adapt to complex patterns within the dataset. The lower accuracy compared to some other classifiers might be attributed to the model's sensitivity to outliers or noise in the data, which it may have focused to hard on correcting. Fine-tuning hyperparameters, such as the learning rate and the choice of weak learners, could potentially enhance Adaboost's performance. Additionally, exploring the impact of different weak learners, such as decision stumps or shallow trees, might provide insights into the model's behavior and avenues for improvement.

Table 7
Accuracy and F1 score performance of Adaboost Classifier

Adaboost	Trial 1	Trial 2	Trial 3	Mean
Accuracy	0.8261407197	0.8271299617	0.8308396191	0.8280367668
F1 score	0.825990099	0.8262922465	0.8305672529	0.8276165328

The Bagging classifier demonstrated robust and consistent performance, as seen in table 8. Because bagging involves training multiple models on random subsets of the data and aggregating their predictions, it proved successful in providing stability and reducing variance. This also allows the classifier to capture diverse patterns within the dataset, contributing to its high accuracy and F1 scores. In addition, the positive outcomes suggest that the combination of models trained on diverse subsets complemented each other, collectively improving predictive performance. Further exploration might involve investigating variations in sampling techniques or adjusting hyperparameters such as the number and types of base models to understand the specific configurations that contribute to Bagging's success.

Table 8
Accuracy and F1 score performance of Bagging Classifier

Bagging	Trial 1	Trial 2	Trial 3	Mean
Accuracy	0.850129838	0.8444416966	0.853592185	0.8493879065
F1 score	0.8525906106	0.8472559495	0.8576238576	0.8524901392

Unsurprisingly, Gradient Boosting, as seen in table 9, exhibited similar results to Adaboost, showcasing its ability to iteratively refine the model and correct errors made by previous weak learners. Like in the case of Adaboost, the moderately competitive accuracy and F1 scores across trials suggest that the boosting strategy effectively contributed to the model's robustness. The iterative nature of boosting allows the model to adapt to complex patterns and nuances within the data, providing a nuanced understanding of distinguishing features in reviews. However, fine-tuning hyperparameters, such as the learning rate, may further optimize Gradient Boosting's performance. Additionally, experimenting with different weak learners or assessing the impact of varying the number of boosting iterations could unveil opportunities for refinement. Overall, the competitive performance of Gradient Boosting indicates its suitability for discerning computer-generated reviews, and further investigations into hyperparameter tuning and model variations may unlock its full potential for text classification tasks.

Table 9
Accuracy and F1 score performance of Gradient Boosting Classifier

Gradient Boosting	Trial 1	Trial 2	Trial 3	Mean
Accuracy	0.8216891307	0.8230493384	0.8299740324	0.8249041672
F1 score	0.8142231384	0.8181933681	0.826848004	0.8197548368

Table 10
Accuracy test performances of each classifier for three trials

Classifier	Trial 1	Trial 2	Trial 3	Mean
Logistic Regression	0.8929145542	0.8995919377	0.8986026957	0.8970363959
Support Vector	0.8800544083	0.8780759243	0.8822802028	0.8801368451
Decision Tree	0.7333992828	0.7270928651	0.7289476938	0.7298132806
K-Nearest Neighbors	0.5542228268	0.5555830345	0.5620131075	0.5572729896
Random Forest	0.8815382713	0.8725114381	0.8832694448	0.8791063847
Extra Trees	0.8924199332	0.8936564857	0.893780141	0.89328552
AdaBoost	0.8261407197	0.8271299617	0.8308396191	0.8280367668
Bagging	0.850129838	0.8444416966	0.853592185	0.8493879065
Gradient Boosting	0.8216891307	0.8230493384	0.8299740324	0.8249041672

Figure 4
Graph of accuracy test performances of each classifier for three trials

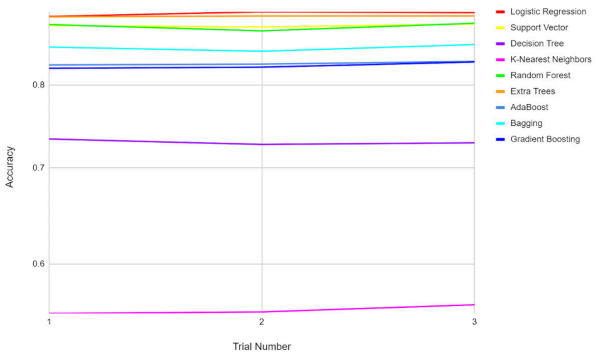
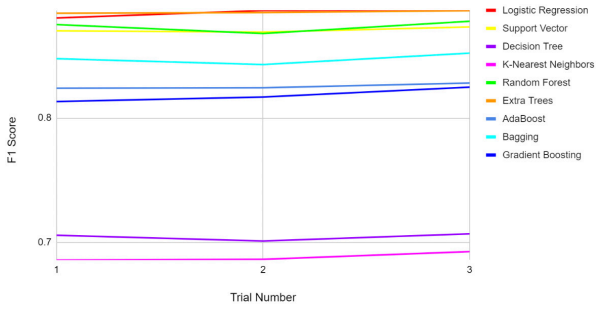


Table 11
F1 score performances of each classifier for three trials

Classifier	Trial 1	Trial 2	Trial 3	Mean
Logistic Regression	0.8907117617	0.8979129997	0.8980606663	0.8955618093
Support Vector	0.8784461153	0.8772715957	0.8821490468	0.8792889193
Decision Tree	0.7052228603	0.7009079821	0.706323687	0.7041515098
K-Nearest Neighbors	0.6867124359	0.6872062663	0.692961165	0.6889599558
Random Forest	0.8844390832	0.8759475394	0.8875387181	0.8826417803
Extra Trees	0.8952564411	0.8959341723	0.8976528059	0.8962811398
AdaBoost	0.825990099	0.8262922465	0.8305672529	0.8276165328
Bagging	0.8525906106	0.8472559495	0.8576238576	0.8524901392
Gradient Boosting	0.8142231384	0.8181933681	0.826848004	0.8197548368

Figure 5
Graph of F1 score performances of each classifier for three trials



In summary, the evaluation of text classifiers for detecting computer-generated reviews clearly revealed that certain classifiers were much more effective and accurate at the task, a disparity that is observable in both tables 10 and 11 and both figures 4 and 5. Logistic Regression consistently excelled, leveraging simplicity and linearity. Support Vector Machine showed potential in high-dimensional spaces but may have fallen short handling outliers. Decision Tree faced challenges, suggesting the need for ensemble approaches, but Random Forest and Extra Trees, both ensemble methods, exhibited robust performance, mitigating overfitting. K-Nearest Neighbors struggled in high-dimensional spaces, emphasizing the importance of exploring optimal parameters. Adaboost and Gradient Boosting demonstrated moderate success, indicating room for improvement through hyperparameter tuning. Bagging displayed consistent and robust performance, highlighting the benefits of model aggregation.

The comparison of accuracy and F1 scores (which have been visualized in figure 4 and figure 5) among the evaluated classifiers serves as a valuable foundation for future investigations aimed at enhancing the performance of text classifiers in the challenging task of reliably detecting computer-generated reviews. The observed variations in accuracy and F1 scores highlight specific strengths and weaknesses inherent in each model, and also suggest that to capitalize on these insights and ameliorate the models' performances, a targeted improvement approach involving a mixture of hyperparameter tuning and closer data analysis is warranted.

Conclusion

As discussed, fake online product reviews have become more and more prevalent, negatively impacting e-commerce platforms. Some of the issues surrounding fake reviews, such as their ability to mimic authentic user feedback and their sheer mass on popular platforms such as Amazon, make dealing with them a very demanding task for consumers. This research sought to address this issue, evaluating various text classifiers and reporting their accuracy and F1 scores. Logistic Regression, Support Vector, and Extra Trees proved to work best, consistently outperforming other classifiers, and demonstrating robust accuracy and F1 scores. K-Nearest Neighbors performed poorly in handling high-dimensional text data, and ensemble methods like Random Forest showed notable success, as did AdaBoost and Gradient Boosting. Logistic Regression emerged as the most accurate classifier for detecting computer-generated reviews, offering insights into the task's unapparent simplicity and proving effective in capturing linear patterns. Further exploration could involve tuning hyperparameters for poorly performing models (where applicable, for instance, the number of neighbors considered by the KNN classifier) and exploring additional classifier or algorithms.

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The Evolution of the Skirt, its Alternatives and their Meaning in the Modern Era

By Thea Hwang

Author Biography

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Abstract

This article depicts the skirt as it morphs from a full-length, heavily petticoated Victorian silhouette to the mini and its trousered alternative from mid-19th century bloomers to the various pant styles worn by women today. Alongside these evolutions of women's dress, the larger socio-historical context in the United States and the women's movement as a whole are noted, in particular the continual cycle of developments in fashion adapting women's wardrobes to accommodate their changing role and place in society, which in turn feed further refinements in the design and function of womenswear. Despite the social progress in the U.S. from the 1850s to the 2020s, it would appear that an individual may dress exclusively to reflect their personal choice and identity only to the extent of any pre-existing privilege they enjoy. For women and girls, even with feminist movement in its fourth wave, recent litigation over school dress codes indicate that pants remain a gendered issue. And with gender increasingly understood as a complex rather than a binary identity and expression, the skirt returns to the conversation over social norms, this time for men and people read as men who may elect to wear the occasional skirt.

Keywords: women's fashion, skirt, pants, dress reform, school dress codes, gendered clothing, gender bending dress

Introduction

American newspaper editor and women's rights advocate Amelia Bloomer did not mean to start a fashion revolution, but she kickstarted the re-entrance of pants into western women's wardrobes in the 1850s. With the emergence of bloomers, a nascent form of pants and alternative to skirts, women's fashion could signify social liberation and change, a progression which in turn is shaped by the design and use of clothes. The Dress Reformation movement (1850-1914), by innovating the design of pants for women, takes both the feminist movement and the feminine wardrobe to a critical turning point. During World War II, fashion again reflected societal change with women en masse putting on pants and jumpsuits to work in factories to support the war effort. Progress on the social and sartorial fronts seemingly marched forward in the ensuing decades.

Yet, an assumption that by the 21st century women are no longer constrained between skirts and pants in their day-to-day wardrobes choices would be premature, as recent litigation over school dress codes requiring girls to wear skirts indicate that pants on female bodies are still considered a gendered dress form. At the same time, another tipping point may be at hand with some men in major metropolitan areas like New York and Los Angeles choosing to wear skirts. The skirt is once again at the forefront of challenging gender norms in fashion and beyond. This paper traces the evolution of the skirt and its alternative, pants, in women's dress in the West over the past 150 years, while noting concurrent developments in the socio-historical context and women's status, and on reaching the 2020s, finds that even as contemporary conceptions of gender identity blur previously bright lines, becoming more fluid and less binary, much of today's considerations in dress remains rooted in gender, and in some cases an anachronistic interpretation thereof.

Pre-Modern Western Sartorial History: A Summary

Pants and gendered clothing did not spontaneously emerge in western fashion. According to Adrienne Mayor, a classics scholar at Stanford University, the Scythians (a name the ancient Greeks used for several nomadic horse-riding tribes from the Eurasian steppes) most likely invented pants for horseback riding. As tailored garments that required multiple pieces of fabric to be assembled together, pants were differentiated from, and more complicated than, the simple rectangular pieces of fabric that the Greeks pinned and draped to use as clothing. The pants worn by the Scythians, for which the oldest archeological fragments date back to 3,000 years ago, were non-gendered. Ancient Greek writings, and some depictions on painted vases, refer to Scythian women wearing pants (Bain, 2019).

The ancient Greeks never adopted pants and their draped tunic and cloak influenced Western dress for the next millennium. Up until the 14th and 15th centuries in the West, both men and women essentially wore long robes, or what might be termed a dress (Brucculieri, 2019). Around this time, men's robes began to shorten, revealing more of their undergarment or hose, which then evolved into outer garments or pants. Women continued wearing long skirts and a clearly defined line between men's and women's clothing developed (Brucculieri, 2019). With gendered clothing emerging, societal norms and, in some cases, laws arose to enforce this division. In 1431, a church tribunal relied on a biblical passage, Deuteronomy 22:5 ("A woman shall not wear anything that pertains to a man, nor shall a man put on a women's garment, for all who do are an abomination to the Lord your God"), to charge Joan of Arc, who wore armor which required the masculine attire of leggings and a form-fitting tunic underneath, with heresy and to burn her at the stake (Ford, 2021, p. 68). Notably, the quoted Bible verse does not actually require that pants be exclusively men's clothing and skirts, women's garments (Bain, 2019).

1850s: Dress Reform

In the April 1851 issue of The Lily, the first women's newspaper, editor Amelia Bloomer told readers about and printed patterns for "Turkish" pantaloons worn with a knee-length skirt, which became known as "bloomers" (Bain, 2019). This was Bloomer's accidental seeding of the Dress Reformation, a fashion revolution for women to wear pants. The Bloomerites, however, did not call for gender equality through pants. Instead, bloomers were portrayed as a safe, practical choice that would not,

unlike long skirts, hinder women in their performance of housekeeping and domestic chores (Bain, 2019). Despite this non-political bent, wearing pantaloons still challenged the harsh lines of gendered dress. Suffragist Elizabeth Cady Stanton saw dress reform as part of the battle for women's rights, saying she felt "like a captive set free from his ball and chain" in the pantaloons (Boissoneault, 2019).

A cartoon of the bloomer costume. National Park Service / Library of Congress

The Dress Reformation and bloomers only lasted a few years, partly because women did not find bloomers all that flattering (Bain, 2019). Women returned to full-length skirts, which had become more palatable with the new invention of crinoline, a light wire under the skirt that created the bell effect that was possible before only with many layers of petticoats. According to Bloomer, women left behind the Dress Reformation because "[w]e all felt that the dress was drawing attention from what we thought of far greater importance–the question of woman's right to better education, to a wider field of employment, to better remuneration for her labor, and to the ballot for the protection of her rights" (Boissoneault, 2019).

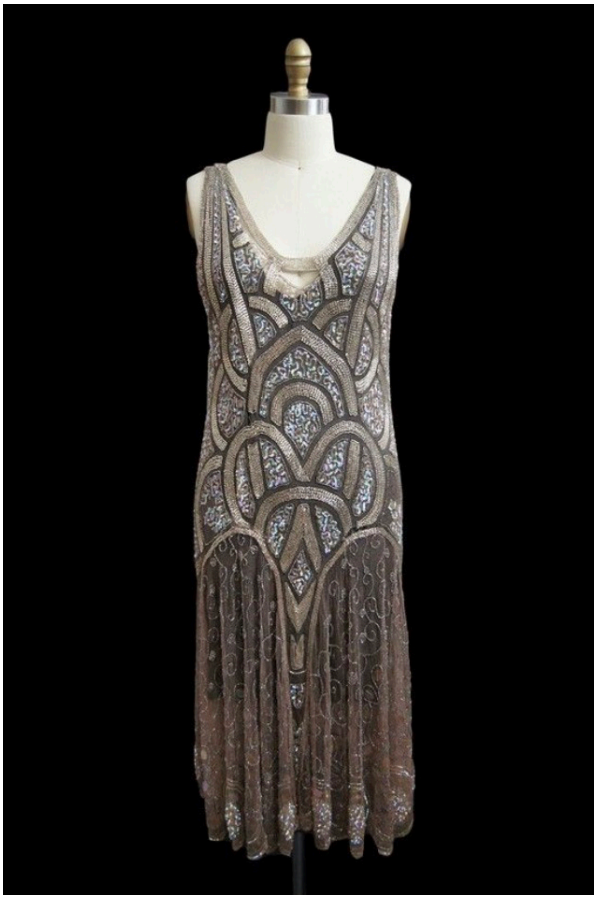
This view of the Dress Reformation as a distraction from the fight for women's rights was shared by other prominent feminists. In a letter, Susan B. Anthony lamented that attention was paid to her clothes rather than to her advocacy (Bain, 2019). The above quotation from Bloomer not only explains why the Dress Reformation ended, but also hints at the role fashion can play in the feminist movement. In the late 1800s, as women were fighting for the vote, better education, and access to the job market, the ability to wear pants distracted from issues more central to women's rights and women's position in society. Yet, even as first wave feminists conceded to the political practicalities of the time, the fact that arguments for "a radical sartorial reworking of clothing in form and function based on a desire for bodily liberation, utility, and sexual equality" (Strassel, 2012, p. 40) by women had been brought forth. The "transformation of [women's] embodied experience as a worthy goal" (Strassel, 2012, p. 39) and the fit and function of fashion had been introduced as a political issue and it would persist.

1920s-1940s: Jazz Age to World War II

Ironically, "the phrase dress reform disappeared in the 1920s precisely at the moment when the goals of rationalized dress became naturalized–when they moved from the realm of marginal social movements and instead were adopted by the mainstream

fashion industry itself" (Strassel, 2012, p. 40). This was the age of the flapper, a figure synonymous with The Great Gatsby, Prohibition era jazz clubs, and roaring '20s' excesses, but also a look that upended conventional gender norms. The flapper's "[s]heath dresses were form-fitting in the way the men's suit was form-fitting: for the first time, women's clothing skimmed the body. The flapper look was angular, athletic, and boyish.

In this sense, the flapper–like androgynous dressers since Joan of Arc–claimed masculine prerogative by adopting masculine sartorial symbolism. This suggested sexual liberation" (Ford, 2012, p. 144). Provocatively, flappers' sleeveless sheaths exposed their arms and, yet more scandalously, their legs with the unprecedented rise of hemlines, first to women's mid-calves, then their knees. While the flapper look may have kept the form of the skirt, the changes brought about in silhouette and length were revolutionary on a scale akin to the introduction of pants into womenswear–the fact that women had two legs was no longer obscured and women's legs in flapper's stockings were even less covered in fabric as compared to pants. The flapper was a highly visible symbol of the times. Behind this image were social, economic, and political changes affecting women's place in U.S. society, and by extension attire. The growing popularity of sports starting in the late 1800s, especially cycling (one magazine editor referred to women's cycling as an "almost compulsory activity in the modern women's movement" (Muellner, 2006, p. 167)), helped encourage less cumbersome clothing for women. Socioeconomic changes included women entering the workforce in large numbers as men were sent to the warfront of World War I.



In 1920, the Nineteenth Amendment extended the vote to American women, removing that legal barrier to full citizenship. These new freedoms in physical, economic, and political activity underpinned the flapper style, which both fed on and drove further changes for women. For instance, flappers signaled their distaste for the gender norms of the times and their limitations on women by "shedding their corsets, chopping their hair" in addition to adopting the shorter sheath dress (Rosenstock, 2023).

Flapper fashions, being lightweight and body-skimming, allowed for ease of movement and communicated a rational

sensibility. This represented a dramatic break from the ornamentation, heavy draping, and cumbersome padding of preceding dress conventions. "This shift, from clothing that symbolized femininity while obscuring most of the actual female body to clothing that expressed the feminine form by suggesting its actual contours, was a visual manifesto for gender equality, an implicit statement that women's bodies were fit for public view and physically capable too" (Ford, 2021, p. 150). The flapper was a visual statement for gender equality. Before the flapper, femininity was symbolized with clothing that covered most of a woman's body. By contrast, the flapper's dress revealed the contours of a feminine body and, in doing so, asserted that women's bodies need not be hidden and could be seen. This celebration of the female body was an application of the ideals of modernism–embracing form and rejecting ornamentation. In this sense, the flapper claimed some of male privilege.

Hellen Hulick appearing in court wearing pants on Nov. 14, 1938. Andrew Arnott / Los Angeles Times Archive / UCLA

While the flapper was the dominant female image of the 1920s, pants continued to infiltrate womenswear. Through the second half of the 1920s, French designer Coco Chanel helped bring menswear staples such as tailored jackets and trousers into women's wardrobes (Bain, 2019). Chanel herself "was often photographed. . .wearing loose, sailor-style trousers, known as 'yachting pants'. The most fashionable young women started to wear trousers for leisure pursuits" (Mendes, 1999, p. 72). Then and into the 1930s, Hollywood actresses like Marlene Dietrich began wearing pants on a more regular basis, shocking audiences by appearing in tuxedos and double-breasted suits in the films Morocco (1930), Blonde Venus (1932), and Seven Sinners (1940) (Michael Andrews Bespoke).

For regular women however, pants were not acceptable wear. In 1938, teacher Helen Hulick arrived in pants at a Los Angeles courtroom to testify as a trial witness, but was sent home and told to return in a dress; when she showed up again in pants, she was held in contempt (although the citation was later overturned) and given a five-day jail sentence (Downey, 2017). Dietrich herself was refused entry into a famed Los Angeles restaurant in 1933 for turning up in pants; The Los Angeles Times reported it would be several decades before that restaurant lifted its ban on female patrons wearing pants (Bain, 2019).

With World War II, unprecedented numbers of women worked in factories to support the national economy and wore pants as their mandated uniform. Although wearing pants was not necessarily their choice, just the fact that more women were wearing pants helped normalize and popularize pants as womenswear. "Though donning overalls and jeans, clothes associated with rough masculinity, initially seemed 'very odd,' even embarrassing, some war workers only reluctantly returned to dresses after leaving the factory for office, retail, or other spaces of women's labor. For slacks–along with having 'your hair tied up' and wearing 'a welder's helmet'–brought. . .'liberation.' Pants, associated with hegemonic masculinity, could signify power and freedom" (Boris, 2006, p. 123).

1960s-1990s: Counterculture to the Power Suit

1960s America roiled with change, from the civil rights movement and anti-war protests to counterculture influences and second wave feminism. The iteration of the skirt during this era of change was the mini. The rise of the mini skirt is often credited to British designer Mary Quant, although she herself attributed the mini skirt to the young women on the street (Calahan & Zachary, 2019). The ever-increasing numbers of women entering higher education and the workforce, the spreading ideals and calls for democracy and equality, and the introduction of the birth control pill all formed a tapestry of change in the 1960s that included a youth-led whole cloth change in who was making and consuming fashion (Calahan & Zachary, 2019). One expression of change in the "youthquake" fashion revolution was embodied by the mini skirt, with young women no longer wanting to dress like their mothers. The mini skirt could perhaps be said to represent the end point of the skirt's evolution, as the counterpoint to the full, heavy, floor-length skirts of the mid-1850s. Following the mini's arrival, hemlines would rise or fall and skirt shapes adapt to trends, but any of these iterations would fall within the spectrum anchored on one end by the Victorian silhouette and on the other by the mini.

The 1960s also saw the increasing normalization of pants as womenswear. This is perhaps best exemplified by American actress Mary Tyler Moore in her role as the lead character's spouse on The Dick Van Dyke Show, the iconic television situation comedy that ran from 1961-1966. Over the objections of the show's sponsors, Moore sneaked pants into her character's wardrobe more and more until fitted capri pants became her signature look (Bain, 2019). Moore would have an even greater influence in women's fashion and second wave feminism when she became the lead in The Mary Tyler Moore Show, which ran from 1970-1977 and was a first in American television for having a single working woman as its central character. Despite this groundbreaking premise, The Mary Tyler Moore Show was not unequivocally feminist. While Mary embodied many of the advancements sought by first wave feminism, having the right to work, vote, and handle her own business transactions, all this fell short of second wave feminists' demands for equality (Fuselier, 2016, pp. 5-6). The "moderate, subtle nature of The Mary Tyler Moore Show" showed a "relatable side of feminism" (Fuselier, 2016, p. 6), whereas second wave feminism, as a

radical movement, ran into opposition on many fronts in the United States.

As foreshadowed by The Mary Tyler Moore Show and inspired by the women's movement, many American women wore their pantsuits and miniskirts into workplaces and schools, and these styles became accepted womenswear at many of these venues by the 1970s (Hillman, 2013, p. 156). Yet, as feminists who promoted the freedom of choice in dress pushed American society to accept changing fashions such as pantsuits and miniskirts for women, gender-bending dress, like women wearing pants, in challenging broader societal conceptions of sex roles and femininity was connected to a politics of gender (Hillman, 2013, p. 156). Questions that divided second wave feminists were "[d]id nontraditional, androgynous, or 'masculine' self-presentations help to create a new feminist version of womanhood, free from socially constructed gender roles? Or did rejecting traditional feminine gender presentation signal that feminists sought to abandon their heterosexual female identities?" (Hillman, 2013, p. 157)

Ultimately, a woman's self-presentation was a question of "what it meant to be a woman in an era of woman's liberation" (Hillman, 2013, p. 157). The era's iteration of the skirt, the mini, and its more widespread use of pants by women signaled that more options in terms of hemlines and tailored wear versus drapery were available to women of the 1960s and 1970s. Importantly, the femininized miniskirt and the more masculine pants were not mutually exclusive options for women. It should also be noted that the "nontraditional, androgynous, or 'masculine" presentation option, in moving further away from traditional, socially constructed gender roles, helped open up possibilities for people who may be gender queer, though transgender was still far from being commonly accepted as an identity.

By the 1980s, the power suit had arrived for women, who adopted the traditional business suit into their wardrobes. The 1980s' power suit, however, generally paired a jacket with a skirt. For another decade or so, pantsuits remained less common and were generally deemed inappropriate attire for women in corporate boardrooms or as members of the bar arguing before the courts. For instance, until 1993 there was an unofficial rule that women in the U.S. Senate could not wear pants (Bain, 2019). In the halls of power, it would seem that pantsuits, due to their gendered association, took longer to gain acceptance than skirt suits. Ironically, these were the very spaces that second wave feminists fought hard for entry into and, once having gotten their feet in the door, competed to succeed on the same metrics as their male counterparts. Perhaps as some women started to break down the gender barriers in government, law, and business, the patriarchy sensed the threat to their previously, exclusively-gendered chokehold on power and sought to hold back women's professional progress in less explicit ways, such as attire. Such a move would not be dissimilar to the challenge faced by first wave feminists and the dress reform movement when bloomers first appeared over a century earlier.

The New Millenium

Today in the U.S., women's right to wear pants persists as a question rooted in gender. For most, pants have become a wardrobe staple that can be worn in formal or informal, public or private spaces. Yet, two recent incidents underscore that pants remain a gendered, and potentially controversial, clothing item for women and girls. In March 2019, senior Hannah Kozak was surprised to learn that female students at her Pennsylvania high school were barred from wearing pants under their cap and gown at graduation. Kozak had to take numerous steps just to be able to wear pants: she spoke to the teacher who was her senior class advisor; she contacted the school principal; she presented her argument in front of the school board; she then received special permission to wear pants, but deeming an individual dispensation insufficient, called her local television news station. It was only after the media interviewed Kozak and reached out to the school for comment that the district reversed the rule, allowing all students to wear professional business attire, including pants, to their commencement ceremony (Mettler, 2019).

The second instance started in 2016 and needed litigation to resolve in June 2023. A North Carolina K-8 charter school had a dress code requiring girls to wear skirts, and not pants or shorts, as part of its "traditional values." The girls found skirts less comfortable on a daily basis and less warm in winter than pants; wearing skirts forced them to pay constant attention to the positioning of their legs during class and led them to avoid certain activities, such as climbing or playing sports during recess, for fear of exposing their undergarments and being reprimanded by teachers or teased by boys; they argued that the skirts rule sent a message that girls' comfort and freedom to engage in physical activity were less important than those of boys. Students and their parents challenged the school's skirts requirement as sex discrimination under the U.S. Constitution's Equal Protection Clause. In 2019, the trial judge agreed that "[t]he skirts requirements causes the girls to suffer a burden the boys do not, simply because they are female" (Mervosh, 2019). In 2022, the full U.S. Court of Appeals for the Fourth Circuit agreed that the skirts requirement violated the girls' rights, observing it was "difficult to imagine a clearer example of a rationale based on impermissible gender stereotypes" (American Civil Liberties Union, 2023). The U.S. Supreme Court declined to review the case in June 2023, leaving the appellate decision as final.

Over 100 years after pants had developed into an alternative to skirts for women's attire, it would seem that pants have not fully shed their gendered connotations when worn by a female body. "[M]ost gendered clothing doesn't refer to human biology; instead it reflects a social convention. 'Women's clothing' isn't clothing that is especially suited to female bodies–it is simply any clothing that women typically wear. This means that every transgression of gender norms is also a potential revision of those norms: if enough women wear pants, then pants will become women's clothing" (Ford, 2021, p. 263). While many might find this statement self-evident, it also does not reflect the reality of 2024. Even as women's position in society has advanced and many

stultifying gender norms have receded, the gender pay gap has stayed much the same for the past 20 years. According to the Pew Research Center, "in 2022, American women typically earned 82 cents for every dollar earned by men" (Kochhar, 2023). The continued hetero-normative domination of the power structures of society and the media and the persistence and weight of "traditional values," as exemplified by the school dress code cases, signal that today's world remains gendered and hence the visual cues of dress will be interpretated on gendered lines.

In the United States today, as fashion is a highly visible form of expression, perhaps women should dress for impact and with voice. Women can continue to wear pants in everyday life as a matter of course as well as embrace and fight for wearing pants as a statement of power and personality. Hillary Clinton, well-known for her pantsuit uniform, used this sartorial choice to both fit in with her male counterparts but also stand apart from them, a visual reminder that as a woman running for President she was different from the male candidates but also familiar (King & Allen, 2020). Fashion historian Cassidy Zachary noted that despite women having by now worn pants for decades, pants "maintain this idea of power, of independence, control" over the body and is still "viewed as a very feminist statement, to this day" (Brucculieri, 2019). As such, the female actors and musical artists who have chosen pants for highly publicized red carpet events over the traditional formal gowns make a statement and actively shape the fashion conversation. Famously, Lady Gaga wore an oversized suit for the 2018 Women in Hollywood celebration as an act of self-empowerment: "As a sexual assault survivor by someone in the entertainment industry, as a woman who is still not brave enough to say his name, as a woman who lives with chronic pain, as a woman who was conditioned at a very young age to listen to what men told me to do, I decided today I wanted to take the power back. Today I wear the pants" (Brucculieri, 2019).

If pants remain a transgressive form of dress for women, at least in some contemporary settings, then for men or people read as men to wear skirts would be taboo. In 2016, actor Jaden Smith wore a Louis Vuitton skirt for the designer's womenswear advertising campaign. The New York Times' fashion critic described Smith's modeling of the skirt as not gender neutral or gender bending or gender free, but in fact, entirely gendered, because the modeled "clothes and their conceptual allegiance have not changed at all" since Smith is "not a man in transition. . .or a man wearing clothing that looks as if it could be worn by either gender. . . .He is a man who happens to be wearing obviously female clothes." (Friedman, 2016). Actor and singer Billy Porter similarly crossed gender dress lines on numerous occasions, including in a fusion of tuxedo jacket and ultra-puffy gown at the 2019 Academy Awards. Musician Harry Styles marked a milestone as the first male to have a solo cover on the iconic fashion magazine Vogue and did so in a Gucci gown to challenge gender-based clothing stereotypes. These instances of men wearing skirts cross gender lines, but have not brought widespread change in standard masculine attire, even as some men today in major metropolitan areas in the U.S. don the occasional skirt. As gender has started being viewed as less binary and more of a fluid identity, more options for gender-neutral

or bending dressing have also materialized, leading to the question as to where the skirt and pants fall on this identity spectrum. As individuals aspire to an era of wear-what-you-want, dress as a visual medium exists within the larger society and may never escape the eyes and judgment of the beholder.

Conclusion

This article traced the evolution of the skirt from the Victorian era to the mini and its alternative from bloomers to the various styles of pants worn by women today. Even in 2024, with the seeming freedom to wear-what-you-want, the conflict between individual choice and social norms persists. Increasingly, gender has come to be understood in the United States as complex and multi-faceted, more of a fluid rather than binary identity, leading to expectations that traditional gendered dress codes would fall away as outdated social constructs are discarded. This may be true to a certain extent and perhaps as a gradual and not always linear progression, but will an individual's dress ever be purely a reflection of their identity? Or will it remain a function of privilege–that an individual will have unfettered freedom to express themself in dress only to the extent they possess pre-existing privilege and apparent social standing? In the case of women, whose position has clearly advanced in the roughly 150 years covered in this brief history of the skirt and its alternative, but yet school dress codes imposing the skirt on girls at the expense of individual choice persist well into the 21st century. As some men and genderfluid or transgender people today choose to wear skirts, will that choice be accepted and held up for the privileged and opposed and denied when the wearer lacks status? Gendered dress may evolve as social norms shift, sometimes ahead of and other times behind the prevailing values, but as a highly visible medium dress will always shape a person's relationship to their physical self as a body covering, to their social self as a sartorial language read and received by the larger world, and to their inner self through the expression of identity.

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A Review of Global Oral Health

By Renee H. Jia

Author Biography

My name is Renee Jia, and I am an 11th grader based in Atlanta Georgia. I am interested in pursuing biology and public health in college with a goal of becoming a dental professional. Outside of academics, I am an artist and a pianist, and I frequently host piano workshops for beginners.

Abstract

The oral cavity and the structures within are essential to life processes such as eating, speaking, and breathing. Main components of the oral cavity include the tongue, teeth, gums, and oral microbiome. The health of the oral cavity has strong bidirectional associations with overall health, and frequent oral manifestations of systemic diseases gives the mouth strong diagnostic potential. With an estimated burden of over 3.5 billion cases, oral diseases are considered a public health crisis. There is a strong and consistent association between socioeconomic status and the prevalence and severity of oral diseases, establishing a disproportionate burden. Factors that can impact the integrity of the oral cavity include age, nutrition, and genetics. Modifiable risk factors include diet, quality of oral hygiene, unhealthy lifestyle choices, and their underlying social determinants. Challenges preventing access to oral care include high expenses, lack of insurance, lack of perceived need, unavailability of dental offices, transportation issues, fear of dental treatment, and scheduling difficulties. These barriers have varying impacts on individuals, but especially impact marginalized communities, and stretch beyond physical health to include mental health challenges. The role of healthcare workers in community based oral health awareness programs is discussed and emphasized. There has been some evidence to show that oral health promotion programs are more effective when delivered by healthcare professionals and targeted towards parents and children under the age of 6.

Keywords: Oral health, systemic health, oral microbiome, oral cavity, field study, oral healthcare, oral health promotion

Introduction

The oral cavity, or mouth, plays an integral role in many bodily functions and quality of life. There has been research to suggest connections between oral diseases and the presence and severity of systemic conditions, and the mouth is often used as a surface level diagnostic tool due to the frequent oral manifestations of systemic diseases. Although largely preventable, oral diseases are some of the most prevalent conditions worldwide, and various barriers to oral healthcare cause large percentages of oral diseases to go untreated. This percentage is seen to increase in marginalized communities.

This paper is split into three sections. The first section will discuss the anatomy and physiology of the oral cavity, while the second will analyze the connection between oral and systemic health and the subsequent diagnostic potential of the oral cavity. The third section aims to examine the global burden of oral diseases, the barriers obstructing oral healthcare, and the efficacy and variables surrounding oral health promotion programs.

Methodology

For this paper, Google Scholar was used to find peer-reviewed resources, and the World Health Organization (WHO), Harvard School of Public Health, National Cancer Institute (NIH), Cleveland Clinic, and Centers for Disease Control and Prevention (CDC) were utilized to obtain additional literature. Literature used included data from all age groups. Peer-reviewed papers were filtered from 2000 and chosen based on inclusion of key terms and relevance to this paper's topic. In researching on Google Scholar, 77 articles were reviewed, 56 were included in the research for this paper, and 21 were omitted for various reasons.

Literature Review

Anatomy and Physiology of the Oral Cavity

The main structures within the oral cavity (mouth) consist of the tongue, gingiva (gums), lips, teeth, and the hard and soft palates (roof of the mouth) (National Cancer Institute, n.d.). The mouth also houses the oral microbiome, a diverse and unique community of microorganisms (Sedghi et al., 2021).

Maintaining the health of the oral cavity is crucial for an individual's quality of life. For this section, the oral microbiome, tongue, teeth, and gums will be discussed.

The Oral Microbiome

The oral microbiome is a collective genome of microorganisms in the oral cavity. Harboring over 700 species of bacteria, it is the second largest microbial community in humans. Different surfaces in the mouth have unique combinations of microbes (Deo and Deshmukh, 2019). The buildup of these microbes forms microbial biofilms (Bertolini et al., 2022) on surfaces such as teeth and the inside of the cheeks. The biofilm protects microorganisms from host defense factors and antibiotics, and harbors both commensal and pathogenic bacteria (Maddi and Scannapieco, 2013). When in equilibrium, the oral microbiome works to maintain the oral health of an individual (Sharma et al., 2018), and is a vital supportive component in protecting teeth, gums, and mouth linings (Curatola, 2013). Interactions within the microbiome also protect the body from invasion of undesirable outside stimulants (Gao et al., 2018). However, disturbance of this equilibrium can lead to onset of various oral and systemic diseases (Sharma et al., 2018).

The Tongue

A healthy tongue should have a rounded, symmetrical shape. Its color can vary between shades of pink and red. A thin white coating is normal and comes from keratin, a protein that protects the tongue from getting injured when eating. The surface of the tongue is covered in tiny bumps called papillae which contain taste buds, sense temperature and touch, and assist in chewing and swallowing food (Harvard Health Publishing, n.d.). Tongue muscles are very complex, allowing for independent movement of separate parts of the tongue (Sanders et al., 2013). The movements of the tongue are used in speaking and eating (Hiiemae et al., 2002).

The Teeth and Gums

Teeth play an essential role in digestion by working with the tongue to break down and shape food into a swallowable ball (bolus) (Cleveland Clinic, n.d.). Healthy teeth have no untreated tooth decay and are firmly attached to the gums. Brushing and flossing should not cause pain or bleeding. Teeth are usually a uniform color and appear off-white (Harvard T.H. Chan, n.d.). Adult humans have 32 teeth, though this can vary slightly, and young children have deciduous teeth that are eventually replaced by permanent adult teeth (Cleveland Clinic, n.d.). Gums surround the base of the teeth while protecting and holding them in place (Koller and Sapra, 2023). Healthy gums are pink or red but can vary in shade. They are firm to the touch and should not bleed when flossing or brushing. Gums should be firmly attached to the teeth with no gaps (Cleveland Clinic, n.d.).

Oral Health and Systemic Health

The oral cavity is closely connected with overall health and quality of life. The mouth is also a useful surface-level diagnostic tool as signs of systemic disease frequently manifest in the mouth (Koller and Sapra, 2023). An estimated over 100 systemic diseases and 500 medications have oral manifestations (Kane, 2017). This involves the oral microbiome, other structures within the mouth, and impacts mental health.

Oral Microbiome

When in equilibrium, the oral microbiome is crucial to maintaining oral health (Curatola, 2013). But triggers in the oral cavity such as poor oral hygiene can cause the bacterial, viral, and fungal species in the oral microbiome to become pathogenic (Avila et al., 2009). This can then trigger an onslaught of oral diseases (Sharma et al., 2018). For example, dental caries (cavities) occur when sugars from the diet fuel the growth of oral pathogens and acidification of the oral biofilm, leading to acid damage to the tooth tissue (Bowen et al., 2017). Periodontitis is also associated with imbalances between pathogens and microorganisms (Sharma et al., 2018). Since the oral cavity is a major gateway to the esophagus, sinuses, middle ear, lungs, etc., pathogens in the mouth may invade these areas (Dewhirst et al., 2010). Sharma et al., (2018) notes that there are many studies reporting a direct relationship between the oral microbiome and major systemic diseases such as cardiovascular diseases, preterm birth, and diabetes (p. 44).

The oral microbiome is a crucial area to study when diagnosing and treating systemic disease as the oral microbiota plays a major role in systemic disease development and aggravation (Thomas et al., 2021). The bidirectional connections between the oral microbiota and overall health make the mouth a great diagnostic tool for systemic diseases.

The Tongue

The tongue can quickly reflect the state of health or disease in the body. Scanning the tongue is a noninvasive complement for the diagnoses of several diseases and allows for long-term monitoring prospects. Since subjective inspection of the tongue has a low reliability index, procedures to analyze the lining of the tongue have been developed (Casu et al., 2021). Each part of the tongue is related to a certain internal organ, and the tongue's color, form, motion, and coating are observed for diagnosis (Jung et al., 2012). For example, thick white patches or sores on the tongue can signal an overgrowth of yeast in the mouth (oral thrush). Oral thrush can be accelerated by conditions such as HIV and diabetes. A bright red tongue can indicate a vitamin B12 deficiency or scarlet fever (Harvard Health Publishing, n.d.).

Figure 1

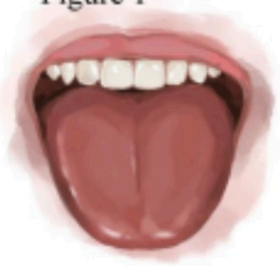
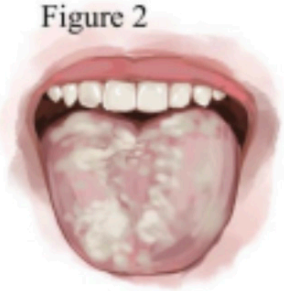


Figure 2



This illustration by Renee Jia depicts the difference between a healthy tongue (Fig. 1) and a tongue affected by oral thrush (Fig.2).

The Teeth

Dental caries (tooth decay) involve the destruction of tooth enamel and dentine by acids produced by the microorganisms in the oral cavity when supplied with high levels of sugar or other stimulants. It is a very common disease and affects 35% of the global population (M. Wilson and P. Wilson. 2021). Tooth loss and chewing difficulties have some impact on restricted dietary choices and can lead to poor nutritional status of individuals (Kossioni, 2018).

Systemic diseases have also been observed to lead to tooth loss. It has been observed that tooth loss was significantly associated with systemic diseases such as cardiovascular disorders, anemia, high blood pressure, etc,. Unhealthy lifestyle habits such as smoking and drug use were risk factors for both tooth loss and periodontitis (Haq et al., 2015).

The health of the teeth impacts overall quality of life as well. Higher numbers of missing teeth reflect poorer oral hygiene (Chin et al., 2010). Reports have additionally linked the level of periodontal detachment and loss of teeth in cardiac patients to higher mortality (Linden et al., 2012). Individuals with less than ten teeth remaining have a seven times higher mortality risk than those with more than twenty five remaining teeth (Holmlund et al., 2010).

The Gums

The relationship between gum diseases and systemic diseases is bidirectional. There are many risk factors associated with periodontal disease (gum disease) such as smoking, poor oral hygiene, age, etc., (Nazir, 2017). Periodontal disease is a chronic inflammatory disease and a main cause of tooth and gum loss (Sedghi et al., 2021). There is a strong association between periodontal disease with systemic diseases such as diabetes. Patients with diabetes showed a 24% increase in the incidence of periodontal disease, and patients with periodontitis had a 26% increase in developing diabetes (Stöhr et al., 2021). Periodontal diseases are linked to an increased risk of various cancers and cardiovascular diseases. The neuroinflammation of neurological diseases such as Parkinson's is possibly linked to periodontal diseases, with periodontitis-induced neuroinflammation affecting cognitive function as well. The bidirectional associations observed between periodontal diseases and various systemic conditions are believed to be linked to inflammatory processes, microbial imbalances, and intertwined risk factors, but more research is needed to fully understand the relationship (Martinez-Garcia and Hernandez-Lemus, 2021).

Mental Health

Clinical studies have suggested that stress may play a role in the development of periodontal disease (Reners and Brecx, 2007). Individuals going through a stressful period may be more likely to smoke, neglect their normal oral hygiene routine and miss routine dental appointments, all of which increase their risk of periodontitis and other oral diseases. There is also evidence to suggest there is a relationship between stress and periodontitis surrounding the immune response of the body (Hudson at al., 2021). There were oral signs and symptoms noted in individuals with severe COVID-19 stress and illnesses. Reports noted rapid loss and breakdown of teeth and implants, fracture of teeth and implants, as well as increased clenching and grinding of the teeth (Zinko, 2020). The presence and severity of depression is significantly correlated with oral health related quality of life, and individuals with poorer oral health tended to have more severe depression (Oancea et al., 2020).

Oral diseases have been reported to have a significant negative impact on self-esteem and oral health related quality of life (Shamim et al., 2022). Khadri et al. (2020) note that studies have reported a positive correlation between good appearance and arrangement of teeth and the self-confidence of children and young adults. For adolescents and young adults particularly, the characteristics and appearance of the face play a crucial role in self-perception, self-esteem, and quality of life (Militi et al., 2021). Children with poor oral health are at risk for diminished self-esteem and social interactions and may experience reduced academic performance due to dental pain (Crall and Vujicic 2020).

Challenges To Improving Oral Health in the Context of Global Public Health

Oral diseases have remained the most dominant and widespread conditions globally since 1990, with the combined number of oral disease cases being one billion higher than the next five most prevalent noncommunicable diseases combined (World Health Organization, 2022). The World Health Organization estimates that globally, close to 3.5 billion people are affected by at least one form of oral disease. Worldwide, and across all socioeconomic and age groups, dental caries (tooth decay) remains the most prevalent condition amongst 313 global diseases (Murtomaa et al., 2022; National Institute of Dental and Craniofacial Research, n.d.). Oral diseases are the fourth most expensive condition to treat (Murtomaa et al., 2022). Oral diseases disproportionately affect the poor and socially disadvantaged members of society and there is a very strong and consistent association between socioeconomic status (income, occupation, and education level) and the prevalence and severity of oral diseases [World Health Organization, n.d.).

For children aged two to five years, 17% of children from low-income households have untreated cavities in their primary teeth, three times the percentage of children from higher income households. Children five to nine from low-income households are twice as likely to have untreated cavities compared to children from higher income households. About 40% of adults with low-income or no private health insurance have untreated cavities. Low-income adults are twice as likely to have one to three untreated cavities, and three times as likely to have four or more untreated cavities compared to adults with higher incomes. Adults with less than a college education are almost three times as likely to have untreated cavities compared to those with a college education (Centers for Disease Control and Prevention, n.d.). Due to its high prevalence and disproportionate burden on disadvantaged populations, oral diseases are qualified as a major public health problem (Petersen, 2008).

There has been an observed connection between untreated oral disease and quality of life. Oral diseases often limit the ability to chew, eat, and communicate (Khadri et al., 2020). In 2008, over 34 million school hours were lost in the US due to unplanned urgent dental care. Over forty-five billion is lost in productivity in the US because of untreated oral diseases. Nearly 20%t of working adults and 30%t of those with lower incomes report that the appearance of their mouth and teeth affects their ability to interview for a job (Centers for Disease Control and Prevention, n.d.). As children reach adolescence, aesthetic motives for good oral health increase, showing correlation between oral health and self-esteem (Kallestal et al., 2006). Children who have both poor oral health and general health are more likely to have poor school performance (Blumenshine et al., 2008).

Causes of Poor Oral Health

Oral health includes many factors, each exerting varying levels of influence. The factors involved in oral health are multifaceted and have varying degrees of effect. This section gives a broad overview of the main risks and lifestyle habits associated with oral diseases.

The oral state of an individual is impacted by many factors including age, education, nutrition, genetics, and income. Systemic variables such as periodontitis, cardiovascular diseases, obesity, and diabetes are all factors of oral health, particularly in tooth loss (Roohafza et al., 2014). Oral diseases are caused by a range of modifiable risk factors common to many noncommunicable diseases (NCDs) which include sugar consumption, tobacco use, alcohol use, and poor oral hygiene (World Health Organization, n.d.).

Poor nutrition and unhealthy habits can affect the integrity of the oral cavity which allows for the progression of oral diseases. Numerous oral pathoses are related to lack of nutrients in the diet. Calcium deficiencies can lead to tooth mobility and premature tooth loss. Protein malnutrition can have implications on antibacterial defense due to its effects on salivary gland function. Individuals living in poverty, developing countries, vegans, and patients undergoing long hospitalization are most at risk for this type of malnutrition. The presence or excess of certain substances such as acidic foods and sugar sweetened beverages contribute to issues within the oral cavity. Unhealthy habits such as tobacco use have oral manifestations such as darkening of the enamel (Pflipsen, 2017).

Barriers to Oral Healthcare

High expenses, lack of insurance, lack of perceived need, unavailability of dental offices, transportation, fear of dental treatment, and scheduling difficulties are some of the most common barriers to oral healthcare seen throughout various studies and surveys (Almalki et al., 2023; Garcha et al., 2010; Sabbagh et al., 2022). The impact of these barriers varies by individual, but they tend to impact marginalized communities more.

Various social and cultural factors act as barriers to accessing and accepting health or dental care. A cross-sectional survey conducted in India by Garcha et al. (2010) revealed that over half of respondents (54%) felt less demand to seek dental care due to the existence of home remedies and other self-care options. 57% of respondents also noted that they only seek treatment when the dental pain becomes unbearable. This study also shows work and time pressure has been shown to inhibit dental attendance. Dental treatments for more severe oral ailments are complex and usually involve multiple appointments. Individuals in the two lowest social classes (partly skills worker class and unskilled worker class) reported that having to take time off to go to appointments acted as an access barrier. For lower classes, missing one day of work means losing one day's pay, making them less willing to go to the clinic. GARCHA These results were also observed in a study by Sabbagh et al. (2022).

Case Examples

Sabbagh's survey was conducted in Saudi Arabia, where the burden of dental caries is very high and has been steadily increasing, with an estimated prevalence of 70% among children. The study involved a questionnaire with 1722 parent respondents. The most common reasons reported by parents for the inability to visit the dentist were the expenses of the appointment (9.9%), inability to make an appointment (9.8%), and fear of COVID-19 (6.6%). Paternal education was a significant predictor of the inability to visit the dentist, and binary regression analysis showed that inability to visit dental clinics when needed was significantly greater amongst children with lower paternal education. Parents with lower education are typically in lower classes and need to work daily; taking time off to take their children or themselves to the dentist would be difficult to arrange or lead to a loss in earnings. This observation and reasoning agree with the findings by Garcha et al. (2010). However, it contrasted a study by Obeidat et al. (2014) who found that age and education level did not make any significant differences in the use of dental services. The difference in results may be attributed to the fact that the studies were all done in different countries (Obeidat's study was conducted in Jordan), further showing that these barriers are not universal.

In addition, transportation and lack of availability of clinics are also large barriers to receiving oral care. The National Survey of Adult Oral Health (2004-2006) showed that tooth loss, mean decayed, and number of Decayed, Missing, or Filled [DMF] teeth were higher outside capital city locations. Dental attendance patterns were less frequent in rural and remote locations. Patient perception of the impact of travel costs are major drivers restricting access for individuals (Curtis et al., 2008). These findings agree with observations in the Colgate Bright Smiles Bright Futures (BSBF) program, an American based program involving traveling by van to lower-income and rural areas to spread dental education and provide basic dental hygiene checks on children 9 and under. The participants are then listed under Categories I, II, and III, with I. representing overall good oral health, and III being the worst. It has been observed that in rural areas there is a significantly higher percentage of category IIIs compared to more urban areas. Dental hygienists and healthcare workers in this program attribute this to the unavailability of dental clinics and significant lack of dental education in more rural areas.1

The costs of dental treatment and lack of insurance are also significant barriers. According to the US Center for Disease Control and Prevention, in 2015, 29% of people in the US did not have dental insurance, and 62% of older adults did not. Many low-income adults did not have public dental insurance. In another part of the world, a Canadian population-based study (5,586 participants) observed that nearly one out of five respondents reported cost barriers to dental care. 17.3% of respondents had avoided a dental professional due to cost within the previous year, and 16.5% had declined recommended dental treatment due to cost. Respondents with lower incomes and without dental insurance were over four times more likely to avoid a dental professional due to cost, and over two times more likely to decline

recommended treatment due to cost (Thompson et al., 2014). This was similarly observed in India by Garcha et al (2010). Individuals that experience a dental cost barrier had overall poorer oral health and more treatment needs compared to those who do not (Thompson et al., 2014).

Lastly, fear of dental appointments and procedures have also been shown to inhibit dental attendance. According to Almalki et al. (2023), "fear of dental procedure is a dental services utilization barrier among the elderly. The same results were reported by some studies" (p. 10). Almalki et al. notes that their results contrasted those of Nitschke et al (2015), who reported that fear was seldom reported as a reason for not visiting the dentist.

This section included studies conducted in various parts of the world and included data from all age groups. Some of the studies agreed with one another, while others reported contrasting results. This may be explained by the fact that while these barriers are present globally, they do not affect all individuals to the same extent. Factors such as the economic state of the country, the country's emphasis on dental health, the respondent's age and education level etc. can all impact how relevant these barriers

I have been involved in the Colgate BSBF program as an active dental health educator and assistant to the dental hygienists since August 2023. are. Everyone's unique living circumstances also affect how much barriers to oral healthcare will affect them.

Role of Healthcare Workers:

According to the World Health Organization, most oral diseases and conditions share behavior-related risk factors with other Non-Communicable Diseases [NCDs]. As a mostly behavioral condition, individuals are expected to play active roles in maintaining their oral health. To support good oral health habits, it is necessary to provide sufficient oral self-care knowledge and provide an enabling environment (Murtomaa et al., 2022).

Good oral health requires a commitment to practicing healthy oral habits, which can be more doable if taught from a young age. According to Fraihat et al. (2019), numerous studies on the clinical effectiveness of Oral Health Promotion Programs [OHPPs] have observed that health promotion programs including promoting health and tooth decay were clinically effective in children under six years old, and less clinically effective for children older than six. The length of the programs is also a factor; longer durations are associated with more favorable outcomes. Results also varied based on the countries in question.

Another factor to consider are the individuals delivering the programs. A field study done in Zimbabwe evaluated the effectiveness of an OHPP on grade 2 and grade 4 children over 3.5 years. Results showed that the one-time training of teachers in aspects of oral health was ineffective in lowering plaque levels over the period (Frencken et al., 2001). The poor outcome of the program despite its length could strengthen the argument that OHPPs are less effective when delivered to children older than six as most of the children in the study would be older than six. The results also suggest the possibility that healthcare professionals delivering OHPPs would lead to more favorable outcomes than non-professionals. That assumption is supported by a study by M B Kowash et al. (2000), in which the efficacy of a long-term OHPP for mothers with young children received regular home visits by trained dental health educators over a period of three years. This program was shown to be effective in preventing nursing caries as well as improving the oral health of the mothers. The assumption that the early start of oral health programs that include parental education are more likely to produce favorable results is also supported by a study by Wennhall et al., (2018).

Conclusion

Overall, the relationship between oral health and systemic well-being is nuanced and often bidirectional. Studies suggest that oral bacteria and the inflammation associated with a severe form of gum disease (periodontitis) might play a role in some diseases (Sharma et al., 2018; Avila et al., 2009; Bowen et al., 2017; Thomas et al., 2021; Martinez-Garcia and Hernandez-Lemus, 2021). The presence of certain systemic diseases can lower the body's resistance to infection, potentially making oral health problems more severe. Oral and systemic diseases are impacted by a range of factors such as genetics, age, gender, and lifestyle and have many shared risk factors

(Haq et al., 2015; Nazir, 2017; Martinez Garcia and Hernandez-Lemus, 2021; World Health Organization, n.d.). This makes it difficult to establish a definitive cause-and-effective relationship between the two. Additional research is needed to fully understand the extent of the association between the two (Martinez-Garcia and Hernandez-Lemus, 2021). However, the interconnectedness between the two systems is undeniable, and it is important to emphasize the importance of maintaining good oral hygiene practices for potential reduction in systemic disease risk and overall quality of life. Oral health and aesthetics have a significant impact on self-esteem and overall quality of life. (Kossioni, 2018; Centers for Disease Control and Prevention, n.d.); Kallestal et al., 2006; Blumenshine et al., 2008; Khadri et al., 2020). An individual's mental state can affect their oral health and oral maintenance, and vice versa (Reners and Brecx, 2007; Hudson, 2021; Zinko, 2020).

Addressing the barriers to oral care is crucial to ensuring equal access to dental care. Most oral diseases are preventable and individuals are expected to play active roles in maintaining their oral health, so promotion of proper oral hygiene and other preventative measures can reduce the burden of oral diseases (Freihat et al., 2019; Murtomaa et al., 2022). It also may be helpful to promote seeking healthcare earlier in oral diseases. It has been observed that some individuals delay seeking healthcare in favor of trying home remedies or simply waiting until the pain becomes intolerable (Garcha et al., 2010; Sabbagh et al., 2022). This behavior may stem from the common perception that oral diseases are not immediately life-threatening, causing individuals to procrastinate seeking help (Dodd et al., 2014). However, this only increases the risk of the dental disease becoming more severe, which may ultimately lead to higher treatment costs (Murtomaa et al., 2022). Because oral diseases are largely preventable, community-based health promotion programs designed to address common risk factors and promote prevention of oral diseases are promising (Fraihat et al., 2019). Studies have shown evidence to suggest that OHPPs are more effective when delivered by healthcare professionals and targeted towards parents and children under 6. (Frencken et al., 2001; Kowash et al., 2000; Wennhall et al., 2018). However, lack of oral hygiene resources and inaccessibility of oral healthcare remains a problem, especially in poorer countries. Recognizing the challenges and promoting preventative measures such as maintaining healthy oral hygiene habits of brushing and flossing regularly are powerful first steps towards lowering the global burden of oral diseases.

The oral cavity is involved in many essential processes such as eating, speaking, and breathing (Hiiemae et al., 2002; Cleveland Clinic, n.d.; Sharma et al., 2018; Gao et al., 2018). Oral manifestations of certain systemic diseases make the oral cavity a great noninvasive diagnostic tool (Koller and Sapra, 2023; Kane, 2017). Although most oral diseases are highly preventable, the estimated global burden of oral diseases is 3.5 billion, making it a global public health crisis (Petersen, 2008; World Health Organization, n.d.). The biggest barriers to oral health include high expenses, lack of insurance, lack of perceived need, unavailability of dental offices, transportation issues, fear of dental treatment, and scheduling difficulties (Almalki et al., 2023; Garcha et al., 2010; Sabbagh et al., 2022; Obeidat et al., 2014; Curtis et al., 2008; Thompson et al., 2014; Centers for Disease Control and Prevention, n.d.). The impact of these barriers varies by individual, but they especially impact marginalized communities and populations in poorer countries, with a strong and consistent association between socioeconomic status and the presence and severity of oral diseases (World Health Organization, n.d.; Centers for Disease Control and Prevention, n.d.; Petersen, 2008).

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Is Democracy Growing or Dying? Transformations Over the Past Half a Century

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Abstract

The issue of whether democracy continues to grow is a contentious matter that deserves considerable attention to unearth the facts. The existing literature reveals how various components have fostered democracy levels over the past fifty years. Specifically, the United Nations (UN) regulations, which have a global effect, serve crucial functions in bolstering democracy. In Arabic countries, the Arab Spring offered a chance to express dissatisfaction with an authoritative approach to political leadership. However, evidence suggests that democracy growth remains relatively constant, and the rate of advancement does not reflect current needs and problems. There are concerns that the number of countries embracing authoritative approaches is increasing, a transformation that could thwart the steps achieved over the past fifty years. Existing global constraints, encompassing health crises and political wars, are major threats to democracy, and their effects are already evident in some countries. Adopting robust interventions would ensure that democracy prevails and nations enjoy its benefits.

Keywords: United Nations; democracy; human rights; political; countries; citizens; governance; Arab Spring; century.

Is Democracy Growing or Dying? Transformations Over the Past Half a Century

Democracy generally refers to the rule by the people. The system allows people to choose their leaders in free and fair elections (Vasilopoulou & Halikiopoulou, 2022). Other descriptions transcend this meaning. For instance, some thinkers perceive democracy as citizens having added individual rights and freedoms and receiving state protection (Herre et al., 2023). Often, democracy offers citizens the power to make impactful choices over their lives and permits them to hold their leaders answerable (Vasilopoulou & Halikiopoulou, 2022). This approach to governance has other gains too, including democratic nations tending to enjoy better governance than those that use autocratic forms, seeming to grow rapidly, and encouraging peaceful relations between and within them (Herre et al., 2023). Today, many nations, comprising leaders and citizens, acknowledge the significance of a democratic approach.

They are fast adopting measures and structures that permit them to align with the ideology. Besides, countries have progressively adopted international frameworks calling for democracy, a transformation that continues to bolster democratic thoughts and practices. However, that does not imply that all countries ascribe to this ideology, considering that some territories continue to deploy alternative political administrative frameworks. Besides, actions in recent years threaten progress achieved over the past five decades and raise questions as to whether global democracy will continue to improve or experience evident challenges. While democracy has become more rampant over the past half a century, trends over the past decade point to a decreasing pattern, which calls for effective intervention considering the gains associated with this political approach on socioeconomic aspects.

Background Information

Many more nations have become democracies over the past two centuries. Evidence by Regimes of the World (RoW) shows how, throughout the 18th century, no country identified fully as a democracy (Herre et al., 2023). For RoW, nearly all nations during this period were closed autocracies in which people lacked the right to elect political leaders via elections (Herre et al., 2023). In the 19th century, elections became rampant but often experienced considerable challenges. Many nations during this time turned into electoral autocracies, in which political leaders ascended to power through elections. Nonetheless, citizens had little influence in making these polls impartial and free of bias (Herre et al., 2023). Only a few nations during the nineteenth century conducted credible elections that qualified them as democratic nations. Fewer countries granted their citizens additional minority and personal liberties, qualifying them as liberal democracies. Liberal and electoral democracy spread to more countries in the twentieth century (Herre et al., 2023). It became a rampant political structure globally by the end of this period and was applicable across all world regions. Today, the world nearly evenly falls between democracies and autocracies (Herre et al., 2023). A substantial portion of non-democracies have transformed into electoral autocracies. At least a third of all democracies provide citizens additional minority and individual rights and allow courts to make rulings independently, which are vital features of liberal democracies. Nevertheless, a thorough view of how democracy has evolved over the past half a century requires an in-depth analysis of various critical influential factors.

Advancements over the Past Half a Century

Throughout the second half of the 20th century, more nations and people attained democratic political rights. In the late 1960s and 70s, nearly 230 million people – largely in Western Europe – experienced liberal democracies in their countries (Herre, 2021). About 239 million people lived in electoral democracies in North America and Western European countries (Herre, 2021). This number steadily increased over the years that followed, and by the end of the 1990s, approximately three billion people worldwide were living in liberal and electoral democracies (Herre, 2021). The broadening of constitutional rights accelerated at the turn of the twenty-first century. Data by Herre (2021) shows that the expansion of democratic political rights became increasingly evident during the initial years of the 21st century. By 2016, Herre (2021) informs that more than 2.7 billion people resided in nations that identify as electoral democracies worldwide. The majority of individuals originate from densely populated countries like Nigeria, Indonesia, and India (Herre, 2021). Another one billion individuals lived in entirely liberal

democracies in 2016, including Kenya, the United States, and South Korea. Nevertheless, only one nation, the People's Republic of China, with more than 1.7 billion nationals, still adheres to closed autocracy (Herre, 2021). The overview suggests that democracy has progressed over the past half a century, depicting this political system's strengths compared to autocratic forms.

Further indications reaffirm that democracy is growing, and nations and their people increasingly accept this political governance as inclusive and non-discriminative. Despite existing constraints, Africa remains unshaken in the face of uncertainty. Nations such as Zambia, Niger, and Gambia continue to make steady strides in fostering democracy (Sawaneh, 2023; The Global, 2022). Addressing problems emanating from constrained civic space, interventions in various countries provide opportunities to restructure social contracts, although outcomes differ based on countries (The Global, 2022). In West Asia, more than 12 years after a series of uprisings across the region, protests, and movements continue to emerge because of government failures to provide necessary services and bolster economic opportunities (Ashwarya & Alam, 2019). As a reaction, disappointed and disillusioned citizens, especially the youth, mobilize resources to advocate for their rights, address their political awareness, and essential function as promoters of change and enhanced leadership (The Global, 2022). These indications portray how much democracy is growing and suggest that the trend might persist if leaders and their followers embrace practices and attitudes that support this form of governance.

Contributions by the UN

A series of events and interventions have bolstered democracy expansion across the globe. Adopting a system of human rights promotion and protection provided by the UN's dual structure served vital roles in bolstering democracy over the past five decades. These include the UN Charter established in 1945 and a series of conventions ultimately adopted by UN affiliates (United Nations, 2023). All 192 UN members follow the Charter-based structure, while only those affiliates that have accepted or ratified certain treaties must follow that segment of the conventional system to which they explicitly accept (Viljoen, 2019). Article 68 of the UN Charter prompted the formation of the Commission on Human Rights by the UN Economic and Social Council. The Commission's greatest achievement was the formation of three guidelines that shaped human rights protection and democracy internationally. These included the Declaration of Human Rights, which became influential in 1948, ICESCR, and the ICCPR, both introduced in 1966 (United Nations, 2023). During adopting the guidelines ratified in 1966, it became evident that the initial intention of adjusting the Universal Declaration into one unifying tool was unsuccessful, chiefly due to an absence of concurrence on the justiciability of socioeconomic rights and freedoms. The formation of the 1235 and 1503 guidelines for reporting violations of democratic procedures and individual rights in 1959 and 1970, respectively, improved the country's compliance with stipulated guidelines (Viljoen, 2019). Both provisions only addressed matters of adverse human rights violations. As a component of its treaty-based structure, the UN promoted the ratification of the International Convention on the Elimination of All Forms of Racial Discrimination in 1965, which, along with the ICESCR and the ICCPR, elevated its emphasis on safeguarding minority groups (Viljoen 2019). Such interventions by the UN served vital functions in bolstering democracy throughout the 1970s, 1980s, 1990s, and at the start of the 21st century (Viljoen, 2019). Therefore, relentless calls by the UN to embrace democracy have served integral roles in promoting growth over the years.

The UN has played several other roles in fostering democracy in the past fifty years through its regulations and interventions that have a global effect. The United Nations fosters democratic governance by advancing human rights, safety, prosperity, and tranquillity (Democracy, 2023). In the more than half a century since the ratification of the UN Charter, the organization has done more to advance and improve democratic governance than any other global body. The establishment encourages sound and appropriate administration, supervises voting, boosts civil society to strengthen transparency and the operations of democratic authorities, assists in the creation of constitutions following conflicts, and supports autonomy in liberated states (Democracy, 2023). The international organization has initiated various programs and institutions to facilitate and exemplify its agenda for democracy. These include the United Nations Democracy Fund and the Office of the High

Commissioner for Human Rights, which promotes civil society initiatives globally to safeguard human rights and democratic processes and champions for and counter violations of such rights, respectively (Texts, 2024). Since 1988, the UN General Assembly has continuously adopted at least a yearly resolution highlighting certain components of democracy (Democracy, 2023). In 2015, heads of state reiterated their commitment to accomplishing the goals of the 2030 Agenda for Sustainable Development, which pushes for an international community where respect for the rule of law, supportive administrations, good governance, and democratic systems all play a role in a sustainable future. In 2012, the UN Human Rights Council accepted the Human Rights, Democracy, and the Rule of Law decision, which emphasized that basic liberties, reverence for human rights, and freedom are complementary and interdependent (Democracy, 2023). This illustration highlights how the UN has played instrumental roles in advancing democracy over the past half a century.

Further analysis of the UN's contribution to democratic growth and stability reveals how the international organization serves instrumental purposes in this particular aspect. The body fulfills this role by identifying threats to democracy and suggesting how to address them. Specifically, the UN points out significant concerns such as poor governance, weak institutions, and democracy deficits that it considers some of the major impediments (Democracy, 2023). Identifying such issues makes it possible for countries to exercise caution and deploy interventions that would create a chance to meet targeted desires. Moreover, this information enables nations that intend to foster and safeguard their levels of democracy to enact adequate measures to prevent such complications from making it difficult to head in the right direction (Democracy, 2023). To counter these issues, the body has assigned the United Nations Development Programme (UNDP) and the UN Human Rights Office (OHCHR) power to alleviate the situation. In nations emerging from war and transitional democracies, OHCHR helps foster a solid and autonomous judiciary structure, human rights institutions, robust and independent civil societies, and parliaments (Democracy, 2023). UNDP, on its part, assists governments in bolstering their public institutions, improving the capacity to suppress graft, and encouraging inclusive indulgence to ensure that no one remains behind (Democracy, 2023). Each year, UNDP commits, on average, $650 million to promote inclusive development and governance locally (Democracy, 2023). This illustration emphasizes the fundamental roles the UN serves in cementing democracy globally.

However, the UN faces specific challenges that limit its ability to reinforce democracy in certain parts of the world. A key issue is that the international body lacks a mandate over certain countries, thereby creating room to indulge in acts that counter democracy without disapproval. For instance, the global organization does not have control over Taiwan, Western Sahara countries, and Kosovo (Countries Not, 2024), which seem democratic based on existing constitutions but sometimes experience instances that contravene democratic principles. Another challenge that threatens ability to respond to situations involving conflict is the lack of its own military or police force (Does the, n.d.). The UN initially planned to include a military unit in the Security Council, but this goal remains on paper until now. This forces it to rely on Member States to contribute police and military personnel needed for every operation. When a breach of democracy through violence exists, and the UN has to play a peacekeeping role, security forces wear their countries' uniforms and are only identifiable by a blue UN beret or helmet and a badge (Does the, n.d.). The UN must overcome such impediments if it aspires to have a more significant effect on building democracy.

Attempts to build democracy would face a significant setback in the absence of the UN or if it were not in existence. It would be difficult to achieve sustained peace without the international organization that promotes and safeguards human rights (Can You, 2022). Besides, democracy would dwindle immensely, inequality would prevail, and people would lack an opportunity to express their views and opinions freely (Can You, 2022). Therefore, the UN's existence is a solid pillar to enhancing democracy, and its absence would be a significant disadvantage to efforts to promote freedom and liberty, which are likely to experience considerable threats. The essential roles the UN plays in supporting democracy should compel Member States to help this international organization achieve its mission and vision.

The Arab Spring

The Arab Spring that started in Tunisia was critical in fostering democracy, especially in the Arab world. This consisted of a wave of rebellions against the government, marches, and insurrections that swept across several Arabic-speaking nations in the 2010s. The upheaval commenced in Tunisia due to economic stagnation and corrupt state practices. The revolts and rebellions moved from North Africa to other states, including Egypt, Libya, Bahrain, Syria, and Yemen (Al-Tamimi & Venkatesha, 2020). Several leaders who appeared dictatorial in their approach lost their seats, including Muammar Gaddafi, Zine Ben Ali, and Hosni Mubarak of Libya, Tunisia, and Egypt, respectively, who all lost their presidencies in 2011 following escalated revolts (Al Shammari et al., 2023). For Ali Saleh of Yemen, aggravating protests led him to evacuate his seat in 2012. Major social violence and uprisings emerged in Sudan, Morocco, Jordan, Oman, and Iraq, encompassing insurgencies and civil unrest (Al-Tamimi & Venkatesha, 2020). Nations such as the Kingdom of Saudi Arabia, Mauritania, and Djibouti experienced minor upheavals (Al Shammari et al., 2023). Hence, a revolt that began in Tunisia with an urge to topple a regime that many perceived as undemocratic became an influential push for change across the entire Arab world.

The first surge of protests and revolutions subdued by mid-2012 following a harsh response to demonstrations by authorities. Militaries, counterdemonstrators, and pro-government agencies were active groups in suppressing revolts (Al Shammari et al., 2023). In some instances, protesting groups responded violently, which prompted escalated conflicts. For instance, in Iraq, the Islamic State of Iraq and the Levant emerged during this time and caused much havoc and unrest ((Al-Tamimi & Venkatesha, 2020). Countries such as Syria and Yemen experienced civil wars following a series of social and economic crises that occurred during that time (Al Shammari et al., 2023). The countries most affected during this period experienced regime change, including those that lacked well-established hereditary succession structures and adequate oil reserves.

Some scholars refer to the subsequent and continuing turmoil as the Arab Winter. Only pleas for democracy and the abolition of other unlawful acts in Tunisia brought about a legitimate democratic government in 2018 (Salisbury, 2024). Recent chaos in Algeria and Sudan demonstrates that the backdrops that triggered the Arab Spring have not subsided, and political opposition to exploitation and dictatorship is still underway (Al Shammari et al., 2023). Beginning at the end of 2018, several marches and rebellions have occurred in Egypt and Sudan, which appear to be the long-term consequences of the Arab Spring. Numerous conflicts persisted as of 2021, which had evident connections with the Arab Spring (Salisbury, 2024). A particular place that continues to feel the effects of the opposition against bad political leadership that commenced in Tunisia is Yemen, where civil unrest continues to influence the country negatively. The scenario is similar in Lebanon, in which a financial meltdown jeopardizes both the country's and its neighbors' economies, particularly Syria's (Salisbury, 2024). The description reaffirms that while the Arab Spring emerged more than a decade ago its effects are still evident.

Recent Trends

While democracy has become rampant and increasingly influential over the past half a century, indications suggest that this political governance is losing prominence. Indication reveals that by the time 2022 ended, the world was stuck due to pressures from old and emerging problems (Matlosa, 2023). Furthermore, indications point to myriad causes of economic and political challenges, encompassing the increasing prices of energy and food, impeding recessions, and escalating inflation (Matlosa, 2023). These occurrences happen in the wavering context of persistent climate change, the COVID-19 pandemic, the Russian attack on Ukraine, relentless unaddressed imbalance, and dropping living standards (The Global, 2022). Today, inter-state conflicts have heightened, encompassing the threat of nuclear attacks, and assumptions that countries have held for many years regarding democracy are dwindling. In addition, emerging post-truth accounts continue to affect the credibility of electoral procedures. Consequently, the number of those who feel that democracy is the solution to some of the identified issues is fast depreciating (Matlosa, 2023). Based on findings by the Global State of Democracy, democracy is declining and nearly stagnating around the globe. A close examination of existing data suggests that while a

significant measure of democracies have the resources and legal guidelines necessary to promote democratic agencies, imbalanced reach to such establishments is a daunting and persistent concern (Matlosa, 2023). Hence, there is a need to pay considerable attention to existing threats to democracy; otherwise, this form of governance will collapse.

Additional proof indicate that democracy levels are depreciating very fast, and the situation could get out of hand soon if nothing happens to salvage the situation. Indications suggest that the number of nations upholding democracy has shrunk, and there has been a sluggish adoption of institutional innovation (Matlosa, 2023). At the same time, nearly half of democracies worldwide are retreating. Further indications suggest that at least 49% of non-democracies are increasingly repressive, reflecting about one in five nations (The Global, 2022). Another indication pointing to depreciating democracy levels is that over the past decade, the number of nations embracing authoritarianism has nearly doubled the measure of states embracing democracy. Some of the worst affected countries, including Nicaragua, Cambodia, Afghanistan, and Belarus, have significantly dropped across numerous Global State of Democracy Indices (The Global, 2022). Many deteriorating states experience considerable challenges conducting credible elections and constituting trustworthy and independent parliaments (Matlosa, 2023). The revelations adequately confirm that democracy is under threat, and not taking measures to safeguard this approach to governance that safeguards the rights and freedoms of citizens could have far-reaching implications.

Further analysis of available data reaffirms that democracy faces imminent threats that could become unbearable if concerned parties do not take immediate and effective interventions. Indications suggest that democracy is not changing to reflect fast-evolving aspirations and desires (Matlosa, 2023). There is insignificant advancement even in democracies that perform moderately or at high levels (Matlosa, 2023). The international estimates of Representative Government, Fundamental Rights, and Checks on Government show little change from what was read nearly two decades ago (The Global, 2022). Most countries operate at the mid-range level. In addition, participation by civil societies and the impartiality of administrative organs have remained unchanged since 2001 (The Global, 2022). These concerns imply that democracy is experiencing considerable strain, especially in the last few years.

Effects on Socioeconomics

Depreciating democracy levels has implications on both social and economic aspects. In his paper, Matlosa (2023) describes how constrained democracy weakens social cohesion and strains social contract. Prioritizing citizens based on their race, educational level, economic status, and religion, which are some factors that deter democratic governance, might deteriorate how people from diverse backgrounds relate. In some instances, Matlosa (2023) explains, undemocratic practices augment illiteracy, inequality, hunger, poverty, and unemployment. Such alienations, and to some extent the authoritarian approach associated with undemocratic states, cause adverse effects on subjects, encompassing health and behavioral problems. It is imperative to promote democratic practices because disregarding the leadership style could cause profound economic implications. Trinugroho et al. (2023) support this claim by asserting that democracy is an important component in nation-level administration to protect human rights and achieve indiscriminate dissemination of wealth among nationals, contributing to rapid economic advancement. The authors who empirically examined the effects of democracy on income inequality and economic growth at the regional level by focusing on Indonesia-based provinces learned that the lack and existence of democratic practices have mixed effects on the economy (Trinugroho et al., 2023). The scholars discovered that while democracy can bolster economic advancement, it could also be detrimental to growth because sustaining a higher level of this form of governance requires immense financial commitment (Trinugroho et al., 2023). However, their research showed that democracy is indispensable in alleviating regional imbalances. It may create avenues to access better education for marginalized populations, directly influencing their income. Conducting additional studies on the implications of democracy on socioeconomic aspects would shed more light on this topic.

Possible Interventions

Democratic entities are particularly essential in times of fear and disaster. They encourage unobstructed avenues for engagement and awareness that governments and citizens require to conduct their operations effectively and responsively (The Global, 2022). To rekindle and reenergize these organs and to rebuild confidence between state authorities and citizens, it is imperative to form novel and creative social contracts that adequately mirror the global environment that is changing rapidly and which foster equal reach to the structures of indulgence. Social contracts refer to well-structured pacts on what governments issue their people while expecting public legitimacy in return (A New, 2023). They represent an awareness of how citizens mitigate shared challenges, handle risks and threats, and utilize resources collectively to provide opportunities and amenities that benefit the public (A New, 2023). The form of the social contract that underscored the immense portion of the expansion following the Cold War is now under evident threat, and the government, in conjunction with citizens, must review the factors fostering their relationships. Consequently, concerned parties must devise evidence-based structures and implement them successfully to form successful social contracts that benefit citizens and encourage them to declare their legitimacy to the government.

People's requirements and aspirations have transformed, and primary social and economic security is still necessary, but emerging constraints have triggered a need for dissimilar forms of guarantees from the government. For example, career development structures, welfare programs, and schooling must adapt to new demands arising from evolving work techniques, different kinds of jobs, and novel technological innovations, as well as recognize the importance of the care economy and various facets of wealth disparity (The Global, 2022). In an interconnected global setting, a social contract has to prioritize the integration of defense systems against potential future dangers (The Global, 2022). Furthermore, it is critical to make sure that equity prevails in rekindled social contracts (A New, 2023). It is not sufficient for government agencies to provide opportunities and stop at that; otherwise, its effects on people, especially those who lack resources and opportunities to uplift themselves, might be insignificant. It is increasingly becoming essential to form structures that enhance reach to existing opportunities in a manner that places traditionally marginalized communities at the center of attention while at the same time ensuring that adequate protection measures exist to counter the formation of newly alienated populations (A New, 2023). In addition, developed social contracts must form structures that counter adverse polarization within communities and societies and distrust between governments and their subjects by offering the needed institutions and mechanisms to form and uphold shared citizenship (The Global, 2022). Effective deployment of this particular intervention would improve democracy and offer a chance to counter existing impediments.

Conclusion

Many countries have adopted democracy as the primary form of political governance. Still, evidence shows how various aspects continue to derail this form of administration that safeguards individuals' rights and freedoms and engages citizens actively in decision-making. This task explores the effects of UN regulations that promote democracy. The international agency develops multiple regulations that encourage the protection of every citizen's rights as part of upholding democracy. Besides, it is behind the establishment of various treaties that are internationally binding. Member states must abide by such regulations. Another event that had a global effect in terms of bolstering democracy was the Arab Spring, which mostly influenced Arab countries. The series of political unrests that began in Tunisia spread to other Islamic countries rapidly with a resounding message being the need for change from an authoritarian to a democratic system. At the same time, not all countries that witnessed such unrest became completely liberal - unrest that called for new leadership sensitized leaders on the significance of democracy. Nevertheless, there are concerns that democracy is fast losing its prominence due to several factors. Authoritative regimes are becoming rampant, and the rate of growth in democracy levels does not reflect current needs and changes. A suitable way to restore democracy is to form social contracts, which entail adopting interventions that adjust to changing circumstances. Social contracts are clear agreements in which authorities benefit their citizens in exchange for public trustworthiness. They symbolize an understanding of how nationals address prevalent difficulties, manage hazards and dangers, and collaborate to offer services that are helpful to everyone.

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Enhancing Child Safety in Vehicles: Advanced Solutions for Mitigating Injury and Saving Lives

By Jonathan Z. Li

Author Biography

Jonathan Li is a freshman at McLean High School, where he has a passion for coding, science, and math. He dedicates much of his time to researching potential issues related to vehicle safety. Beyond academics, he thrives as the 1st chair cellist in the school orchestra, an avid artist and photographer, he finds joy in expressing himself creatively through various mediums.

Abstract

Despite significant advancements in vehicle safety technology, motor vehicle crashes continue to pose a significant risk to child passengers. This paper addresses the persisting issue of inadequate child safety measures in vehicles by proposing innovative solutions to mitigate injuries and save lives. Drawing upon original research and a comprehensive review of existing literature and safety data, this study explores the implementation of adaptive airbag systems tailored to the unique needs of child passengers.

The research methodology involves developing a video-based camera that accurately identifies infants, toddlers, and children within vehicles. Experiments and testing regimens determine optimal airbag deployment angles and forces based on passenger height and weight. Additionally, the paper discusses the integration of a system to adjust airbag deployment angles in real time, ensuring maximum protection for child occupants.

Consumer insights are essential, prompting a survey to gauge public opinion on current child safety measures and proposed solutions. The survey results highlight widespread concern among respondents regarding the effectiveness of existing safety precautions, particularly airbag systems.

Ultimately, this paper presents a holistic approach to enhancing child safety in vehicles, combining original research efforts with insights from existing literature to propose practical solutions. By implementing adaptive airbag systems tailored to the unique needs of child passengers, this study aims to significantly reduce the incidence of injuries and fatalities in motor vehicle crashes, safeguarding the well-being of young passengers for generations to come.

Keywords: Engineering Mechanics; Ground Vehicle Systems; Vehicle safety; Adaptive airbags; Vehicle collision protection

Introduction

After many decades of engineering efforts to improve vehicle safety, it has come to a point where the implements added have severely decreased the severity of collision car crashes for humans, helping save countless lives1. However, there is an age group that is still heavily impacted by these accidents: children. According to the Centers for Disease Control (CDC)2, 607 child passengers ages 12 and younger were killed in motor vehicle crashes in the United States, and more than 63,000 were injured in 2020; 711 child passengers ages 12 and younger were killed in 20212. These data indicated that children still need better protection against motor vehicle crashes. Additionally, safety procedures fail to prevent the irresponsible/dangerous actions (e.g. not wearing seat belts, crawling out of the seat belt, etc.) these unaware children do, also resulting in these young children being harmed.

We need to fix this problem quickly. This is for these children who, when faced with an unfortunate incident, are still able to see the light of tomorrow. Several design solutions can be implemented in modern vehicles to solve the problem. First, one option is setting up a sensor inside the seatbelt to detect if it was buckled on. From the information on iihs.org6, I learned that in current vehicles, we have sensors that detect if a seat belt isn't on7; however, that only applies to the front row. This implementation in the back can ensure that the safety belt is on, a step forward to increase the safety of toddlers/children. Second, the airbag deployment could be at a different angle based on the child's height. Due to children's short height compared to teenagers/adults, airbags do not deploy in the right position to help children in car crashes. Due to this, they receive the impact full force, along with potential injuries from the airbag itself. So, by reading about how airbags deploy from the Canadian National Transportation Agency (https://tc.canada.ca/) 3, we can angle the deployment of the airbag depending on the child's height, which provides them with full protection from collisions in the future.

However, it is important to obtain consumer insights and preferences before more resources can be allocated to such research and development. Therefore, this study aims to collect consumer opinions on these two solutions and explore other possible solutions to minimize the fatality rate for children.

Method

Survey

To start, I will conduct a survey online by creating a Google Form to gather the opinions of several adults throughout nearby Virginia communities. I will ask the question "Do you think the safety precautions in the backseat of a car can protect children?" to which they will then answer "yes" or "no". After this, a follow-up question, asking them why they chose their answer. This will show what the majority think about current child safety practices and whether this research is crucial to conduct.

Airbags - Research

To initiate the research, the primary step involves developing a video-based camera system to differentiate between infants, toddlers, and children. Utilizing advanced computer vision technology, we will craft an algorithm capable of effectively identifying an individual's height and age. This information will enable the system to dynamically adjust the airbag within the vehicle to an angle where the head, shoulder, and chest are maximally protected. Moreover, the system will be able to discern supplementary elements, particularly those pertinent to child safety. Notably, this pertains to infants and young children in car seats. Once the camera identifies the presence of these supplementary extensions, it will proceed to validate their usage and subsequently factor in these external sources.

In addition to height, the video-based camera system will also incorporate a methodology to calculate the child's weight. The camera will be able to consider the subject's structural characteristics and height to assess and estimate the passenger's potential weight further accurately. This information will then be stored in the car's Electronic Control Unit (ECU) for further use.

Furthermore, a critical aspect of a child's safety within the system is their orientation and posture. To ensure the system functions effectively, the child must be facing forward and maintaining an upright sitting posture. To enforce this safety requirement, a dedicated camera system will continuously monitor children's posture in the vehicle's rear. If the camera detects any deviation from

the optimal position, it will transmit a signal to the car's control system, alerting the driver to the issue and prompting corrective action.

After developing this system to collect data from the passenger, our priority will shift to the derivation of a formula that computes the optimal release angle of the airbags concerning the height and weight provided by the video-based camera system. This endeavor will need a testing regimen involving a diverse collection of children and infant dummies with varying heights and weights to compute this relationship. Through simulated collisions and subsequent airbag deployments, we will record the impact points of three types of dummies: infant, toddler, and child. In these experimental trials, our primary focus will center on the impact points of the shoulder, head, and chest on the rear airbags. In these trials, our objective is to pinpoint the optimal positions for these body parts to ensure safe contact with the airbags and determine the precise angle at which these positions should be implemented to achieve maximum safety and effectiveness.

Furthermore, our research will examine the interplay between a passenger's height and weight during collision events. This analysis will then be used for us to create an equation that constantly calculates the optimal angle at which the airbag is positioned for a specific height.

Afterward, the insights gained from these experiments will then be gathered and examined to formulate an equation that consistently aligns the passenger's impact location with the optimal region of the airbag.

We will also acknowledge the significance of the force exerted by the airbag upon deployment. To attain an optimal balance in force exertion, we will continue our experimental efforts, concentrating this time on establishing a relationship between height, weight, and exerted force. Through systematic testing involving child and infant dummies of diverse weights and heights, we will collect data encompassing the impact of both the airbag deployment and the subsequent collision force between the dummy and the airbag. This data will then be accumulated to find the relationship between the 3 factors to find the optimal force needed to be exerted.

Airbag- Implementation

Following the completion of our research phase, our attention will shift toward the development of a system designed to adjust the angle of airbag deployment relative to the passengers' height and weight.

To achieve this objective, our focus will be an investigation into the dynamics of airbag deployment. This investigation will include emphasizing the triggers of deployment, the chemical processes in airbags, and the diverse systems of airbag configurations. We will then locate an area in the airbag system where our A.I. technology can be integrated successfully.

With this foundation established, we will then go through a series of rigorous innovation tests. The tests will involve the same child and infant dummies in the cars but with our adaptive system implemented to be tested with them. A series of trials will commence, enabling us to assess the fatality rates with our system in a car. If any areas of our project need refinement, we will then focus on fixing the flaws and further enhancing the efficacy of our system.

Results and Discussion

Survey:

From the 250 survey responses by Google Forms, around 76% think that the current safety precautions do NOT protect children from harm, while others think it does. Their reason for this answer all direct to one specific safety precaution: airbags. As stated by one of the respondents, "The airbag system especially concerns me. I don't feel safe for my children when acknowledging that airbags are the only safety precaution available for collisions."

According to the results, many people around the communities of Virginia does not believe in children being safe in the backseats and that the safety procedures don't protect the children entirely.

Video-based Camera System:

The camera that we will use is a pinhole camera. It can keep hidden in the car and efficiently give us the necessary information for the program to work. The video-based system will then revolve around the coordinate system.

Height:

The camera implemented will lay out an x-axis, y-axis, and z-axis on the ground and coordinate the following places: feet, knee, waist, chest, shoulder, and head. We will then use these key points and the distance formula (sqrt (x^2 + y^2 + z^2)) to estimate the child/infant's height.

If there is any external material that lifts a child/infant's height, it will be thoroughly estimated from the width of the seat using image processing techniques. In these cases, the implemented coordinate system will only focus on where the bottom of the seat is and the layer where the child is sitting. Subsequently, we will use the distance formula to calculate the width and proceed to add the calculated value to the height of the passenger present.

Lastly, we will round to the nearest tenths and store the information in the database for further usage

Weight:

To estimate a passenger's weight, we first need to know their gender. Using the camera implemented before, it can then identify certain types of characteristics that can tell the gender of a passenger. After this step, the average weight per height for males and females can be estimated from the following tables [4].

Table 1 Females: *Height vs Weight [4]*

Height	Weight
33.7”	26.5 lb
37.0”	31.5 lb
39.5”	34.0 lb
42.5”	39.5 lb
45.5”	44.0 lb
47.7”	49.5 lb
50.5”	57.0 lb
52.5”	62.0 lb
54.5”	70.5 lb
56.7”	81.5 lb
59.0”	91.5 lb

Table 2 Males: *Height vs Weight [4]*

Height	Weight
34.2”	27.5 lb
37.5”	31.0 lb
40.3”	36.0 lb
43.0”	40.5 lb
45.5”	45.5 lb
48.0”	50.5 lb
50.4”	56.6 lb
52.5”	63.0 lb
54.5”	70.5 lb
56.6”	78.5 lb
58.7”	88.0 lb

Using these two tables, we are then able to determine the average weight corresponding to a passenger's height.

However, it's important to note that many, either underweight or overweight, might fall outside the typical weight range for their height. To address this, we can use the same coordinate system used to find height. By using the same methodology, we can derive the passenger's body width. If an individual has a broader and thicker body composition, the system will add an appropriate number of pounds to the average weight. Conversely, if a passenger has a leaner and slimmer physique, the system will subtract a certain number of pounds from the average weight. These adjustments are necessary to approximate the actual weight of the passenger better, increasing their safety during collision.

Posture and Orientation Check:

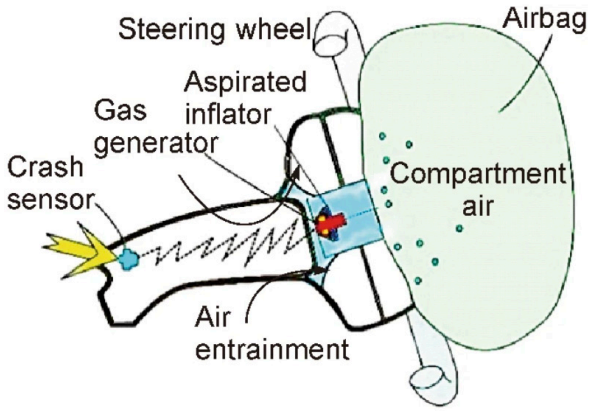
To assess a child's posture accurately, the video-based camera system will identify where the passenger's head and shoulders are. If the head and shoulder locations are relatively perpendicular to the

ground, then they are in the right position. If not, a signal will be sent to the car's control system to alert the driver of the corrective measures needed to be taken.

In addition to monitoring posture, the camera system will also gauge the child's orientation by tracking the direction of where their nose is pointing towards. The child faces the correct direction if their nose is oriented toward the camera. If not, a signal will also be sent to the car's control system to alert the driver of the corrective measures needed to be taken.

Airbag – Implementation

To implement this system, the part of the airbag system that we will modify is the part between the aspirated inflator and gas generator in the diagram below.

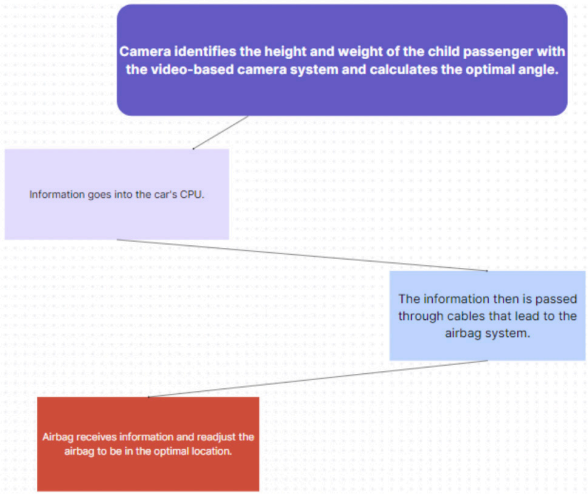


Figure/Image_X_ Airbag Aspirated Inflator Operation [5]

In this section, we will create a designated surface for the aspirated inflator and its surrounding cushion to rest on. This surface will provide a stable foundation for the mechanisms already present in this design. We will then add a motor mechanism that will be affixed to this surface. This extension allows the surface to move up and down without problems.

A cable system will be established to connect the car's Electronic Control Unit (ECU) to facilitate the motor's movement based on the passenger's information. This cable system will serve as the passageway for crucial data, including the calculated adjustment angle and the force required to be applied. This entire process will be initiated once the passenger enters the car, enduring that the airbag is positioned intelligently to provide the optimal safety measures in the event of an incident, as shown in the following diagram.

Image 1: Flow Chart of our Intelligent Airbag system



Conclusion

Across the nation, a distressing number of children are suffering severe injuries in car crashes, often due to inadequate safety measures. Despite the presence of various safety features within vehicles, these measures are predominantly targeted towards only teenagers and adults, leaving children unprotected. This issue is considered to be a problem by over 76% of citizens of a large community , as revealed in my survey.

Fortunately, my research proposes a solution that can change this forever. By integrating advanced video-based camera systems, we can accurately measure children/infant's height and weight. Subsequently, it will allow the airbag system to rotate to an optimal angle for the child. Furthermore, the airbag will then be programmed to exert a certain amount of force that will protect and not harm the child. This approach holds the potential to substantially reduce the likelihood of child injuries and, most importantly, save their lives.

With this project set in motion, it creates better safety for children/toddlers across the nation and puts them at less risk of losing their lives in accidents. This project improves the safety of everyone, which is a good step in the direction of car safety.

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Embrace Emptiness to Prevent Suffering: A Journey through Santideva's Philosophy on Perception, Reality, and the Path to Liberation.

By Richard Liao

Author Bio

Richard Liao, a senior at the Hill School in Pottstown Pennsylvania, interested in religion and philosophy. He travels constantly to Tibet and hopes to address religious and philosophical topics in Tibet into everyday situations to navigate challenges in life. In the future, Richard wishes to address philosophy as an important soft skill that goes beyond its academic purposes as he hopes to continue under the mentorship of Professor Allison Aitken from Columbia University in College.

Abstract

The paper explores the profound philosophy of Santideva, focusing on the concept of emptiness and its implications on human agency and ways to prevent suffering through an argument reconstruction using analogies. A major issue Santideva highlights is how conventional truth, shaped by societal consensus and labels, veils the ultimate truth – the reality of things. Emptiness, as the absence of intrinsic nature in phenomena, becomes a cornerstone for understanding reality beyond conventional appearances. Santideva's arguments challenge the notion of a self and illustrate how conditions influence experiences and the illusion of a continuous, unchanging "I ." This examination extends to self-awareness, refuting the mind's ability to perceive itself independently. Navigating through the complexities of suffering and categorizing it into various forms - all stemmed from attachments and ignorance – that ultimately advocate the path to liberation through the Four Noble Truths, this paper encourages a practical application of Santideva's philosophy in daily life, highlighting the need for practice and action over mere contemplation, paving the way toward understanding and embracing the elusive quest for liberation from suffering. The paper does not provide an answer; nonetheless, it should help inform readers without previous knowledge and researchers of the questions Santideva implores us to consider and offer a modern interpretation of Santideva's definition of how to attain liberation from suffering.

Keywords: Emptiness, Human agency, Suffering, Liberation, Tibet Studies, Religion, Philosophy, Mental Health

Introduction

What if our perception of life is not the reality we fathom and that our attachments to the world are, in fact, misconceptions? While the phenomenal level of the world exists as appearance, it is the misconception we overlay that the world is an illusion. The 8th-century Indian Buddhist philosopher wrote on the importance of understanding wisdom in the Perfection of Wisdom chapter in A Guide to the Bodhisattva Way of Life, offering us insight into a potential possibility for how reality can be presented before us and make decisions with new wisdom. In this essay, I will argue that emptiness enables us to understand human agency (the capacity of individuals to make choices and act on those decisions) and to clarify the perception of matters, providing practical implications in our everyday lives to prevent us from suffering.

Santideva consolidates his argument by emphasizing defusing life's delusional appearance and grasping the nature of reality through the realization of emptiness. The concept of emptiness will be the central concept that I will consistently bring up throughout the essay. This essay will begin with understanding the two truths before approaching the idea of suffering. As we move along, Santideva argues for realizing the absence of a self to liberate from suffering. Then, we will take a deep dive into what is defined as a true reality, which will help lead us to the question of what suffering is and what the methods are. The concept of emptiness will permeate throughout the discussion as we begin to understand how the idea of emptiness fits into the picture. From Santiveda's perspective, keeping his emphasis on emptiness in mind as we move along the argument is important.

SECTION 1 - Understanding the Two Truths

According to Santideva, to approach the subject of suffering, one must grasp the concept of the two truths - conventional and ultimate - and develop the wisdom to go beyond the surface aspects of all things. The conventional truth represents the appearances and the world presented to us through our ordinary minds and senses. It conceals reality and blurs the absolute knowledge of things as they are. For instance, when we see a leaf, we can recognize it instantly. However, it is not intrinsically a leaf from its own side. It does not exist independently of how we think and speak about it. Instead, we recognize it intuitively because we are familiar with the so-called color "green" and the familiar structure and shape we associate with a leaf. The labels and definitions we granted to this object for convenient communication purposes in our life at a phenomenological level reflect our conventional truth. In constructing our experiences, our minds - influenced by consensus - distort how things truly exist. Such "ignorance" and "misconception," developed from over-simplified consensus constructed by superficial labels, has proven to be the easy way to understand the world since we fail to delve deeply enough to explain the reasonings that justify our current knowledge. Thus, such wisdom is just some sort of conventional wisdom.

More closely scrutinizing the conventional truth, it could also be split into two kinds: true conventional truth and false conventional truth. Confusion may arise regarding how a conventional truth can be true when, according to Santideva, it is already faulty. Going back to the leaf example once again, Santideva would very likely respond that while the image, the concept, and the feelings we generate from our experiences and knowledge are false in nature, there is conventional wisdom that is true in the sense that it engages with a deeper understanding of our world that will guide us on the path to the ultimate truth. Rather than accepting the leaf as merely a leaf, one should develop an awareness of the leaf's illusory appearance and actively seek ways to approach the ultimate truth by eliminating one's faulty perception. This is the first step to the understanding of the concept of emptiness.

On the other hand, the ultimate truth refers to the true nature of reality, the world in its undistorted form, established on the ground of the concept of emptiness, referring to the universal absence of an intrinsic nature or empty of a permanent and unchanging essence. In our case, there is a tendency for our natural way of conceptualizing things to directly determine or influence our interpretation of objects rather than verifying facts with reasons since the sorts of concepts we use to structure our experience are influenced by the language we speak and the conventions of the society we live in. Instead of questioning why we would call any object by its name or give any objects their meanings, we automatically accept these as universal truths from

birth. Our knowledge is constructed by what our parents, teachers, and people told us, who are also educated by similar mindsets in their time or last generation. Gradually, conformity becomes the dominating factor in establishing " facts. " But in the world of ultimate truth, these "facts" are merely names and vowels coming from our mind and mouth, both conducted by the same delusion – our conventional truth. This tendency makes attaining the ultimate truth incredibly difficult as we must cast away our existing interpretations to grasp the ultimate truth. In other words, we must disbelieve all concepts we once held true to ourselves and approach the world without notions. According to Santideva, "Ultimate reality is beyond the scope of the intellect. The intellect is called conventional reality" (Santideva, 1997). Therefore, such an attempt to remove our existing interpretations constructed by the way we developed and to be aware of this so-called ultimate truth that exceeds the scope of our intellect is extremely hard for us or may even seem impossible.

Then what is the point of pursuing this ultimate wisdom when it is difficult to grasp? While the intellect cannot perceive this because of its nature of conceptualizing things even when nothing is presented, there are ways for people to have a breakthrough. According to Santideva, when a mind breaks free from the chain of conventional thinking and fully grasps the ultimate truth, the mind is no longer referred to as an ordinary intellect, which refers to the mind that uses concepts to understand the world. Then, the question becomes how one can access the ultimate wisdom. Santideva states, "In light of this, people are seen to be of two types: the contemplative and the ordinary person." And "the ordinary folks are superseded by the contemplatives" (Santideva, 1997). Prajñākaramati's commentary on the Guide shows that a contemplative meditates and reflects on all phenomena free from concepts. At the same time, an ordinary person remains in the cycle of samsara as the cause of the origination. Both parties live with the conventional truths, except that "ordinary people see and imagine things as real and not illusory" (Santideva, 1997).

In contrast, the contemplatives see reality through the conventional truth and potentially utilize the conventional truth to approach the ultimate truth. However, it is crucial to bear in mind that in both cases, subtle illusions continue to exist, as the Buddha in the sutras says, if both the contemplative and the ordinary people believe in an intrinsic nature in themselves. If that is the case, such subtle illusion is the highest form of illusion—the belief that there is an "I," the self. This subtle illusion, being one of the highest forms of illusion, is the belief that there is an "I," the self (Goodman & Schultz, 2020).

SECTION 2 – The Illusion of a Self and the Reality.

If "I" does not exist, then what exists? What exactly supports all these thoughts and information I produce every second? In response to this line of questioning, Santideva says that all aspects that comprise an experience are, in reality, products of the conditions around us. Conditions are the trigger of a response, and according to Santideva, we often misunderstand the true nature of these conditions and wrongly attribute experiences and suffering to an independent existing variable self or the concept "I." However, we cannot be the sole condition that is producing everything that we claim as an experience; and perhaps we might not think that we are creating our experience, but we might think that we are the sole agent/condition responsible for our actions (Santideva, 1997).

Let us experiment with our minds by trying to think of something original. If you are attempting to think of anything at this moment, then you have failed to think of something original because my suggestion of an experiment triggers your act of thinking. No matter how original your idea may be, my condition prompted you to think. Whenever we do or think something, an essential framework in how we think and act must exist. So, if we broaden our understanding of this experiment, you might realize my suggestion was not the only element that triggered your response. Your environment, senses, and location could factor into the answer you produced after I pitched the experiment to you. Therefore, the actual reason why we feel like we experience the world so real is because of the infinite number of conditions triggering your endless number of responses that make everything appear so smooth and authentic, just like how movies are made – fast-forwarding frames that create the illusion of continuity. In reality, they are just static pictures connected.

Consequently, the experience we believe we have regarding "my life" is an illusion. The concept of an "I" as an independent variable that can live all the frames in life fails to withstand the analysis of it because if that were to be the case, then we are essentially saying at every frame of a second, the "I" remain consistent, which that is not the case at all. Santideva says, "What happens earlier is remembered but not experienced by what arises later. It does not experience itself, nor is it experienced by something else" (Santideva, 1997). Try to perceive anything right on the spot, and one might notice no one can perceive their experience instantaneously. It is after what occurred that we then analyze the input information post-experience. Therefore, the nature of a self does not exist. It is just the collection of information from each of your senses that consists of the illusive feeling of a self, combined with the recollection of your relationships to many other things you experienced.

At this point, one may wonder if "I" is an illusion; my mind must be an illusion, too. Then, if my mind is also an illusion, what is perceived by what? How do you explain self-awareness? In response to this question, Santideva would likely respond based on the assumption that his opponents would argue that the mind has this ability to perceive itself: "The Protector of the World stated that the mind does not perceive the mind. Just as a sword cannot cut itself, so it is with the mind" (Santideva, 1997). To demonstrate his point better, Santideva used the lamp and the color blue as primary examples. A lamp cannot illuminate itself because it is not surrounded by darkness. The presence of darkness allows the light to illuminate, not the light illuminating and creating darkness. Like how a blue object cannot grant itself blueness, "What blue by itself could make itself blue?" (Santideva, 1997). Putting this in the modern context, we know that elements determine the final visual presentation of an object, and no element by itself generates the color blue. As Santideva put it, "Nowhere does a single condition have the ability to produce everything," Ultimately, no mind is possibly capable of perceiving or being aware of itself. Assuming self-awareness is even true, it is not only the mind that does the reflection. So, this means the process of "self-awareness" is prompted by dependence on something else, proving the existence of self-awareness unreasonable. Thus, this logic further supports Santideva's argument that a self cannot possibly exist considering that the self is not all that is producing everything of what we are calling "experiences," and if one were to argue that the self is a collective whole that generates an experience, then what part or parts would be considered as the "self" to produce an experience? Thus, Santideva rejects the notion of the existence of a "self" for its irrationality and its ability to recognize itself.

Additionally, it is imperative to understand that an illusion can continue to exist as long as the conditions are not destroyed. Even if the illusion exists as an aspect of the consciousness, it would be something different in reality. (Santideva, 1997). To elaborate on the point that consciousness fails to exist, Santideva comments that one can truly be understood as existing when one can produce everything independently. However, nothing can truly achieve that since there will always be a diverse account of conditions that add multiple layers to the composition of the thing. In other words, what may appear to be unique "characteristics" or "personalities" cannot be identified as independent factors. They cannot exist independently due to their inability to maintain the same conditions and qualities throughout time. Otherwise, it would be a different matter as the conditions change, which causes the change in the matter. You are who you are at this very moment because of all the conditions that lead you up to this point, not that you have the choice to develop yourself, considering no one can manipulate the conditions around them.

If the mind does not exist, are there still wrongs in committing murder or any other forms of sins since nothing truly exists? To this extent, Santideva responded it is, in fact, on the contrary and circled back to his point earlier. "When one is endowed with the illusion of consciousness, vice and merit do arise" (Santideva, 1997). The falsehood of our mind does not fall on the conditions themselves. In reality, whatever happened did happen, but it is certainly not the way we interpreted it. Take the example of a murderer swinging a knife at another innocent man, and we can see how this is a terrible sin to commit. However, in its ultimate form, it could just be an object carrying another object hitting the other object. We implemented the moral codes into the situation, while the situation itself holds no ethical aspects. Therefore, any products of the illusory mind are ultimately illusory since their origin is faulty to begin with. If a creature is genetically (inherently) diseased, its offspring are also diseased.

But don't all things exist based on reality? Otherwise, wouldn't all just be nothingness? However, an illusion can be presented even when it does not exist. Furthermore, Santideva asked, "How can something that does not exist have any efficacy by being based on something real" (Santideva, 1997). He challenges the notion that something which lacks an inherent existence can have any actual efficacy. The assumption that something unreal can have real efficacy is not only a misconception of the nature of existence but also an attempt to attach the ultimate truth to the conventional world. If we agree that the mind has a nature of existence, then we are treating the mind as "an isolated unity" (Santideva, 1997). This then brings back the problem of the interdependent nature of all phenomena where nothing can exist independently. However, there is one distinction Santideva stresses: "The manner in which something is seen, heard, or cognized is not what is refuted here, but the conceptualization of its true existence, which is the cause of suffering, is rejected here" (Santideva, 1997). It is precisely the misconception we hold for the reality that causes us the suffering we ought to get rid of. While it is true that even illusions sometimes need a foundation to manifest, in ultimate reality, nothing has the intrinsic nature of existence. It is we who mistake our conceptual conducts as ultimate truths when we forget the labels we use are merely conventional truths, not an indication of inherent existence. Although it seems impossible to break free from the illusion of our lives so far, given how everything is being argued to be fake, there is still a path to enlightenment.

SECTION 3 – Understanding the Nature of Suffering and Embracing the Path to Liberation through Emptiness.

After a deep dive with Santideva into the world's knowledge, how exactly do we acquire the ultimate truth and prevent our suffering? Knowing our sufferings before approaching suffering is crucial, not simply as we might expect it to be. According to Carpenter, a known scholar in the field of Indian Buddhist philosophy, suffering can be classified into four categories:

(i)the physical suffering. One kind of suffering that we relate to brute force is a bruise, a scratch, a cut, and so on. Such suffering is the most common, as well as the surface level of suffering.

(ii)the phenomenological suffering. This refers to emotional pains, such as misery, anguish, anxiety, fear, and desire. Such suffering extends to what we want and what we wish to avoid.

(iii)the suffering for lack of control. Despite our drives and desires, the world has proven not always to work as we wanted it to. The fact of impermanence ensures that the suffering of unexpected changes constantly reminds us of our impotence and inability to control, even when it is not occurring presently.

(iv)the metaphysical suffering. Everything is subject to the effects of other things.

Therefore, nothing is fully independent or free from conditions. This suffering is subtle, as we tend not to be aware of it.

The fact is that there is no "agency" in a free-will form as we take ourselves to have or to be (Carpenter, 2014). All suffering is an outcome due to the weak imprint of emptiness. Emptiness is the intrinsic nature of all things and phenomena, simply nothingness. It is the assertion that nothing has an inherent, independent existence. They all lack an intrinsic value and exist interdependently, with their existence influenced by various causes and conditions. To better understand what emptiness is, you can try to look at your water bottle as an example. It is currently a water bottle because you are familiar with what a water bottle will likely appear in general. The shape, material, and logos are all clues to how you identify a water bottle. But in reality, what defines a water bottle? Nothing. You can break it down into atoms and particles. Yet, regardless of how we define a water bottle, the terms are just labels we put as the characteristics of a water bottle. In the ultimate reality, the so-called water bottle is emptiness, for there is no true intrinsic nature attached to a water bottle. Inevitably, all things and phenomena fail to withstand the analysis of the possession of an inherent nature. According to Santideva, "When neither an entity nor a non-entity remains before the mind, then since there is no other possibility, having no objects, it becomes calm" (Santideva, 1997). When calm and aware, one liberates oneself from suffering and breaks free of

the cycle. Therefore, the only path to liberation is the knowledge that uses emptiness as its basis – the Four Pillars of Truth (Santideva, 1997).

SECTION 4 – The Four Noble Truths

The Four Pillars of Truth, also known as the Four Noble Truths, are fundamental principles of Buddhist philosophy. These truths form the core of Buddhist teachings and set the framework for understanding the nature of suffering and the path to liberation. Referencing the work by Carpenter, the Four Noble Truths states as follows:

1. This is suffering. It acknowledges that suffering is deeply integrated into human existence. The key idea of this truth is that no one can escape the reality of suffering.

2. This is the cause of suffering. It connects to the notion that suffering arises from attachments and our ignorance. In this context, attachment means our desires and attachments to things, people, and environments. Ignorance means misunderstanding reality's true nature and failure to recognize the impermanence, interdependent, and non-existing nature of all things and phenomena.

3. This is the cessation of suffering. This addresses the hope by asserting that suffering can be ended. By eliminating the causes of suffering (attachment and ignorance), it is possible for one to achieve the path of liberation or enlightenment where suffering ceases to exist (Carpenter, 2014).

4. This is the way to the cessation of suffering. The path is known as the Eightfold Path, and it serves as a guide to development, emphasizing the importance of wisdom.

While there are many terminologies related to the concept of the Four Noble Truths, most of which are an extension of the knowledge acquired after accepting emptiness. More specifically, one should be able to and must identify the irrationality in all things and phenomena without being blinded by ignorance and strong attachment to the illusory world. Among the arguments, Santideva engages in a context that challenges prevailing theories that may not align with contemporary viewpoints. Thus, I intend to explore and interpret the philosophy of Santideva in a more straightforward and modern manner. It will gradually become clear that he is advocating for the avoidance of any irrational wrongdoings, which is the right step towards attaining the ultimate truth.

SECTION 5 – Overcoming Suffering

If one struggles with the more subtle form of suffering and cannot correlate so well to the issue on that level, then let us try a straightforward example of suffering and see how Santideva goes about it. The simple example we will be using is anger. As our daily experience has demonstrated to us: when we lose our temper and we are agitated from an event, we suffer deeply from that. Considering our lives essentially consist of events, we have a high chance of becoming angry due to events. Santideva claims that anger is a product of conditions. "I am not angered at bile and the like even though they cause great suffering. Why be angry at sentient beings, who are also provoked to anger by conditions" (Santideva, 1997)? We respond to things or events angerily because we are provoked by the conditions in which we are involved. Pain is undoubtedly inevitable. Yet, the possibilities one may argue to be changeable are inevitable results prompted by conditions. For instance, the act of punching will very likely trigger the feeling of anger, whether the punch lands or not. Additionally, Santideva says: "A person does not intentionally become angry, thinking: 'I shall get angry,' nor does anger originate, thinking: 'I shall rise'" (Santideva, 1997). It is the interpretation of the intention that mainly triggers the anger, which occurs after the recollections and understanding of the event, not the direct effect of the event at the time it happens. If we were to assume the anger is a product of the interpretation of a "self," then how does the interpretation even stand when there isn't even a "self" to be the subject of these thoughts, considering the "self" immediately after the punch and the "self" one year after the punch will interpret this same "anger" completely different. If "self" does exist and has an intrinsic nature, then it will remain unchanged, which means it would likely have the same interpretation of the same anger even after years. Thus, it must mean that such so-called "anger" is merely a product of conditions since no other agent can withstand a rational analysis. Conditions that hold no conscious

thoughts of how and why it shall rise occur without the input of any emotional elements. Ultimately, if the anger is not the agent with the intention, nor can a "self" genuinely have its original intention. All sentient beings - subjects to anger - should be under the influence of conditions. And if both are subject to conditions, then there should be no valid reason for one person to be angrier than another on the same exact event.

As you may have noticed, the arguments begin to be repetitive. However, these few philosophies are the significant ones that one has to learn to set oneself on the path toward the ultimate truth. Although it is as simple as one can put it, there is another issue when utilizing it in real life. People constantly worry about improper things. They fear that they will never get what they want and that one day bad luck will get to them. Yet, this very mindset intimates the cycle of endless suffering. There would never be a threshold of satisfaction as long as one lacks the wisdom to understand he is not a human agent who holds his life in his hands. A great way to navigate away from this mindset would be meditation on emptiness. "If there were something called "I," fear could come from anywhere. If there is no "I," whose fear will there be?" (Santideva, 1997). To put Santideva's words in layman's terms, we set ourselves up for most suffering. By learning to let go of the obsession with an identity of the self, one will feel much more relieved without the burdens one puts on one's shoulders. Ultimately, it is the courage to face reality without so many of its glorified elements that we hope it had and to accept and contemplate the world for how it truly is.

SECTION 6 – Understanding Compassion

I can only manage to save myself. Should I care about others' sufferings? If I should, why so? This is a complex concept that fits into the natural tendency of human beings – genuine empathy. Santideva argues that despite the varying degrees of suffering and happiness, they nonetheless have the same nature, which applies to everyone. While it may seem that it is not one's responsibility to protect others from suffering due to differences, Santideva argues for the importance of protecting others just as one protects oneself. Just as the body, which has many parts owing to its division into arms and so forth, should be protected as a whole, even though the hand and the feet share nothing alike. Why is this the case? Pain applies to both body parts, and the feeling of pain is avoided at all costs. Considering this, one may strongly argue that the case for the hands and the feet makes more sense in comparison to "myself" and the others since it would make the most sense for an individual to protect themselves against the suffering that applies to themselves than to those of the others. However, Santideva pointed out that if the above is considered reasonable, then why do people protect their bodies from future suffering, which is not the pain I can feel at this moment? One may continue to argue that it is still within the spectrum of avoiding suffering for myself. Yet, this notion of "it will be the same me even in the future" is incorrect. "It is one person who has died and quite another who is born." There is no evidence that I will hold the exact same qualities and thoughts five seconds later when I would be affected by the condition, causing my thoughts to change. This will again lead to the idea that "I" is a delusion built up by the continuum of consciousness. Ultimately, we think significantly, or even selfishly, of our own sufferings because we bind ourselves to this attachment and notion of the "self." The underlying issue with this is that we would assume we are exceptional in terms of suffering, which is also an unsupported and inappropriate assumption.

CONCLUSION

I find Santideva's arguments compelling in that they point out the irrationality behind the reasons for many of our decisions. Instead of eagerly trying to prove that his points are right, he offers perspectives and raises good questions about the worth of our thinking. The essence of Santideva's philosophy here lies in the unwavering pursuit of avoiding inappropriate and irrational, whether the knowledge pertains to oneself or others, regardless of the existence of the self or the presence of the two truths. It has been proved to be difficult, even impossible, to always do the proper thing as a human being. The pattern of seeking refuge or a comfort zone is in our blood. We are so familiar with what we have and what is around us, without even questioning anything until things go wrong. The path to liberating life from pain is not a well-kept secret but more of an elusive quest. Like Santideva's methods to find the path of liberation,

we need to confront our ignorance and act instead of just thinking. Monks go on pilgrimages; they meditate for a long while to clear their minds and be closer to the truth. All of these recommend one's practice instead of just using one's thoughts. Santideva's work covers an exceptional amount of information, which takes us a long time to digest. However, a thinker with all of the knowledge in the world will stride no further than a practitioner who integrates his daily knowledge into his everyday life. Start here, and at this moment, we set off our first step. It is a mark of our journey to somewhere ultimate. If we are still confused about where to start, try to track back and draw out that first question Santideva has asked you.

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Guo Moruo's *The Nirvana of the Feng and Huang* (1921) as a Chinese modernist poem that reinvigorates traditional myths and legends

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Jiayi Luan is currently a junior studying at Dulwich College Shanghai Pudong in China who is interested in studying history, literature, and political science. She is interested in studying the intersections of these subjects which provide insights into the societies in question. Currently, she is taking IB courses with Higher Levels in History, Geography, and English Language and Literature, aiming to deepen her understanding of global dynamics and cultural contexts. She is particularly fascinated by the symbiotic relationship between literature and history, as shown in this research paper.

Abstract

This research paper explores the intersection of modernist poetry and Chinese cultural revival during the early 20th century, focusing on the poetry of Guo Moruo (1892-1978), a prominent figure in modern Chinese literature. It delves into the adaptation of Western modernist techniques in Chinese poetry as a means of critiquing and rejuvenating traditional cultural forms in the face of social and political upheaval. Guo Moruo's engagement with Western influences, particularly through his translations of Walt Whitman, exemplifies the broader movement among Chinese intellectuals to seek new modes of self-expression and challenge the rigid structures of Chinese society. Examining Guo Moruo's poem The Nirvana of the Feng and Huang (1921) as a case study, the paper analyzes how modernist poets reanimated ancient Chinese myths and legends to convey contemporary social and political commentary. Through the voices of the mythical Feng and Huang, Guo Moruo critiques the oppressive conditions of late Qing society while expressing a fervent desire for change and rebirth.

Keywords: Modernism, contemporary Chinese poetry, poetry, Chinese literature, Guo Moruo, May Fourth Movement, social movements, reanimation, myths, Fenghuang, identity, 20th century

Introduction

By the twentieth century, even literary traditions that were previously closed off to Western influence began to engage with the literary forms of Western modernity. While in some cases this threatened to overshadow more traditional cultural forms, it was also often a means of reinvigorating them.

Although modernism may be of Western origin, it has developed its characters and forms in China. Chinese modernists used the idea of self-expression to voice their disappointments against the rigid structures of Chinese society and sought a new mode of literature.

Guo Moruo (1892-1978), a prominent Chinese poet, writer, and historian, was a significant figure in modern Chinese literature. His writings, often introspective and contemplative, were heavily influenced by modernist movements. Guo read and translated Walt Whitman's works, which he believed matched the core concepts of the Chinese May Fourth Movement in 1919 (Huang, 1998). He was also a prominent critic and theorist of modernism in China, arguing that it was a way of life that rejected traditional values, fostering experimentation and innovation.

What is modernist poetry?

Modernism, a literary movement in the early 20th century, rejected traditional forms and techniques, focusing on unconventional structures like free verse and enjambment. Influential poets like T.S. Eliot and Ezra Pound aimed to capture the fragmented nature of modern life through collage-like structures and imagism, emphasizing clarity and directness. Modernist poetry transcended geographical boundaries and developed unique characteristics in different countries. The movement embraced experimentation, innovation, and a desire to break away from traditional forms.

Chinese openness to the West

When China opened to the rest of the world towards the end of the 19th century, the Western world surprised it with a "gift." Much like Pandora's box, this "gift" brought its share of good and bad to the Chinese: fear, death, opium, but most importantly, the dawning realization that their empire was incredibly backwards, and the perception that it was unassailable was merely a figment of their own imaginations. However, there was also hope. The introduction to Western culture and literature gave hope to people longing for change or escape from the rigidness of Chinese society, especially from the impenetrable class hierarchy, something that kept the rich richer, and the poor even poorer.

The May Fourth Movement (1919) was one that emerged as a response to China's weakness and corruption, as well as the influence of Western culture and ideas. It sought to modernize China and make it a more equal and just society. Many young intellectuals involved in the movement expressed their ideas and critiques of society through literature and art. The Chinese New Period (traditional Chinese: 新詩; simplified Chinese: 新诗; pinyin: xīnshī) poetry movement was a product of this social movement. It refers to the post Qing dynasty poetry (1644 to 1912) that challenged the traditional themes of nature and the court found in classical Chinese poetry, instead focusing poetry on the everyday lives of ordinary people (Goldblatt, N/A). Many believed that Chinese modern poets wanted to reform classic poetry because they believed that traditional forms of poetry had become stale and outdated, but was this the case?

Out of the various forms of classic Chinese poetry, the most widely regarded and the most revered were Tang Shi and Song Ci. There were differences among them: Tang Shi (of the Tang Dynasty, 618–907 ce) is more structured and concise, expressing a myriad of ideas such as socio-political commentary, philosophy, and religion; Song Ci (of the Song Dynasty, 960 to 1279 ce) on the other hand was more musical, free, and was composed mainly for the expression of personal experiences, such as love, sorrow, and nostalgia. (Jevid, 2023) Both were produced prolifically in their dynasties. Their impact could not be limited simply to those who write literature, but more so upon society, where they created an ability to appreciate beautiful things and the want to express deep emotions through artistic ways. As a result, originality was celebrated.

That is, the Chinese modernist poets of the early 20th century never wanted to denigrate the Tang Shi and Song Ci, which had a profound impact on Chinese literature and were deeply ingrained in Chinese culture.

At the time, poets like Hu Shi considered the classical verse of the late Qing period to be a "degenerate epigone" of the Tang and Song poetry (McDougall, 1994). Why was the poetry of the late Qing period so criticized? Firstly, since the Tang Shi and Song Ci were considered to be the pinnacle of Chinese poetry, any works produced subsequently had to fit the impossibly high standard or be written in the mainstream way in order to be considered good poetry. Anything that did not meet standards was considered "out of touch", in a way that did not fit the mainstream success criteria (Hu et al., 2020). Secondly, the economic state of the late Qing could in no way compared to the prosperity of the Tang dynasty. The unstable economy could not allow for prolific poetry publication since there were many fewer poets and fewer works churned out. The Chinese society then was not at an age for the appreciation of the arts, as people struggled for their own subsistence. The quantity and quality of the poetry were considered so pathetic that most people considered the period to be the decline of Chinese literature. Poetry and its significance seemed to fade out of prominence in society.

People thought that Chinese literature at the time reflected the pervasive phenomenon of classism. Only the elites had access to great works of art and literature, as they were written in complex language no proletarians (members of the working class) could decipher.

This is because the Chinese written language and spoken language were very different at the time, hence the inability of less educated or uneducated individuals to understand them. In classic Chinese poetry, each word was commonly expressed by a single syllable (Hu et al., 2020). They are heavily abbreviated (in comparison to the spoken Chinese language), and yet they often express subtle, nuanced meanings. Furthermore, due to the late Qing dynasty being a period of political and economic uncertainty, the amount of background studies required to compose a single "appropriate" classical Chinese poem was not accessible and affordable to everyone, thus making the craft an activity for the elites/rich.

So, in a search for "real" self-expression for Chinese poets, modernists turned to baihua or vernacular language. In a conversation between Hu Shih (1891-1962) and Lu Xun (1881-1936), both renowned Chinese philosophers and writers that contributed to the Chinese language reform: Hu Shih said, "A dead language cannot produce a living creature." Lu Xun added, "To renovate or reinvigorate Chinese fate, we must try first to reform Chinese literature" (Wang, 2014).

Unfortunately, the vernacular was never considered appropriate for its use in Chinese poetry. It was never fully accepted. Rather, many of those modern poets are still considered literary "hooligans" to this day due to their use of vernacular language, believing that the modern poets tainted the sophisticated, celestial beauty of classical Chinese poetry.

All the above is inseparable when evaluating and considering Guo Moruo's The Nirvana of the Feng and Huang (1921), since like many other poems written of the New Period, it is a critique of the degeneracy of Chinese society and literature then.

One of the most significant characteristics of the poetry of the period was an attempt at reverting back to the prime of literature – the Tang Shi and the Song Ci – and poets like Guo Moruo sought to achieve this by reanimating the legends and myths that proliferated during the era. Most importantly, it called for an appreciation of the past forgone that was obscured by the corruption of the period.

Reanimation of legends and myths

Guo Moruo is perhaps most known for his poetry collection named Goddess (1921). The most "thematically emblematic" poem is "The Nirvana of the Feng and Huang" ("Fenghuang Niepan"), which represents both the "spirit" of the collection and that of the May Fourth Movement. According to Yi Zheng, "The literary revolution of early twentieth-century China, the height of which was usually marked by the 1919 May Fourth Movement, is noted in modern Chinese literary history for its antipathy to tradition and passion for rebellion." (Zheng, 2018).

The Fenghuang are the characters that guide us through the poem. The Fenghuang in ancient Chinese folklore were creatures who resided upon the faraway Mount Danshe, perched on wutong trees, drank sweet wine, and ate bamboo.

In the notes Guo wrote before the poem, he explains that the idea of rebirth, or "niepan" in Chinese, was not a known trait of the Fenghuang. Instead, Guo had said himself that he borrowed the idea from ancient Arabia. It could also be traced back to origins such as Greek mythology.

This poem is divided into various songs: a preface, the Song of the Feng, the Song of the Huang, the Choral Song of the Birds, and finally, the Rebirth Song of the Feng and Huang. It tells the story of a pair of Feng and Huang preparing for their death and rebirth.

Song of the Feng

The ancient folklore does not elaborate upon the Feng's personality, so it is safe to say that the poet reanimates this ancient legend by instilling in it both rationality and a strong sense of indignance. He comes alive as a legend and symbol of the glorious past, and curses the world that he finds himself in, stating that, "To exist in the mire and gloom of this world/would cause even a diamond sword to rust." (Guo, 1928) He is not only describing a world so oppressive that the sharpest swords could not penetrate, but also a world that forces everyone to assimilate, ridding each individual of their individuality, and uniting people in a streamlined approach that somehow resembles the cyclical nature of the Fenghuang: there is no escape in life or death; after life there is death, and after death comes life.

Furthermore, the fact that Guo likens the situation to a "mire" shows the helplessness of Chinese modernist writers. This shows the inflexible minds of the Chinese people towards accepting new, pioneering ideas. Their reluctance makes the Chinese modernist writers appear like a singular force trying to maneuver across a mire. Similarly, Guo uses the imagery of a world full of chaos and destruction to emphasize the modernists' hardships and despair:

We fly westwards:
the west, alike, is a slaughterhouse.
We fly eastwards:
the east, alike, is a prison.
We fly southwards:
the south, alike, is a grave.
We fly northwards:
the north, alike, is a hell.
Living in such a world
we can but learn from the lament of the sea.
(Guo, 1928 translation)

The Feng sees the world (presumably the late Qing dynasty) as it was: a mess in need of repair. He leads people to believe that he is a pessimist, which is understandable considering he describes the world as "cruel as iron," "somber as lacquer," and "rank as blood."

However, the Feng looks for hope in every situation: they travel westwards, eastwards, southwards, and finally northwards, looking for a place that is not eroded into ruins, looking for hope, and find the opposite. The Feng is sorrowful, but he is not pessimistic. He finds the world as a slaughterhouse, a prison, a grave, then a hell. There is a gradual exacerbation in the severity, from a slaughterhouse to hell, a metaphor for the state of the country that could hardly be remedied. Astounded and disappointed, but the Feng did not lose hope.

I raise my brow and ask of Heaven,
but Heaven is reserved and aloof, and has no knowledge of these things.
I bend my brow and ask the earth,
but the earth is dead, it has no breath.
I look out and ask the sea,
but the sea is raising its voice in grieving.

This section describes the world at its breaking point. The Heaven appeared distant and unresponsive, which could reflect the sense of isolation or detachment the Chinese revolutionists felt from spiritual powers. Guo was perhaps trying to highlight their despair by illustrating the fact that fate and luck were not on their side. The earth was lifeless. The ground that once provided people with stability was silent and immobile. The earth represents the past societal structure that once glued them all together. However, as time revealed much of its flaws, more and more called for a revolution. The constraints of

existence in the 'Old Society', as modernists and revolutionists like to call it, could no longer answer the existential inquiries that arose from people as a result of exposure to Western culture. In literature particularly, people questioned the way poets wanted to recreate the classic poetry of Tang Shi and Song Ci instead of experimenting with new forms of poetry.

But more significantly, people inquired about the potential of Chinese writers and Chinese literature. Modernists, especially scholars studying the West, thought the current 'earth' or societal structure that held people together limited creative freedom, as it preserved the idea that literature was sacred and restricted to a certain class of people. Writers like Guo looked towards Western poets like Walt Whitman and Ezra Pound, and how their work was so unrestricted and accessible. Guo said it himself, "Whitman's poetic spirit which seeks to do away with everything old and restrictive is especially suitable for the Sturm and Drang of May Fourth, I am completely shaken by his majestic and unconstrained tone." (Zheng, 2018). So, people wondered, what would Chinese literature look like if it was similar to Western poetry and accessible to the wide majority? This question was left open in the poem, leaving the answer for the reader to discover.

The undying spirit of the Feng reflected the spirit of modernist poets in China. Even in desolate times, the Feng did not give up hope, seeking for an answer that even the Heaven does not behold. The Feng was the epitome of the fervent passion and fieriness of young writers during the May Fourth Movement, their fearless expression of self that resulted in an outpour of thoughts and feelings – "volcanic", as Guo described himself – that could not be deliberately replicated by successors.

Song of the Huang

Compared to the Feng, who is more aggressive and strongly expresses his disdain at the current state of the world, this section of the poem was written in a more slow-paced, melancholy elegy.

The Huang portrayed the corruption of the late Qing rule did irreversible damage to the Chinese identity and culture. She sings about her 'Unceasing flow of tears/filth that cannot be washed away/flame of passion that cannot be extinguished'. When juxtaposed with the past Chinese historical periods, the 'stain' stands out conspicuously. However, it could not be washed clean regardless of how much people lament and regret. The opening of this section introduces the Huang as a modern feminist character who challenges the convention that female characters are only capable of shedding tears. Huang realizes that her tears cannot wash away the "filth" but instead fuel the "flame" of her intense passion.

Rather than the physical barriers that seemed to trap the Feng, the Huang touches more upon the psychological:

Ah, this shadowy, drifting life of ours
is like a drugged sleep on such a dark night as this.
Before us is sleep,
Behind us is sleep.
We come like a gust of wind,
We go like a whisp of smoke.
Coming like wind,
going like smoke,
sleep behind,
sleep before.
In the midst of this sleep
we are but a fleeting breath of smoke.

Ah!
What sense is there in it?
What sense is there in it?

The Huang becomes a sort of an observer in this stanza, floating above and watching. "Sleep" becomes synonymous with death – Guo famously said, "Life and death are on the same line. Life is struggle, death is rest; life is activity, death is sleep." Sleep and death, in this case, appear in a "lifelike omnipresence". (Zheng, 2018)

"Sleep" could be found weaving through this stanza, creating this circular loop that was inescapable. "Sleep" was all-encompassing. It was used in a way that does not provide comfort and relaxation to the readers, but rather in a way that evoked urgency, as it becomes an entity that was always looming behind and before.

Guo is suggesting that the minds of Chinese modernist writers were asleep and numb. Through the melancholy croon of the Huang, Guo expresses his

feeling of loneliness as a modernist writer. Another Chinese modernist novelist Lu Xun captured this sentiment perfectly in an enduring metaphor in his short stories, Call to Arms:

"Imagine an iron house without windows, absolutely indestructible, with many people fast asleep inside who will soon die of suffocation. But you know since they will die in their sleep, they will not feel the pain of death. Now if you cry aloud to wake a few of the lighter sleepers, making those unfortunate few suffer the agony of irrevocable death, do you think you are doing them a good turn?" (Lu Xun, 1923)

Lu Xun wrote this in 1923, and it is entirely plausible that Guo was referring to this then-immensely popular idea. It is the story of being the only one awake in a room filled with people asleep, trapped in a room of iron, on the course to death. Would it be better to keep your silence, or to rely on the scanty hopes of waking people up and making an escape? The answer that Lu came to, according to Evan Osnos, was that "Silence […] was tempting but inexcusable; awakening even the few might also save the others. And so [Lu Xun] wrote, in order to "encourage those fighters who are galloping on in loneliness," as he put it, in the introduction to "Outcry," his first collection of stories." (Osnos, 2020) To put this in context, Guo was talking about the difficulty and unlikeliness of persuading Chinese writers to distinguish themselves from the degenerative and constrictive thinking of the late Qing Chinese society. The "drugged sleep" also translates to a "sweet dream", and the poet suggests that people were reluctant to distance themselves from the deteriorating society and the malfunctioning government because they simply chose to ignore those faults and live their lives in pretended complacency. Guo expressed his disdain for the people who chose to live an overtly sugarcoated version of life.

For a minute, however, the Huang seemed to succumb to this 'drugged sleep'. It seemed to conform to the status quo of keeping silent despite its obvious dissatisfaction. It describes its own presence (or the spirit of Chinese modernist writers) as just as easily forgettable and negligible as a "gust of wind" or a "whisp of smoke", so, what would be the use of struggling against a system that was deep-rooted in society? But the Huang struggled against this idea, questioning the senselessness of the world. She was stronger than merely a 'gust of wind' and showed no signs of relenting. Guo also changes "whisp of smoke" to "breath of smoke" near the end to suggest that the purpose of Chinese modernist writers would be to revitalize the spirit of Chinese people, just like breathing air into them. The scale of their influence did not matter as much. Just like Lu Xun wrote, "But if a few people are aroused [replied Ch'ien], you can't say absolutely that there is no hope of destroying that iron house."

Despite conspicuous differences between the Feng and Huang, they unite upon many traits. For example, they were both portrayed as rebellious figures: when facing a world that confines its prisoners in a claustrophobic cell, they did not choose indifference and conform to the prescribed standards. Even though the Feng expresses his resentfulness intensely, and the Huang sobs through her sorrow, in the end, they come to terms with the harsh reality and aspire for change instead of burrowing themselves in anger and sadness. Their awareness was reinstated in the fact that they were willing to pay the price of burning in the scorching fire for the price of rebirth. In their final songs, they sing together as a completed pair ready to set off to the new world stressing the importance of a united front. The resilience and free-spirited self-expression that they embody serve as an inspiration for not only the young writers of the May Fourth movement but also people generations to come who are dissatisfied with the status quo.

Conclusion

In conclusion, the revitalization of traditional myths and legends in modernist poetry from China serves as a powerful tool in the nation-building project of both countries. Through the exploration and reimagining of these ancient narratives, poets have successfully instilled a sense of cultural pride and communal identity among their people. By intertwining the past with the present, modernist poets not only pay homage to their rich historical heritage but also present an innovative approach to literature that encourages societal reflection and progression.

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The Impacts of Different Types of Exercises on Caregivers Stress Levels for persons with Alzheimer's Disease

By Lydia Sun

Author Bio

Lydia Sun is currently a junior at the Bishop Strachan School in Toronto, Canada and she is taking great amounts of science courses as she is interested in studying Neuroscience. She wants to pursue Neuroscience and Research later on in University and in her career. Some of her major hobbies are the following: running her non-profit Cognitive Compass Connections, dancing (ballet and contemporary), volunteering at organisations such as Alzheimer's Society of Canada and Sisters of St. Joseph (CSJ), baking, catching up on a few episodes of Grey's Anatomy. Lydia has been particularly interested in exploring more about Alzheimer's Disease and how it can not only affect not only the individual diagnosed but also their caregivers. She has realised the lack of research targeted towards caregivers and thus why she conducted this research. Lydia's non-profit Cognitive Compass Connections is actually dedicated towards spreading awareness and raising funds for people with Alzheimer's Disease. Her organisation has currently raised over $1300

Abstract

Alzheimer's Disease (AD) is the most common type of Dementia, affecting over 55 million individuals. This type of disease is caused by the abnormal chemical changes causing toxic taus to detach from microtubules and attach to other taus, forming tangles in the brain. Leading to form tangles inside neurons, disturbing the synaptic communication between these individual neurons.

Keywords: Alzheimer's Disease, caregivers, aerobic exercises, anaerobic exercises, resistance exercises, stress response

Methods

We analysed the responses of 105 individual caregivers, caregiving for people with AD. We focused on asking questions that resolve to multiple-choice answers asking about the type of exercising being performed by caregivers and the most stress-relieving types of exercises. Surveyors' responses were analysed and percentages as well as results were generalised and averaged, to form a single and accurate conclusion.

Results

The survey among Alzheimer's caregivers showed that aerobic exercises, like jogging, significantly reduced stress levels, with a consistent reduction shown across all participants. Dance also proved beneficial, not just physically but also socially, enhancing emotional well-being through increased social interactions.

Conclusions

Different exercises affect caregiver stress differently. Aerobic activities offer the most stress relief, likely due to improved physical health and emotional well-being. Dance adds unique social benefits. Caregivers might consider integrating these exercises into their routines for better stress management and overall health.

Hypothesis

Aerobic and resistance exercises, along with dance interventions, are expected to beneficially influence the stress levels of caregivers looking after individuals with Alzheimer's Disease, though the advantages will differ between these interventions. Aerobic and resistance exercises are likely to increase brain health and reduce caregiver stress. On the other hand, dance interventions are anticipated to be more effective in improving social interactions, thereby affecting the stress levels.

Introduction

Alzheimer's Disease (AD) is a neurodegenerative disorder characterised by cognitive decline and memory impairment. According to the World Health Organization, over 55 million people currently suffer from dementia, a category that includes AD, with nearly 10 million new cases annually (J (Ott)., 2017). In the United States, approximately 6.7 million people aged 65 and older are living with AD, a condition that incurs substantial societal costs (Pubmed, 2023). In 2023, the national expense for caring for individuals with Alzheimer's or other dementias is projected to reach $345 billion (Pubmed, 2023). Looking toward the future, the importance of AD and other dementias is expected to rise significantly. The number of Americans living with these conditions is projected to nearly double to about 13 million by 2050 (Doyle, 2020). Globally, the number of people with dementia is forecasted to nearly triple, increasing from an estimated 57.4 million cases in 2019 to around 152.8 million cases by 2050 (Alzheimer's Disease Fact Sheet, 2023). This dramatic increase is largely attributed to population growth and ageing (Alzheimer's Disease Fact Sheet, 2023). Current pharmacological treatments, while beneficial, offer limited efficacy and often come with side effects for people with AD, prompting the exploration of alternative approaches. Often, when AD worsens, people experience an exponential loss of memory and experience other cognitive difficulties, such as vision issues and spatial issues (Alzheimer's Disease Fact Sheet, 2023).

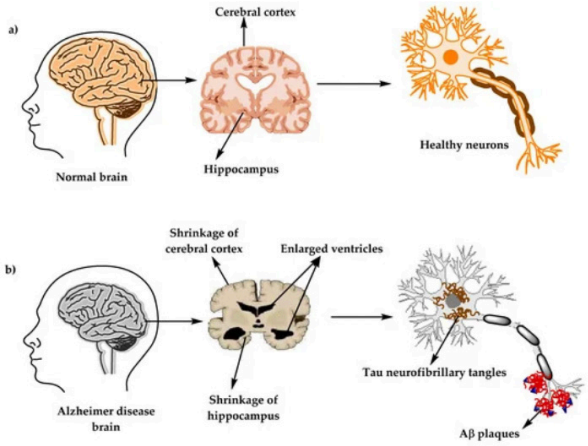

Figure 1. The physiological structure of the brain and neurons in (a) healthy brain and (b) Alzheimer's disease brain (acquired from Breijyeh, 2020)

AD consists of three general stages: mild, moderate, and severe. Most people experiencing AD on a mild level experience possible occurrences such as losing themselves or wandering to unfamiliar settings. On a moderate level, memory loss and confusion get worse, and often people forget how to proceed with actions they would normally do with ease, such as putting on clothes or utilising technologies (Llanque, 2014).

In the last stage of AD, plaques and tangles spread through the brain system and impair the brain tissues by shrinking them down, making the person affected lose most of their memory (Llanque, 2014). In the brain of people with AD, toxic changes happen in the brain, destroying the healthy balance that maintains the system within the brain (Llanque, 2014). These changes occur years and even decades before the first signs and symptoms of dementia formed within a person. As researched, scientists believe that the two proteins involved in this process, named beta-amyloid and tau proteins, when abnormal tau accumulates it forms tangles within a neuron and beta-amyloids clumps into plaques building up between neurons (Llanque, 2014). Currently, many advances in technology have been made to further study the effects of AD and pathology, these common methods include brain imaging allowing doctors and scientists to see the course of plaques and tangles allocated in the brain. These studies enable designed drugs to reduce the increase of tau and amyloids building up, exercising and dietary implementations are also reinforced to reduce the chance of this occurring in a person. Despite research on developing AD medication, there are currently a lack of effective treatment options thus medications are being made to treat the progression of the disease by targeting its cause, beta-amyloid and tau proteins (Llanque, 2014).

As AD advances in society with the increase in ageing and population rate, the need for caregivers also increases at an exponential rate. Currently, there are more than 15 million unpaid caregivers for persons suffering from AD, being stressful for caregivers due to the chronic nature of the disease's progress, as well as other factors such as – balancing their personal life and relationships with others (Schulz, 2016). Walter Cannon, proposed the terminology of caregiver stress. It was around the twentieth century in which describing stress as a fight or flight response or a heightened arousal state allows animals to flee from threat or fight off threat (Schulz, 2016). Following the discovery of Cannon, Hans Selye popularised this idea of concept of stress, where they hypothesised the idea of three stages of a person's response to stress, in which there happens to be a cognitive appraisal in the stress response. The concept of family caregiving was first appointed around the 1980s, to describe persons caring for elderly family members in their homes.

Formal caregivers are volunteers or paid employees connected to the social service or healthcare systems, assisting with the daily care and needs for the care receiver potentially resulting in caregiver stress (Schulz, 2016). It is usually depicted as a burden or strain that most caregivers face when caregiving for someone with a chronic illness or disease, accompanied with depression and other mental health issues. This stress often refers to the mental health of caregivers as studies have shown that the physical health of caregivers remains constant rather than fluctuating, unlike mental aspects (Schulz, 2016). The defining attribute associated often with caregiver stress is the unequal distribution of responsibilities on the caregiver as a result of caring for someone with prolonged impairment. Due to the lack of support, and the daily needs of care receivers, the build-up of duties often cause a breakdown in the majority of caregivers on the route. Research shows that studies on caregiver stress often look at it from both subjective (personal feelings) and objective (measurable events) perspectives (Schulz, 2016). This creates a contradiction because objective signs of stress, like a care receiver's challenging behaviour, are seen as leading to the caregiver's feeling of stress. Essentially, caregiver stress is about the caregiver feeling overwhelmed due to an imbalance in the caregiving relationship, feeling tired, or tense, which stems from experiencing challenging situations with the person they are caring for.

Researchers in the Current Field go into the Research of Caregiver Stress and Bring in Interventions

The increasing importance of chronic illnesses, especially AD, has brought attention to the immense burden carried by caregivers, showing a demand for effective strategies to suppress all of these caregiver's stress (Vu., et al, 2022). Despite

the role caregivers have within a healthcare system, the comprehensive toll—spanning from physical, emotional, and psychological aspects—have been examined in an abundant amount of research and a lot of policy discussions currently existing in our society. However, recent shifts in academic and clinical paradigms have allowed an era of increased attention towards implementing intervention-based and preventative strategies aimed to increase a caregivers' quality of life. Caregiver stress, characterised by a complex combination of emotional turmoil, physical strain, and financial insecurity, emerges distinctly in those caring for AD patients due to the disease's progressive, unpredictable trajectory (Vu., et al, 2022). The emotional distress of witnessing a loved one's cognitive decline, added by the exhausting demands of daily care and economic burden, establishes a foundation for stress, anxiety, and depression amongst caregivers.

In response, contemporary research allows a shift towards an approach depicting psychological support, technological innovations, and preemptive measures to combat the onset and escalation of caregiver stress (Liu, 2020). Psychological interventions, including counselling, stress management training, and educational programs about disease management, have shown efficacy in ameliorating feelings of helplessness and enhancing caregivers' emotional resilience (Vu., et al, 2022). Such initiatives not only provide caregivers with essential coping mechanisms but also deepen their overall understanding of the disease, empowering them to navigate the caregiving journey with increased competence and confidence. Concurrently, the emphasis on lifestyle modifications underscores the importance of caregivers' self-care, advocating for regular physical activity, balanced nutrition, and adequate rest as pivotal components in sustaining mental and physical well-being. Research the positive correlation between physical well-being and reduced stress levels, spotlighting the critical need for caregivers to prioritise their health alongside their caregiving responsibilities. Preventative strategies represent a forward-thinking dimension of caregiver support, focusing on early identification and intervention for at-risk individuals (Schulz, 2009). By offering resources and support preemptively, these approaches aim to forestall the accumulation of stress, preserving caregivers' health and prolonging their capacity to provide care. The burgeoning body of intervention-based research on caregiver stress signifies a promising trajectory toward developing holistic, effective support systems that acknowledge and address the challenges caregivers face (Alzheimer, 2022). Nevertheless, the path forward is fraught with obstacles, including the need for personalised intervention strategies that reflect the diverse experiences of stress among caregivers and the broader implementation of proven interventions.

The variability in stress experiences necessitates an approach to support, underscoring the importance of continued innovation and research in the field. Moreover, the effective dissemination of intervention strategies remains uneven, highlighting the imperative for policy reforms and enhanced funding to expand caregiver support programs, such as the longitudinal impacts of these interventions and explore avenues for scaling successful models to benefit a wider caregiver population (Alzheimer, 2022).

Studies have shown that exercising is highly beneficial to improving the health of caregivers and significant increase in health outcomes of caregivers after exercise training in this analysis supports that physical fitness activities can be somewhat beneficial for the well-being of caregivers (Farran, 2016).

In conclusion, to mitigate caregiver stress is an ongoing journey marked by significant advancements and persistent challenges. The collective efforts of researchers, healthcare professionals, and policymakers are crucial in forging a supportive ecosystem that uplifts caregivers, ensuring they receive the recognition, support, and resources necessary to thrive in their pivotal roles. Through other research and the use of evidence-based interventions, there can be other potential to substantially increase the overall quality of life for caregivers, allowing better health and well-being of caregivers to be regarded as more important.

This research paper aims to compare the impacts of different lifestyles: aerobic, anaerobic, resistance exercises, and dance activities, on the amount of caregiver stress reduced on caregiving for people with AD. Focusing on studying the hypothesis on how aerobic and resistance exercises, along with dance interventions, are expected to beneficially influence the stress levels of caregivers looking

after individuals with AD, though the advantages will differ between these interventions. Aerobic and resistance exercises are likely to increase brain health and reduce caregiver stress. On the other hand, dance interventions are anticipated to be more effective in improving social interactions, thereby affecting the stress levels.

Methodology

To identify the impacts and correlation of different lifestyles on caregiver stress, a survey was given to caregivers of all age, race, gender and demographic and also made available on google form online. This survey was made on Google Forms and was later on sent to 100 caregivers based in China for more research to be collected. The survey fabricated (primary research) consists of a total of 14 questions given out to caregivers of all age, race, gender and demographic.

Survey Participants

The participants are found through different organisations, institutions and databases. All participants are verified to be legitimate caregivers, caregiving for only people with AD. Participants are verified as a caregiver through a self-reported question in the conducted survey. All participants gave their consent on using their shared information for research purposes. We will be de-identifying any personal information that can be associated with you and utilise the survey results only for research purposes.

Questionnaire Design and Data Collection

The survey conducted aims and directs questions to specifically caregivers for persons with AD, asking whether or not aerobic or anaerobic exercises, as well as resistance and dance exercises, help reduce the amount of stress that builds up within the individual. As well as the different levels of stress that pertains within an individual due to caregiving and the different levels of mediation from the different types of exercises being performed. This is a platform for caregivers for people with AD to respond to questions that target their emotional and psychological effects of caregiving.

To gain an understanding of the levels of stress being mediated from caregivers, especially through the process of caregiving for people with AD, the researcher conducted a series of multiple choice questions and short response questions. These specific types of exercises demonstrated a diverse cross-section of the caregivers, including aerobic, anaerobic, resistance and dance exercises. Each survey responded was methodically structured to last 5-10 minutes, ensuring for participants to share their thoughts accurately and not be bored by the specific survey. The survey format was curated, including a broad range of questions designed to have a broad perspective on the chosen topic of this research paper.

This questionnaire consists of two parts, the first part is self reported including different aspects – consisting of two aims, ask questions regarding exercises and the type of exercises performed. The second aim is understanding caregivers' stress that they are faced with and the potential reasoning behind their stress levels. The second part consists of a caregiver stress scale adapted from Headway Organisation. This survey is constructed with primarily multiple choice questions, in order to make the answering process faster and more efficient. All questions that are slightly broader, consist of an "other" option for individuals to choose from. The question focuses on finding out the main reason for a caregiver's stress, the amount of hours per week a caregiver puts into the designated sport or sports. Questions such as the reason as to why they have specifically to perform this type of exercise and their own beliefs if the chosen exercise/exercises have improved their overall stress levels. These questions are able to help us build our conclusion for the research study and allow us to understand the process of managing stress as a caregiver for persons with AD.

Amongst the numerous questions posed, some of the most important ones included:

1. Types of exercises done by caregivers: "Which exercise did you prefer to do the most?"
2. The main cause of their caregiver stress: "What is the main reason that contributes to your caregiver stress?"
3. Their belief if these exercises affected their

caregiver stress: “Do you believe that your experience in resistance exercises have affected your caregiver stress ?”

4. Types of exercise that impacted their stress levels: “Which exercise do you think impacts your caregiver stress the most?

The intent behind these informed questions was to understand the immediate cause of stress in caregivers and also be informed on the different types of exercises that caregivers undergo in order to mediate their stress or subconsciously mediate them. The data from the survey is collected after the caregiver finishes his/her response, it is collected through forms of short response texts and selected choices from multiple choice sections.

All responses is extracted from Google Forms and *platform*. A brief summary of those responses are made in an Excel Document.

Results

5 caregivers have filled out the caregiver burden form, thus, we’ll be summarising at the end the overall collection of the 5 average results that we have calculated alongside with the 105 responses correlation with the study. The survey was conducted with 105 caregivers, with a level of stress of mean 4.01/5, standard deviation of 0.8 and variance of 0.63. The highest score was a 5 from caregivers and the lowest score given was a 1, this graph happened to be skewed to the left and had a mean lower than the median, with most of the responders replying with a stress level of 4 or higher. Demonstrating a high level of caregiver burden within the sampled caregivers. We have received a total of 105 answers to the survey, including caregivers from different geological areas, such as China, Canada and The United States.

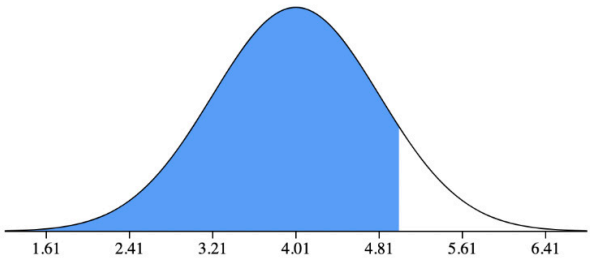

Figure 2. Normal Distributed Graph, demonstrating the z-score and where most of the data lies (blue area indicates where most of the data lies ranging from levels 1-5)

Table 1. Most common answers to these 5 important questions targeting Aerobic Exercises

Common Questions and Common Answers	Caregiver 1	Caregiver 2	Caregiver 3	Caregiver 4
Q1.Which exercise did you prefer to do the most?	Aerobic	Aerobic	Aerobic	Aerobic
Q2. Why did you prefer the chosen exercise?	Easier to learn	Requires less commitment	Believes that regular physical activity can also reduce the risk of many diseases	Read a lot in terms of dealing with stress and feels like exercising might help
Q3. Do you believe that your experience in aerobic exercises have affected your caregiver stress?	7/10	7/10	7/10	7/10
Q4. Which type of caregiver stress do you think is most affected by these activities?	Psychological and emotional Stress	Psychological and emotional Stress	Psychological and emotional Stress and Physical Stress	Psychological and emotional Stress and Physical Stress
Q5. Which exercise do you think impact your caregiver stress the most?	Aerobic Exercises	Aerobic Exercises	Aerobic Exercises	Aerobic Exercises

Of the 105 caregivers surveyed, 45% spend around 3-5 hours caring for their people with Alzheimer’s Disease, 44% of the caregivers spend 1-3 hours caregiving and 11% spend over 5 hours on caregiving.

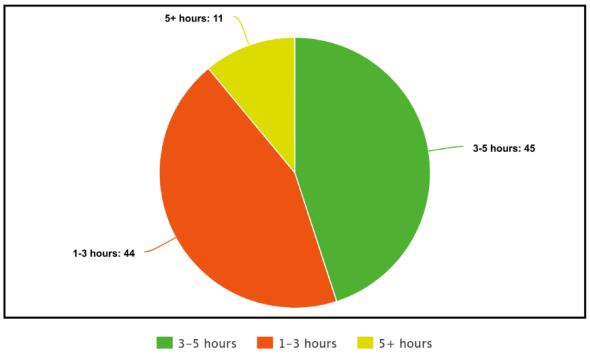

Figure 3. Percentage of number of hours caregivers spent on caregiving

The caregivers replied in their last week, 27% spent less than 1 hour on exercising, 47% spent 1-3 hours exercising, 21% spent 3-5 hours exercising, only 4% spent over 5 hours and 1% not exercising at all. The primary exercises that were engaged consisted of (main categories): 12% doing yoga, 24% doing dance, 31% doing aerobic activities, 18% on strength training,

7% with free combat and other exercises consisting of 8% of the caregivers surveyed.

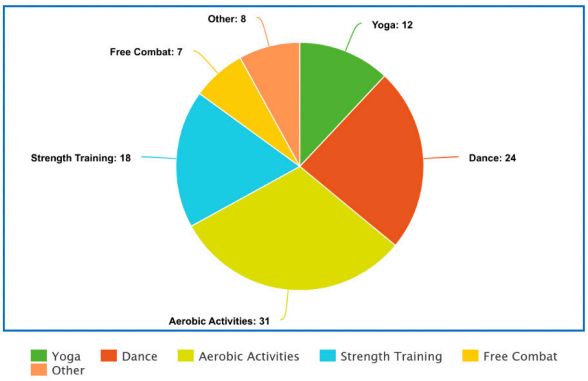

Figure 4. Percentages of each exercise Caregivers participated in

The type of exercise from the named ones that help relieve stress the most happens to be jogging with 63% (type of aerobic exercise) answering so, happening to be a type of aerobic exercise. The overall responders who think aerobics exercising helps relieve stress the most is 84% of the entire sampled responders. When asked why they chose the considered type of exercise, 64% of responders responded with "no special equipment or venue needed, resulting in easier accessibility and can exercise anytime". 72% of caregivers also responded that it is easier to learn and time efficient. When asked if they exercised regularly before becoming a caregiver for people with AD, 70% responded with yes and 30% responded with no. Lastly, when asked the question if they think regular exercise practices helps with resilience in becoming a caregiver for people with AD, 89% responded with "yes", and 11% responded with "no".

Induced from the survey, the majority believes that regular exercise practices can enhance their capacity to manage stress related to their caregiving responsibilities. Shown through a large proportion of caregivers engaged in exercising, primarily jogging,which they find effective for stress relief. The choice of exercise is influenced by its accessibility, ease and level of learning, and minimal equipment and monetary requirements. The detected challenges that induce stress for caregivers are the communication and self-care difficulties when they have to balance their personal life with the life of the people with AD that they are taking care for (Han, 2019). Exercising is shown to be a prominent form of self-care, allowing caregivers to maintain a healthy physical life but also a mental life when approaching and balancing the stress refracted from caregiving. Exercises prove to be a coping mechanism for most caregivers, allowing them to have time for themselves in an effective and easier way, reducing stress and prominent mental health issues such anxiety and depression. Most replied with exercising allowing them to have time to reflect upon their lives, switching from a negative perspective to a more positive scope, finding the joys of caregiving and why they became caregivers in the first place For example, "caregiver 99" replied before exercising they thought about the difficulty in communication and after exercising they had satisfaction in helping others. .

Discussion

The majority of caregivers who responded to this survey are males (61%) and relatively young, with the largest age group being 25-30 years old (42%). This demographic distribution reflects the overall trend of societal and familial relationships across the globe where younger family members, possibly children or siblings, take on caregiving roles for possibly their parents or grandparents who developed AD. The survey reveals a high level of commitment, with most caregivers spending between 1 to 5 hours daily in caregiving tasks. As expected, the emotional implications and situation of caregivers is extremely high and significant, as indicated by the high average stress level of 4.01 on a 5-point scale. Challenges that have induced these mental stress, occurred when managing incontinence and communication difficulties to dealing with the people with AD's non-compliance and memory issues.

These difficulties show the demands on caregivers for constant representation of vigilance, patience, and adaptability. Despite these emotional turmoils, caregivers also detected joy in what they performed, showing moments of clarity and recognition from the patient, child-like innocence, and the overall emotional fulfilment of helping someone in need are highlighted by responders (McCoy & Raver, 2011). Furthermore, the survey explores the overall role of exercise in managing caregiver stress and the negative correlation with exercise and caregiver stress. A significant portion of respondents engage in

regular physical activity, with jogging being the most popular form of exercise, anaerobic exercise, due to the easy integration into daily routines and minimal requirement for equipment. The majority of caregivers believe that regular exercising improves their resilience and ability to cope with the stress associated with their caregiving duties. This finding is consistent with research suggesting that physical activity can reduce symptoms of depression and anxiety (Cadore, 2013). Exploring this correlation more, physical activity is widely recognized as a beneficial strategy for managing stress and improving mental health, with numerous studies supporting its overall effect. According to the National Institutes of Health (NIH), regular exercise can significantly decrease symptoms of depression and anxiety (Craft & Perna, 2004). The mechanism behind this benefit also applies to other correlational variables such as exercising; this promotes the release of endorphins, which are known to be natural mood lifters and also helps regulate the body's stress hormones, such as adrenaline and cortisol.

Physical activity also has the ability to serve as a distraction, allowing individuals, caregivers, to find respite from negative thoughts or stressors (Mahindru, 2023). Exercise has also been shown to improve sleep, which can be negatively impacted by stress, anxiety, and depressive states (Craft & Perna, 2004). Better sleep schedules increase the overall mood and energy levels, contributing to mental health stabilities and can improve the performance of caregivers when they take care of people with AD. For AD caregivers, who often experience extremely high levels of chronic stress and emotional strain, incorporating exercise into their routine can be particularly beneficial as seen with the gathered data. Caregivers usually who engage in regular physical activity reported better emotional well-being and reduced feelings of burden compared to those who do not exercise (Doyle, 2020). Furthermore, specific forms of exercise, such as aerobic activities (including jogging as the main choice caregivers go to shown in the conducted survey), have been shown to benefit their cardiovascular systems, which is known to be directly linked to improving brain health. This could also be relevant for caregivers, who need to maintain optimal health to manage their duties effectively. Overall, the study reports that caregivers are aware of the benefits of exercising as well, as most answered that it helps release endorphins and helps reduce stress to have time for themselves.

Amongst the participants, there was a differentiation in stress relief depending on the type of exercise performed. Aerobic exercises, known for enhancing cardiovascular health, also appeared to improve emotional well-being more significantly than anaerobic exercises. Resistance training participants highlighted improvements in physical strength and endurance, which indirectly contributed to better stress management by enhancing overall health resilience (Strickland & Smith, 2014). Dance, as a form of exercise, stood out for its social and emotional benefits. Participants reported not only physical relief but also a significant enhancement in social interaction, which is crucial for mental health (King, 2002). This social component of dance may explain its unique position in reducing caregiver stress through increased emotional support and community feeling (Champagne, 2023).

Conclusion

The survey results suggest that different types of physical activities— aerobic, anaerobic, resistance exercises, and dance—have different impacts on stress levels among caregivers for individuals with AD. Aerobic exercises seem to offer the most significant reduction in stress, likely due to their impact on both physical health and emotional well-being through endorphin release and improved cardiovascular function. Resistance exercises, while beneficial physically, may not offer the same level of stress relief as aerobic activities but still contribute positively to overall health. Dance exercises provide a unique combination of physical activity and social interaction, which can be especially beneficial for emotional relief and stress reduction. These findings support the hypothesis that while all exercise types are beneficial, the context of the exercise—such as the social interaction involved in dancing—can enhance the stress-reducing effects. Given these results, caregivers can be advised to incorporate a combination of exercise types into their routines, prioritising those that offer both physical and emotional benefits. This approach can be crucial in managing the high stress levels associated with caregiving for individuals with AD, potentially leading to better overall health outcomes for caregivers and improved care quality for recipients.

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Cognitive Behavioral Art Therapy in Treating Adolescent Generalized Anxiety Disorder: A Narrative Review

By Yuan Tao

Author Biography

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Abstract

As Generalized Anxiety Disorder (GAD) continues to become a prevalent psychological disorder that creates profound impacts on adolescents, concerns regarding substantial variances in cognitive development between adults and adolescents have been raised. Due to such differences, current research suggests that the effectiveness of current GAD treatments has been less effective for adolescents. Thus, new therapeutic methods are emerging. This narrative review addresses and synthesizes existing theoretical frameworks and research for one newly developed therapeutic method - Cognitive Behavioral Art Therapy (CBAT). This narrative review is conducted through search engines and databases of Google Scholar, JSTOR, and ProQuest. Results indicated that CBAT holds high theoretical potential and although active researchers in this field have only conducted 3 clinical trials, all trials demonstrated positive results in addressing adolescent GAD. This paper further discusses the theoretical analysis, implementation, and limitations of CBAT. Overall, although CBAT is potentially highly beneficial to adolescent GAD, research done on this therapeutic method is still very limited, and future studies and clinical trials should be done to further explore its effectiveness on adolescent GAD.

Keywords: Cognitive Science, Psychology, Art Therapy, Cognitive Behavioral Art Therapy, Cognitive Behavioral Therapy, Therapy, Generalized Anxiety Disorder, Anxiety

Introduction

Within the rapid pace of modern life, anxiety has become an increasingly prevalent problem. While anxiety is a normal stress reaction and is something that everyone experiences, anxiety that involves excessive fear or anxiety to an extent that affects one's daily activities and differs far from normal feelings of nervousness or anxiousness then becomes a disorder. Globally, in 2019, over 301 million people were living with some form of anxiety disorder, including 58 million children and adolescents (Klaudia et al., 2023). Recent global events have only contributed to the rise of anxiety (Mental Disorders, n.d.). The COVID-19 pandemic doubled the prevalence of anxiety and depression, with rates being the highest in older and female-identifying adolescents (Racine et al., 2021). Emphasis on adolescent anxiety becomes a necessity.

Anxiety disorders can be classified into four types, Generalized Anxiety Disorder, Panic Disorder, Social Anxiety Disorder, and Phobia-related Disorders (Anxiety Disorders - National Institute of Mental Health (NIMH), 2023). Each type differs from one another and influences individuals afflicted with an anxiety disorder differently. For the purpose of this paper, only Generalized Anxiety Disorder (GAD) is discussed as it is the most common of the four types (Anxiety Disorders, 2023).

Generalized anxiety disorder is a mental health disorder that produces excessive fear, worry, and a constant feeling of being overwhelmed (Griffin, 1990). Major symptoms and criteria for the diagnosis of Generalized Anxiety Disorder are characterized by DSM IV and DSM V:

Table 1. *DSM-IV to DSM-5 Generalized Anxiety Disorder Comparison*

(Substance Abuse and Mental Health Services Administration, 2016)

DSM-IV	DSM-V
Disorder Class: Anxiety Disorders	SAME
A. Excessive anxiety and worry (apprehensive expectation), occurring more days than not for at least 6 months, about a number of events or activities (such as work or school performance).	SAME
B. The person finds it difficult to control the worry.	SAME
C. The anxiety and worry are associated with three or more of the following six symptoms (with at least some symptoms present for more days than not for the past 6 months): Restlessness or feeling keyed up or on edge, Being easily fatigued, Difficulty concentrating or mind going blank, Irritability, Muscle tension, Sleep disturbance (difficulty falling or staying asleep, or restless unsatisfying sleep).	SAME
D. The focus of the anxiety and worry is not confined to features of an Axis I disorder (e.g., the anxiety or worry is not about having a panic attack [as in panic disorder], being embarrassed in public [as in social phobia], being contaminated [as in obsessive-compulsive disorder] being away from home or close relatives [as in separation anxiety disorder], gaining weight [as in anorexia Nervosa], or having a serious illness [as in hypochondriasis]), and the anxiety and worry do not occur exclusively during posttraumatic stress disorder.	F. The disturbance is not better explained by another mental disorder (e.g., anxiety or worry about having panic attacks in panic disorder, negative evaluation in social anxiety disorder [social phobia], contamination or other obsessions in obsessive-compulsive disorder, separation from attachment figures in separation anxiety disorder, reminders of traumatic events in posttraumatic stress disorder, gaining weight in anorexia nervosa, physical complaints in somatic symptom disorder, perceived appearance flaws in body dysmorphic disorder, having a serious illness in illness anxiety disorder, or the content of delusional beliefs in schizophrenia or delusional disorder).
E. The anxiety, worry, or physical symptoms cause clinically significant distress or impairment in social, occupational, or other important areas of functioning.	SAME (Part D)
F. The disturbance is not due to the direct physiological effects of a substance (e.g., a drug of abuse, a medication) or a general medical condition (e.g., hyperthyroidism) and does not occur exclusively during a mood disorder, a psychotic disorder, or a pervasive developmental disorder.	E. The disturbance is not attributable to the physiological effects of a substance (e.g., a drug of abuse, a medication) or another medical condition (e.g., hyperthyroidism).

Although GAD is clearly defined and characterized by the DSM-IV and DSM-V, many studies have shown there are substantial differences between the way adolescents and adults experience GAD. During adolescence, emotional control is subdued, fear conditioning is underdeveloped, and reward and stress response systems are heightened thus exacerbating the symptoms of GAD. (Xie et al., 2021). Moreover, there are shifts in the functional connections between brain regions, particularly involving the striatum, amygdala, and prefrontal cortex for adolescents (Xie et al., 2021) As these are all key regions involved in the processing of emotional stimuli and the regulation of emotional responses, the lack of connectivity between these regions may contribute to excessive anxiety and development of GAD (Qi et al., 2023). As adolescent brains are actively developing, both cognitively and physically, current treatment plans must consider the level of neurological development and the life stage for which the treatment has been designed (Girolamo et al., 2011).

Previously completed psychological and clinical trials have indicated that other than psychopharmacologic treatments like Selective Serotonin Reuptake Inhibitors (SSRIs) or Selective Serotonin-Norepinephrine Reuptake Inhibitors (SSNRIs), Cognitive Behavioral Therapy (CBT) as the most effective psychotherapy method used to treat both adult and adolescent GAD (Wehry et al., 2015).

However, due to the differences in adult and adolescent brains, the effectiveness of therapeutic methods is significantly different. The overall relapse rate for psychiatric treatments and psychological interventions for adults with GAD fluctuates between 14% and 58% (Bruin et al., 2022), while the adolescent relapse rate ranges from 39% to 72% (Robberegt et al., 2023). When specifically considering CBT for the treatment of adult GAD, remission rates are 48% (Levy et al., 2021). For adolescents, CBT only allowed about 22% of youth to achieve stable remission, even when combined with pharmaceutical treatments (Ginsburg et al., 2018).

Possible reasons for Cognitive Behavioural Therapy (CBT) not being as effective for adolescents lie within its fundamental principles. CBT is a psychotherapy approach that has been widely used to treat GAD and is based on the concept that one's thoughts, feelings, physical sensations, and actions are interconnected (Kaczkurkin & Foa, 2015). CBT underscores the notion that negative thoughts and feelings can trap you in a negative cycle (Halder & Mahato, 2019). Thus, it could easily be influenced by factors within one's living and social environment. Specifically, CBT is less applicable to adolescents due to limitations that include but are not limited to familial and cultural factors, acceptance and stigma, and assessment and dysfunctional cognitions. Familial, and cultural influences significantly affect how therapy is tailored for children and adolescents (Karver et al., 2006). Parents' attitudes and beliefs could affect their recognition of the need for psychotherapeutic treatment, often relying on teacher referrals (Baker-Ericzén et al., 2013). Despite an increase in mental health awareness, parents often deny their child's mental health condition, impacting therapy outcomes (Villatoro et al., 2018). Similarly, therapeutic goals might diverge between parents and children, especially with adolescents when children are beginning to seek more independence. Adolescents may hold conflicting emotions with parents and perceive situations differently (Moretti & Peled, 2004). Additionally, identifying and addressing dysfunctional cognitions, a core element of CBT, can be significantly more challenging for adolescents than adults due to communication barriers as the brain is underdeveloped. Furthermore, distinguishing thoughts, emotions, and behaviors can be difficult, and thus the guided discovery process might not always yield lasting insights (Halder & Mahato, 2019).

The discrepancy between adults and adolescents undergoing CBT for the treatment of GAD has created the need for new therapies to be developed. One such therapy is Cognitive Behavioral Art Therapy (CBAT) - a newly developed therapeutic technique that is gaining more attention from researchers and practitioners due to its potential to treat GAD (M. L. Rosal, 2015). The merge of cognitive-behavioral principles with artistic expression in CBAT introduces a transformative intersectionality of treatments that goes beyond traditional therapeutic boundaries (Rubin, n.d.). This integrative approach becomes especially relevant in the context of adolescent cognitive development, where the exploration of emotions can be intricate and demanding.

The ultimate objective of this narrative review is to synthesize existing research regarding Cognitive Behavioral Art Therapy (CBAT) as a treatment option

for treating youth GAD to understand current opinions and to quantify and determine the possibility of future implementation.

Methodology

This narrative review was conducted using Google Scholar, JSTOR, and ProQuest search engines. English sources found on the above platforms were considered. The narrative review also reviewed three sources in Mandarin that were found through CNKI. Other search engines were not considered in this narrative review due to a lack of access. Search strings that were used include keywords like Cognitive Behavioral Art Therapy, Art Therapy, Cognitive Behavioral Therapy, Generalized Anxiety Disorder, and Adolescent and combinations between the words. Acronyms for the listed words were also used during the research process, including CBAT, CBT, and GAD.

The selection process of this narrative review is focused primarily on Cognitive Behavioral Art Therapy in treating Generalized Anxiety Disorder, thus sources that discuss only Cognitive Behavioral Therapy or Art Therapy were excluded from the review process. Any article that explicitly discussed CBAT was included in this review. Understandings of both Art Therapy and Cognitive Behavioral Therapy are used when explaining the fundamentals and concepts of Cognitive Behavioral Art Therapy. As such, sources that simultaneously address the possibility and theoretical framework of both therapeutic methods combined were kept despite not using the term "Cognitive Behavioral Art Therapy". For the purpose of this review, CBT and art therapy used in tandem is equivalent to CBAT. Furthermore, this review focuses only on youth Generalized Anxiety Disorder and no other form of mental illness. Thus, only results that are related to the effectiveness of treatments in treating adolescent GAD were kept.

Conceptualization and Literary Review sections specifically regarding CBAT were taken from the papers reviewed. Most sections discussed the theoretical possibility for adoption or the differences between CBAT and CBT. For studies that included clinical trials, information regarding patient information, sample size, remission rate, and other relevant information useful in evaluating the effectiveness of CBAT was taken.

Results

When conducting searches in Google Scholar, "Cognitive Behavioral Art Therapy" yielded 1,380,000 results, "Generalized Anxiety Disorder" yielded 2,610,000 results, "Cognitive Behavioral Therapy" yielded 3,780,000 results, "Cognitive Behavioral Therapy+Art" yielded 1,280,000 results, "Cognitive Behavioral Therapy+ Art+Adolescents" yielded 375,000 results, "Cognitive Behavioral Therapy+Art+Adolescents+Anxiety" yielded 220,000 results, and "Cognitive Behavioral Therapy+Art+Adolescents+Generalized Anxiety Disorder" yielded 20,900 results. Corresponding searches using acronyms did not yield more relevant results. Relevant sources were reviewed and 25 results were kept and used from all the results yielded in Google Scholar. Using the same search string, 1 source was taken from JSTOR, 4 sources were taken from ProQuest, and 2 sources were taken from CNKI (search conducted in Mandarin). The above concludes all sources used to discuss CBAT and the search process.

Most studies found during the search process were theoretical analyses or discussions of the potential synthesis of CBT and Art Therapy. Only three sources in this study were found to have clinically applied CBAT to adolescents and have experimented with GAD.

The three clinical trials were performed by Rosal (Rosal, 2001), Wang and Zhang (Wang & Zhang, 2023), and Morris (Morris, 2014). All three studies are conducted in English and Western countries under the influence of Western culture. Morris and Rosal's studies are highly interconnected as Rosal provided support and advice throughout Morris' research process. Both conducted research that was case study specific – where they only performed CBAT on adolescents with GAD that they considered suitable for this treatment option. Although Wang's research investigated a group of 66 adolescent patients, his study was conducted with the patients having anorexia and with some that have GAD. However, his study measured the Beck Anxiety Inventory (BAI), which is commonly used to measure the overall conditions of GAD patients, for all patients within the study so this study was included. All three clinical trials showed success to a certain extent in alleviating anxiety disorder and in lowering remission rates.

Discussion

Theoretical analysis

Art therapy was first integrated into CBT through the Marchand et al (2007) brief CBT model in an attempt to address its critique that CBT is too verbal and abstract (Morris, 2014). Throughout time, there has been a progressive development for CBAT. The foundation of CBT and CBAT begins with the onset of behaviorism or what is now regarded as the first wave of CBT. The second wave of CBT and CBAT started when there was an emergence of cognitive science and the subsequent integration of it into behaviorism. The third wave of CBT and CBAT approaches has tried to fully integrate art therapy within more so than the first two evolutions of CBT and CBAT and is the current stage of exploration (Rosal, 2018).

CBAT is a problem-focused and practical approach to art therapy (Rosal, 2001). Art-making involves numerous cognitive skills that are targeted and expanded through CBAT. CBAT therapists use the intrinsic cognitive properties of artmaking and imagery in treatment and apply CBT principles to uncover problematic cognitive processes that interfere with positive adaptation and develop art-making strategies to challenge these cognitions and form new perspectives and behaviors. Specifically, CBT and CBAT share common elements as being flexible in strategies to enhance treatment; being understanding of differences in cognition, including inner speech and mental imagery; and promoting pragmatic solutions to aid individuals under stress and offer an efficient means to relieve and cope with it (Rosal, 2018).

Based on these characteristics, CBAT offers several characteristics that prove highly beneficial to adolescents, including but not limited to, points such as acceptance and externalization that allow the mental problem to be visualized on paper and liberate the client from the belief that the issue is fixed and inherent. This visual externalization makes it easier and safer for patients to explore, as well as to expand and reframe problems to help break patients' fixed perspectives on issues (Wang, 2023). While the method is similar to CBT, this alteration is more effectively achieved through art therapy. The intervention helps teenagers uncover the positive aspects of their art skills and be able to reimagine their applications (Morris, 2014). Furthermore, studies demonstrate that CBAT offers a solution superior to verbal communication in helping adolescents gain clarity about their concerns amidst mental chaos (Griffin, 2014). The role of art in children's development and problem-solving suggests that image-making assists children in comprehending the world and is reflected through the complexity of their art (Yu & Nagai, 2020).

Implementation

In implementing CBAT, psychologists should have experience with both CBT and art therapy in order to be able to provide comprehensive CBAT treatments. The current standard CBAT treatment plan involves over 10 sessions, each lasting 60-70 minutes, with painting and collage as the predominant art forms (Liao, 2023). Since it is a fairly flexible approach, full treatment details always vary by patient (Kendall et al., 2008).

CBAT may help patients with skills such as: understanding and reconstructing thoughts and ideas, understanding feelings and emotions, altering self-schema, using mental imaging, and applying problem-solving skills (Blackwell, 2021). CBAT employs CBT as a theoretical framework and utilizes art as an intervention tool. Usually, therapists engage patients in discussions about the physical, cognitive, and behavioral components of their GAD. Patients were often instructed to use collage materials to create mind maps triggering anxiety attacks. The therapist then explored anxiety elements within these collages, prompting patients to recognize their panic, perceive themselves in space or surrounded by related imageries, and express abstract anxiety perceptions through art forms (Rosal, 2016).

Therapists also help patients with cognitive reconstruction. Cognitive restructuring involves identifying, challenging, and modifying irrational automatic thinking to shift rigid patterns and reduce negative emotions and problematic behaviors stemming from distorted perceptions. Therapists discuss negative thoughts related to social anxiety with patients and instruct them to create an "unlikely cognition" diagram. The therapist then assigns homework to create an artwork depicting a "likely perception." The resulting artworks were analyzed by psychiatrists and often are used to help gain a better self-perception and escape their habitual mindset (Rosal, 2018).

Therapists also try to use systematic desensitization and exposure to imagery to allow patients to face fears and allow gradual anxiety reduction through repeated exposure and relaxation. Therapists guide patients through desensitization exercises using art to simulate and visualize the anxiety they experience. Patients engaged in activities such as mandala coloring and abdominal breathing relaxation exercises. The resulting artwork served as a reminder of the process and understanding of the positive physiological changes that these exercises bring to them. Image exposure, another desensitization technique using artwork to bring imagined aversive images to life, is also employed in CBAT. After trials of systematic desensitization with both methods, patients are categorized by fear level and complete artwork depicting their fears allowing therapists to determine the appropriate future treatments (Rosal, 2015).

One case study has proven the effectiveness of CBAT intervention over GAD. In the initial sessions, the subject engaged in psychoeducation about GAD, using art to visually represent her anxiety cycle. Through the sessions, she participated in all three methods, where she created images of her support systems and coping skills, breathing retraining exercises, and cognitive restructuring tasks. Imaginal exposure was introduced to address her feared activities and situations, allowing her to confront and re-evaluate her anxieties through art. Her progress was visually documented in desensitization drawings, providing records of her achievements and challenges faced throughout the therapy session (Morris, 2014). The impacts of intervention have then culminated in a relapse prevention session, where she reviewed her artwork, acknowledging a positive shift in her mindset and coping strategies. Overall, Aurelia found that the integration of art into the therapeutic process helped her symbolize and cope with her anxieties, bringing a positive outlook on challenging situations (Morris, 2014).

Similarly, a study was conducted with 66 adolescent patients in a statistical analysis, with 31 patients in the control group and 35 patients in the treatment group. Although patients did not all have GAD, they were diagnosed with anorexia, and most all had symptoms of GAD. After the intervention through CBAT and CBMT (cognitive behavior music therapy), their cognitive and behavioral ability, emotional reaction, and treatment satisfaction changes were compared and analyzed in the two groups. After the intervention, Beck Anxiety Inventory (BAI scores were significantly lower than they were before the intervention, and the scores in the treatment group were significantly lower than they were in the control group ($P < 0.05$) (Wang C; Xiao R, 2021).
CBAT has the possibility of guiding patients through image and problem analysis, answering questions through art, with key processes encompassing creating images of stressors, preparing for stressors, step-by-step problem management, and imagery for stress reduction.

Further Experimental Studies

This review found only 3 sources reporting clinical trial results. With a small sample size, it is important to acknowledge the potential restrictions in generalizations to adolescents across the board. Factors of culture, individual conditions, and art abilities might have played a role in the outcome of the 3 clinical studies (Alemi et al., 2009). All three studies are conducted in Western countries and through the English Language. Although CBAT is highly reliant on art as an expressive form, the involvement of CBT includes cultural and linguistic concerns regarding the final outcome. Previous studies have pointed out that the conceptualization and measurement of culturally responsive interventions, client-therapist language, and ethnicity match are important variables affecting the utilization of all kinds of therapy (Sue et al., 2009). Thus, with all studies being conducted within the same culture and language background, the generalization of these results might have been limited.

Furthermore, all three clinical trials failed to provide participant demographics. No specification was done in the study conducted by Rosal and Wang (YEAR). All participants were generalized as adolescents with GAD and adolescents with anorexia and GAD. Only Morris specifically addressed her subject being a 19-year-old white female diagnosed with GAD and also meeting partial criteria for Attention Deficit Hyperactivity Disorder (ADHD).

As two out of the three studies were conducted based on single-participant case studies, it is important to acknowledge the differences that individuals exhibit and how they might have affected the outcome of CBAT. As all individuals have different

levels of comfort with art, outcomes of CBAT may vary significantly. The individualized nature of the art-making process introduces variability in the impact of specific components on participants. The preferences and responses to different art modalities may contribute to variations in outcomes (Van Lith, 2016). Specifically, in single-subject cases, understanding whether improvements are solely attributable to the art-based elements or a combination of factors is another methodological challenge.

Conclusion

This narrative review offered a synthesis of existing theoretical frameworks and research on Cognitive Behavioral Art Therapy (CBAT) to suggest its potential to address the rising Generalized Anxiety Disorder (GAD) in adolescents using databases including Google Scholar, JSTOR, and ProQuest. Results indicated that CBAT holds high theoretical potential and although active researchers in this field have only conducted 3 clinical trials, all trials demonstrated positive results in addressing adolescent GAD. CBAT capitalizes on the inherent cognitive benefits of artmaking, offering a tangible and creative outlet for adolescents to explore and challenge negative thoughts and emotions.

Based on positive outcomes, current research suggests implementation to have at least 10 sessions, each lasting 60-70 minutes, with painting and collage as the predominant art forms. Overall content should also involve a combination of CBT techniques and art therapy modalities, which better suit one's individual needs and preferences. Specifically, techniques such as cognitive reconstruction, image exposure, and systematic desensitization.

Despite the promising findings, this narrative review acknowledges several limitations, including the lack of clinical trials and the lack of diversity in data sources. Future research should aim to address these limitations by conducting rigorous trials with larger and more diverse samples and exploring optimal treatment protocols and session formats.

In all, as CBAT continues to gain prominence, it represents an improvement and adaptation in mental health interventions (Rosal, 2018). Although necessary research is needed to push it forward, the nature of artistic expression within CBAT allows adolescents to communicate and explore their emotions and is extremely insightful in providing therapists with what may remain obscured through traditional verbal communication. This dynamic fusion of cognitive-behavioral and artistic modalities not only acknowledges the developmental nuances of adolescence but also positions CBAT as a transformative and integrative therapeutic tool.

Limitations

The results of the narrative review were limited by search engine access and restrictions to academic and medical journals. As such, this review may not include all available clinical trials and experimental studies. Future recommendations are to repeat this review after access to such resources becomes available to gain a more holistic understanding of CBAT in treating adolescent GAD.

Future narratives or literature reviews should focus not just on understanding the possibility of synthesizing the two therapeutic methods but also on performing trials to test for the effectiveness of CBAT on adolescent GAD. Furthermore, those experiments could have examined the most suitable number of sessions and topics within each session to aid overall implementation in the future.

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Ornithological Identification from Images Using Convolutional Neural Networks

By Jialin Wang

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Abstract

As society works towards solutions to address environmental concerns, a crucial task emerges: the conservation of species, including avian species, through precise identification and monitoring. This paper shows that it is necessary to develop a quick and efficient way to identify birds in pictures. This project aims to improve the efficiency of bird identification by using a convolutional network to identify 10 distinct species of birds based on their visual representations. The results of the model are good: eventually, the model achieved decent performance indicators, including an accuracy of 0.75, macro average precision of 0.76, and macro average recall of 0.75. These metrics reflect the model's ability to not only correctly identify birds but also minimize false identifications. Notably, this model demonstrates remarkable performance in classification of common birds such as the American Crow and the California Gull. Moreover, it can also distinguish some nuances between distinct species of birds and distinguish the bird from the background environment.

Keywords: Computer Science, Machine Learning, Neural Network, Convolutional Neural Network, Image Classification, Image Identification, Bird, Birding, Ornithology

Introduction

During the long journey of species evolution, birds have played a significant role in ecosystems throughout the world. They can also be a significant indicator of habitat health and species richness (Niemi, Hanowski, Lima, Nicholls, & Weilland, 1997). Understanding the differences between different bird species also allows biologists to understand the evolutionary process and the mysteries of life. Ornithology, the study of birds, is popular among many people, partly because non-professionals can also play a significant role, such as observing, recording, and identifying birds (Encyclopedia Britannica, Inc., 2018; Storer, Gill, & Rand, 2018). Anthropogenic factors, including pollution, diseases, and climate change, are posing a threat to many types of birds, such as endangered birds of prey (Azzarello & Van Vleet, 1987; Crick, 2004; Tella, 2001).

As concerns for environmental conservation grow, it is increasingly necessary to identify species for environmental conservation purposes. Identification of birds has been a problem for ornithologists, birders, biologists, and environmentalists alike. The main challenge of bird identification is the sheer variety of bird taxonomy and the nuanced differences between species. This presents a formidable challenge for many, which can be solved with various machine learning algorithms, including convolutional neural networks, a type of algorithm that excels in extracting features from images and classifying them into categories, which will be the focus of this paper. In recent years, machine learning has emerged as a new technique for various tasks, including image classification. This research will attempt to solve a bird identification problem based on images using machine learning techniques.

Previous research on this topic has used machine learning. For example, one previous research by Allison M. Horst, Alison Presmanes Hill, and Kristen B. Gorman aimed to classify three different penguin species based on data collected from Palmer Archipelago islands. However, the classes were limited to Gentoo, Chinstrap, and Adelie penguins. The dataset was textual instead of image. (Horst, Hill & Gorman, 2022).

This research project is an attempt to improve upon previous research. There are 10 different bird species the model will classify.

1. American crow (Corvus brachyrhynchos)

A highly intelligent and social bird found in most parts of the US that feeds on a variety of food sources, from berries to little birds. They often work together for food and are active in many rural and urban areas (Montgomery, 2023).

Figure 1. *American Crow*

Note. Mr.TinMD. (2011). American Crow Closeup [Photograph]. Flickr. https://www.flickr.com/photos/mr_t_in_dc/5518400133 Licensed under CC BY-ND 2.0 DEED

2. Blue Jay (Cyanocitta cristata)

This species is found to the east of the Rockies, with a perky crest and blue plumage. They often feed on nuts and insects, and often harvest acorns and hoard them in the ground (National Audubon Society, 2023).

Figure 2. *Blue Jay*

Note. Jacqui Trump. (2009). Blue Jay in Snow [Photograph]. Flickr. https://www.flickr.com/photos/shannonlite/4182330198. Licensed under CC BY-NC 2.0 DEED

3. Vermillion flycatcher (Pyrocephalus rubinus)

As its name suggests, this is a subtype of the tyrant flycatchers in which males typically show a bright red color. They feed on insects by catching them while in flight in a behavior known as flycatching (National Audubon Society, 2023).

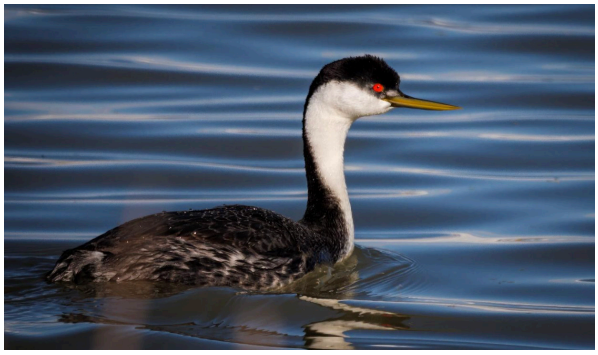
Figure 3. *Vermilion Flycatcher*

Note. Mick Thompson. (2016). Vermilion Flycatcher [Photograph]. Flickr. https://www.flickr.com/photos/mickthompson/26149270104/in/photostream/. Licensed under CC BY-NC 2.0 DEED

4. Western Grebe (Aechmophorus occidentalis)

A type of waterfowl that is found in western US and Mexico. It is signified by its red eyes, red beak, and is well known for its unique mating dance in which the male and female "run across" the surface of the water (Cornell Lab of Ornithology, 2023).

Figure 4. Western Grebe



Note. Charles Peterson. (2023). Western Grebe [Photograph]. Flickr. https://www.flickr.com/photos/petechar/52904315530/. Licensed under CC BY-NC-ND 2.0 DEED

5. Yellow Warbler (Setophaga petechia)

A subtype of the wood warbler family, the yellow warbler is signified by its mostly yellow plumage, with a few stripes of chestnut color on the breast for males and overall yellow for females (Cornell Lab of Ornithology, 2023).

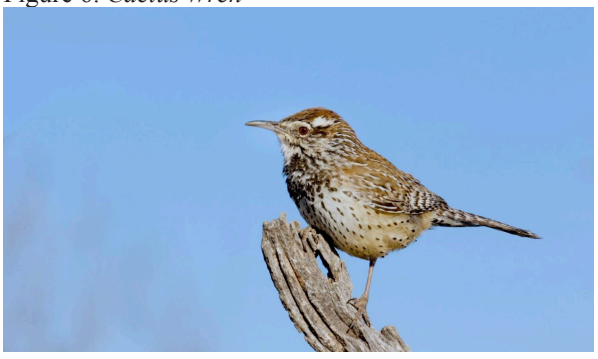
Figure 5. *Yellow Warbler*

Note. Keith Williams. (2016). Yellow Warbler in the Willows [Photograph]. Flickr. https://www.flickr.com/photos/keithmwilliams/28440856005. Licensed under CC BY-NC 2.0 DEED

6. Cactus wren (Campylorhynchus brunneicapillus)

A type of wren found in North American desert environments, from southwestern US to Mexico, signified by deep brown spots throughout its body. Its population is facing a decline due to rapid urbanization destroying its habitat (Cornell Lab of Ornithology, 2023).

Figure 6. *Cactus Wren*



Note. Gregory Smith. (2024). Cactus Wren (Campylorhynchus brunneicapillus) [Photograph]. Flickr. https://www.flickr.com/photos/slobirdr/53437130920. Licensed under CC BY-SA 2.0 DEED

7. Indigo Bunting (Passerina cyanea)

A type of songbird found throughout eastern North America. Breeding males are signified by a bright blue color and females are signified by a brownish color. It is worth noting that non-breeding males have a blue and brown plumage. For identification purposes, the indigo buntings in this dataset are all breeding males (National Audubon Society, 2023).

Figure 7. *Indigo Bunting (Breeding Male)*

Note. Amy Evenstad. (2012). Indigo Bunting [Photograph]. Flickr. https://www.flickr.com/photos/magnificentfrigatebird/7212558410. Licensed under CC BY-NC-SA 2.0 DEED

8. Eastern Towhee (Pipilo erythrophthalmus)

An eastern songbird that is relative to spotted towhee found throughout the west. Males have black back, rufous sides, and white belly, while females have brown back, rufous sides and white belly (Cornell Lab of Ornithology, 2023).

Figure 8. Eastern Towhee

Note. Rodney Campbell. (2014). Eastern Towhee [Photograph]. Flickr. https://www.flickr.com/photos/acrylicartist/14067360876. Licensed under CC BY 2.0 DEED

9. California Gull (Larus californicus)

A type of seagull found through the western US and Mexico. Not to be confused with Herring gulls or Western gulls since they have yellow legs instead of pink and have dark eyes (National Audubon Society, 2023).

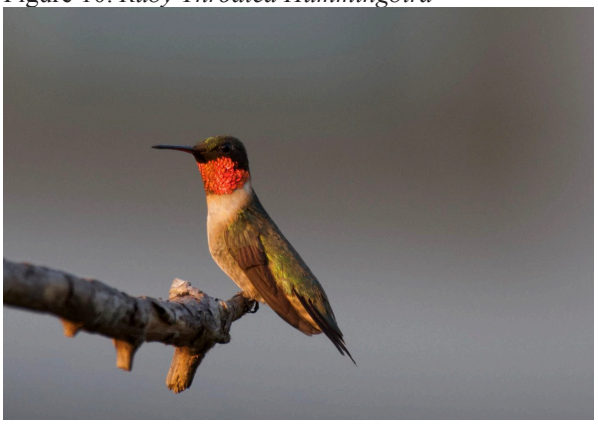
Figure 9. *California Gull*

Note. Mick Thompson. (2019). California Gull – Adult Nonbreeding [Photograph]. Flickr. https://www.flickr.com/photos/mickthompson/48782857673. Licensed under CC BY-NC 2.0 DEED

10. Ruby Throated Hummingbird (Archilochus colubris)

The only hummingbird species that is found east of the Great Plains. They are excellent flyers and can flap their wings more than 50 times per second (National Audubon Society, 2023).

Figure 10. *Ruby Throated Hummingbird*



Note. Kevin Milazzo. (2021). Ruby-throated Hummingbird at Sunset (Archilochus colubris) [Photograph]. Flickr. https://www.flickr.com/photos/milazzoyo/51473533011. Licensed under CC BY-NC-SA 2.0 DEED

Method

Data Source

The source of the data used in this project is Caltech-UCSD birds 200, which contains images of 11788 images of 200 common bird species in North America taken in 2011 (Caltech, 2011).

Data Preprocessing

For the sake of simplicity, we decided to limit the classification categories to 10 instead of 200. Each bird category consists of 60 different images. To increase the size of the dataset, we augmented the number of images in each category to 120 by flipping each image sideways. This is because the original data sample is too small to perform adequately, and the new data sample had a significant improvement. However, we realized that there is still room for improvement for data diversity. As a result, we further augmented the number of images in each category to 240 by flipping each image upside down, which improved the performance even more. The training and test dataset are split with the ratio of 80:20 ratio, respectively. The random state is set to an arbitrary seed 100 to ensure that the train set and test set are consistently split. The training set is used to train the data, and the test set is used to evaluate the same model's accuracy in another random sample.

Models Used

This project utilizes Convolutional Neural Network. Convolutional Neural Networks are a type of computational algorithm that has a similar structure to interconnected human neurons. The neural network consists of multiple layers, each layer filled with a certain number of nodes. Each node has a unique activation function and parameter associated with it. The neural network algorithm aims to find the optimal value of parameters that minimizes the loss function, which is a measure of error of the classification of the test set (A. Ilesanmi & T. Ilesanmi, 2021). Convolutional Neural networks consist of two types of layers: convolutional and dense, the former used to process 2d images, and the latter used to process 1d tensors after flattening (Mishra, 2020).

The Structure of the Model

The final version of the Convolutional Neural Network uses the Adam optimizer, the categorical cross entropy loss function, and consists of:

- One input layer
- One convolutional layer with the activation "ReLU"
- One 2d pooling layer
- One flattening layer
- Two Dense layers with ReLU as the activation function
- One output Dense layer with 10 nodes and softmax as the activation function

Results

Tables 1 to 8 below show the metrics of each version of the model using holdout validation. The eighth model performed the best. The metrics of each version improved from the previous one. The validation accuracy of the best-performing model (i.e. the eighth) was 75%. The macro average recall and the macro average F1-score was 75% as well, while the macro average precision was 76%.

Overall, the bird species that was the most accurately identified was #3(Western Grebe). This is likely because of its unique shape as a member of the order Podicipediformes. Bird #0(American Crow), #2(Vermilion Flycatcher), and #4(Yellow Warbler) also were well-identified, likely because of their distinctive color. Though the performance was impressive, the model was more mediocre in identifying birds #1(blue jay) and #7(eastern towhee). This is likely because of these species' mixed colors, causing the model to confuse them with similar-looking species, such as confusing blue jays with indigo buntings.

The first version of the model, i.e., Version 1, consists of 1 convolutional layer without applying an activation function. It also includes 1 flattening layer, and 1 output layer. Table 1 below shows the performance of version 1.

Table 1. Classification Report of Version 1

	Precision	Recall	F1-Score
American Crow	0.33	0.33	0.33
Blue Jay	0.23	0.31	0.26
Vermilion Flycatcher	0.95	0.95	0.95
Western Grebe	0.60	0.09	0.16
Yellow Warbler	0.50	0.32	0.39
Cactus Wren	0.12	0.50	0.19
Indigo Bunting	0.29	0.50	0.37
Eastern Towhee	0.00	0.00	0.00
California Gull	0.71	0.18	0.29
Ruby-Throated Hummingbird	0.57	0.38	0.46
Micro Average	0.33	0.33	0.33
Macro Average	0.43	0.36	0.34
Weighted Average	0.44	0.33	0.32
Samples Average	0.33	0.33	0.33

For version 2, an activation function of ReLU was added to the convolutional layer in the model. Table 2 below shows the performance of version 2.

Table 2. Classification Report of Model 2

	Precision	Recall	F1-Score
American Crow	0.74	0.83	0.78
Blue Jay	0.39	0.38	0.39
Vermilion Flycatcher	0.95	0.95	0.95
Western Grebe	0.67	0.69	0.68
Yellow Warbler	0.90	0.86	0.88
Cactus Wren	0.44	0.50	0.47
Indigo Bunting	0.56	0.62	0.59
Eastern Towhee	0.62	0.21	0.31
California Gull	0.51	0.64	0.57
Ruby-Throated Hummingbird	0.61	0.67	0.64
Micro Average	0.63	0.63	0.63
Macro Average	0.64	0.64	0.63
Weighted Average	0.63	0.63	0.62
Samples Average	0.63	0.63	0.63

For version 3, a dense layer with no activation function before the output layer was added. Table 3 below shows the performance of model version 3.

Table 3. Classification Report of Version 3

	Precision	Recall	F1-Score
American Crow	0.86	0.79	0.83
Blue Jay	0.53	0.34	0.42
Vermilion Flycatcher	1.00	1.00	1.00
Western Grebe	0.68	0.72	0.70
Yellow Warbler	0.95	0.82	0.88
Cactus Wren	0.26	0.31	0.20
Indigo Bunting	0.67	0.75	0.71
Eastern Towhee	0.48	0.42	0.44
California Gull	0.47	0.57	0.52
Ruby-Throated Hummingbird	0.60	0.71	0.65
Micro Average	0.64	0.64	0.64
Macro Average	0.65	0.64	0.64
Weighted Average	0.65	0.64	0.64
Samples Average	0.64	0.64	0.64

For version 4, another dense layer with leaky ReLU as the activation function was added. Table 4 below shows the performance of model version 4.

Table 4. Classification Report of Version 4

	Precision	Recall	F1-Score
American Crow	0.79	0.79	0.79
Blue Jay	0.67	0.34	0.45
Vermilion Flycatcher	0.87	1.00	0.93
Western Grebe	0.85	0.69	0.76
Yellow Warbler	1.00	0.77	0.87
Cactus Wren	0.56	0.62	0.59
Indigo Bunting	0.52	0.71	0.60
Eastern Towhee	0.61	0.46	0.52
California Gull	0.55	0.79	0.65
Ruby-Throated Hummingbird	0.69	0.86	0.77
Micro Average	0.69	0.69	0.69
Macro Average	0.71	0.70	0.69
Weighted Average	0.71	0.69	0.69
Samples Average	0.69	0.69	0.69

For version 5, another dense layer with leaky ReLU as the activation function was added to the model. Table 5 below shows the performance of model version 5.

Table 5. Classification Report of Version 5

	Precision	Recall	F1-Score
American Crow	0.78	0.75	0.77
Blue Jay	0.63	0.41	0.50
Vermilion Flycatcher	0.78	0.90	0.84
Western Grebe	0.85	0.88	0.86
Yellow Warbler	0.94	0.77	0.85
Cactus Wren	0.61	0.69	0.65
Indigo Bunting	0.58	0.75	0.65
Eastern Towhee	0.47	0.33	0.39
California Gull	0.61	0.79	0.69
Ruby-Throated Hummingbird	0.73	0.76	0.74
Micro Average	0.70	0.70	0.70
Macro Average	0.70	0.70	0.69
Weighted Average	0.70	0.70	0.69
Samples Average	0.70	0.70	0.70

Although version 5 was already achieving impressive performance, we realized that the data diversity in the original sample can still be improved. Thus, we augmented the data sample once more by flipping each image upside down, so each bird now has 240 images. Table 6 below shows the performance of model version 6.

Table 6. Classification Report of Version 6

	Precision	Recall	F1-Score
American Crow	0.77	0.85	0.81
Blue Jay	0.70	0.40	0.51
Vermilion Flycatcher	0.84	0.76	0.80
Western Grebe	0.77	0.85	0.81
Yellow Warbler	0.87	0.76	0.81
Cactus Wren	0.48	0.73	0.58
Indigo Bunting	0.59	0.80	0.68
Eastern Towhee	0.42	0.27	0.33
California Gull	0.45	0.60	0.51
Ruby-Throated Hummingbird	0.75	0.65	0.70
Micro Average	0.67	0.67	0.67
Macro Average	0.67	0.67	0.65
Weighted Average	0.68	0.67	0.66
Samples Average	0.67	0.67	0.67

After augmenting the image data once more, we realized that the performance fell a bit. To adjust for this change in version 7, we made a few adjustments to version 6, including adjusting the pooling layer's filter size and changing the first dense layer's activation function to ReLU. This improved the performance significantly. Table 7 below shows the performance of model version 7.

Table 7. Classification Report of Version 7

	Precision	Recall	F1-Score
American Crow	0.79	0.88	0.83
Blue Jay	0.66	0.56	0.61
Vermilion Flycatcher	0.91	0.74	0.82
Western Grebe	0.81	0.83	0.82
Yellow Warbler	0.88	0.83	0.86
Cactus Wren	0.46	0.79	0.58
Indigo Bunting	0.69	0.85	0.76
Eastern Towhee	0.65	0.49	0.56
California Gull	0.63	0.70	0.67
Ruby-Throated Hummingbird	0.82	0.60	0.69
Micro Average	0.73	0.73	0.73
Macro Average	0.73	0.73	0.72
Weighted Average	0.74	0.73	0.73
Samples Average	0.73	0.73	0.73

For version 8, the final and best performing version so far, we made some final adjustments to further improve the model's performance, such as adjusting the number of nodes and adding another dense layer with ReLU as the activation function. Table 8 below shows the performance of model version 8.

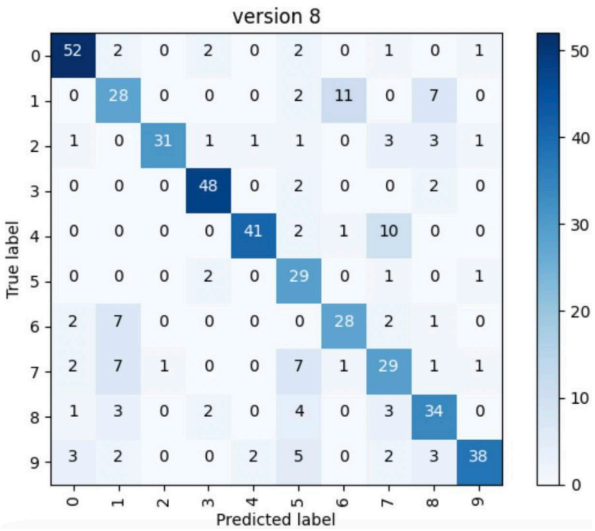
Table 8. Classification Report of Version 8

	Precision	Recall	F1-Score
American Crow	0.85	0.87	0.86
Blue Jay	0.57	0.58	0.58
Vermilion Flycatcher	0.97	0.74	0.84
Western Grebe	0.87	0.92	0.90
Yellow Warbler	0.93	0.76	0.84
Cactus Wren	0.54	0.88	0.67
Indigo Bunting	0.68	0.70	0.69
Eastern Towhee	0.57	0.59	0.58
California Gull	0.67	0.72	0.69
Ruby-Throated Hummingbird	0.90	0.69	0.78
Micro Average	0.75	0.75	0.75
Macro Average	0.76	0.75	0.75
Weighted Average	0.77	0.75	0.75
Samples Average	0.75	0.75	0.75

For version 8, the final and best performing version so far, we made some final adjustments to further improve the model's performance, such as adjusting the number of nodes and adding another dense layer with ReLU as the activation function. Table 8 below shows the performance of model version 8.

Another way to visualize the performance of the models is through a confusion matrix, with the grids symbolizing the true label and predicted label of an image. The ideal performance would align on the diagonal from the top-left corner to the bottom-right corner, symbolizing that the true labels and the predicted labels match each other. The confusion matrix below represents the model with the best performance, which is version 8. As shown in Figure 11 below, the model had a great performance most of the times, especially when identifying birds assigned the true labels #0(American Crow), #2(Vermilion Flycatcher), #3(Western Grebe), and #4(Yellow Warbler), achieving a robust F1-Score of 0.86, 0.84, 0.90 and 0.84, respectively. While the model can often identify birds assigned the true labels #1 (blue jay) and #7 (eastern towhee), the performance is more mediocre when compared to the other types of birds. This can be explained because it is possible to confuse these birds with other species that look similar, such as confusing #1(Blue Jay) with #6(Indigo Bunting) because they both have blue in their colors, and confusing #7(Eastern Towhee) with #8(California Gull) because they both have white in their colors.

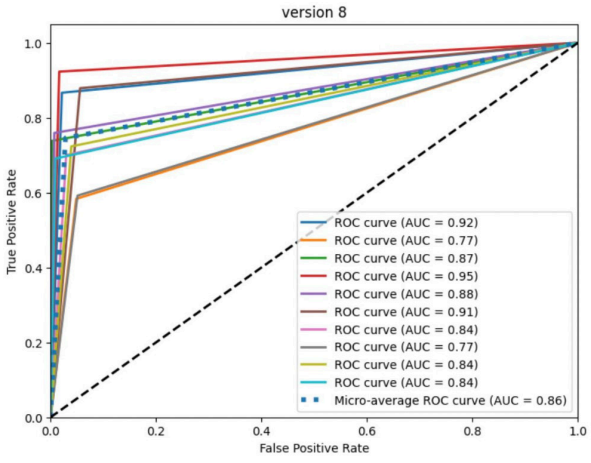
Figure 11
Confusion Matrix of Model Version 8



Another visualization method is to use a Receiver Operating Characteristic (ROC) curve, which is a graph of the true positive rate (TPR) as a function of the false positive rate (FPR) in the domain and range of [0,1]. The TPR, which is high in ideal cases, is calculated as (True positive) / (True Positives + False Negatives), and the FPR, which is low in ideal cases is measured as (False Positives) / (False Positives + True Negatives). This means that in ideal cases, the curve would be as close to the top left corner as possible, signifying that there are only true positives and no false positives. A method to measure how accurate the model performs is looking at the area under the curve (AUC) of an ROC curve. Models that have better performance have an AUC closer to 1.

Figure 12 below shows the ROC curve of version 8. The black line is the diagonal of the graph, representing the curve if the decision is made entirely randomly. As shown in Figure 12, all curves are far away from the diagonal and close to the top-left corner, meaning that they performed fairly well. The model performs exceptionally well at identifying American Crow (represented by the dark blue curve) and Western Grebe (represented by the red curve), achieving an exceptional AUC of 0.92 and 0.95, respectively. The ROC curve of Blue Jay (represented by the orange curve) and Eastern Towhee (represented by the grey curve) are close to the black diagonal, meaning that they performed relatively mediocre compared to the others.

Figure 12
ROC Curves of Version 8



Discussion

When the model makes random guesses, predicted accuracy is 10%. After many adjustments to the model, the accuracy increased to 75%, which is

a substantial increase in performance. This increase in accuracy illustrates that it is a reliable method to classify the images in the dataset. Though initially we faced some limitations, we managed to tackle them all through a variety of methods.

When initially processing the data, we faced some limitations, such as data diversity. However, we addressed it through data augmentation: artificially increasing the data amount without adding new data into the dataset, which is often done when data is not readily available (Chlap, Min, Vandenberg, Dowling, Holloway, & Haworth, 2021). We managed to address this problem through data augmentation by flipping the image sideways and appending them to the data files. This significantly increased accuracy. However, after revising the data we realized that there is still room for improvement, so we augmented the dataset once more by flipping all the images upside down, significantly increasing the data size to 4 times the original size. As shown in figure 13, 14, and 15 below, there is a visible increase in performance of the model each time the data gets augmented as the ROC curves shift towards the top-left corner, meaning a higher TPR and a lower FPR.

Figure 13
ROC Curves of Version 8 Before Image Augmentation

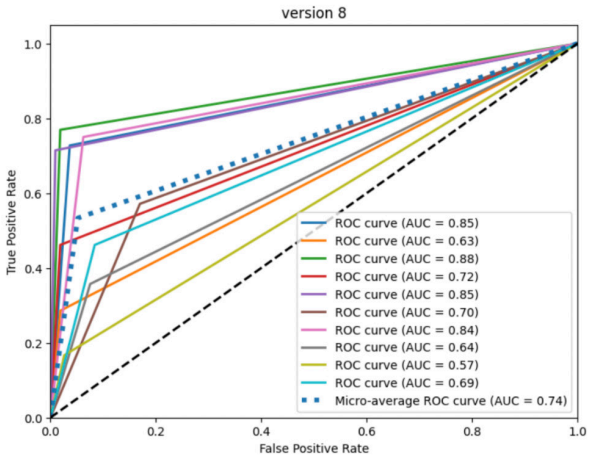


Figure 14
ROC Curves of Version 8 after Augmenting the Dataset to Twice its Original Size

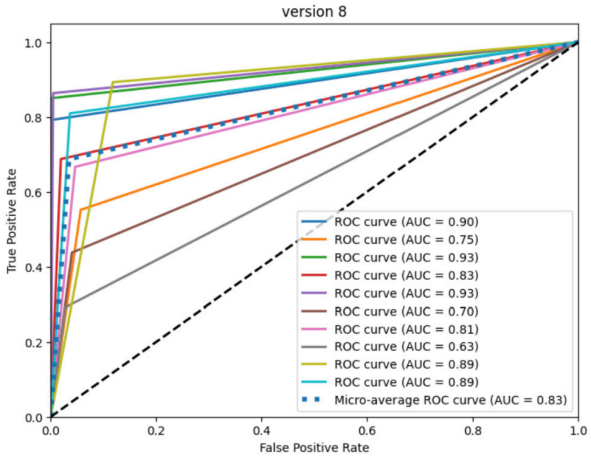
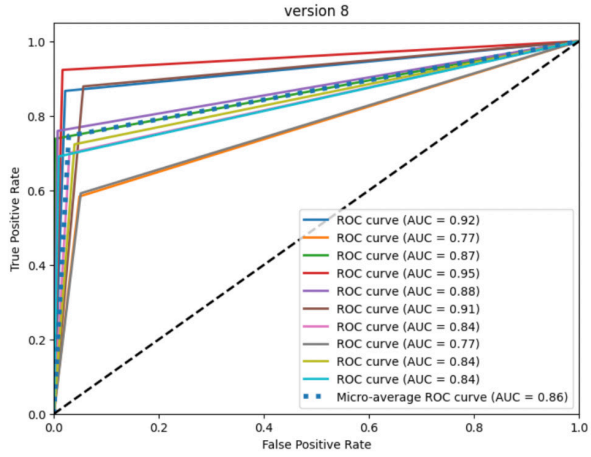


Figure 15
ROC Curves of version 8 after augmenting the dataset to four times its original size



Another limitation is the hardware requirements. To train the data, large storage is required. The most developed layout of seven layers has shown to take a large amount of computing resources. However, we also managed to tackle this problem by using Google Colaboratory. Shifting the project online allows us to utilize Google Colaboratory's high computing power, allowing us to build a more robust model without worrying about the program crashing.

Conclusion

This research project aims to develop a convolutional neural network that serves as an efficient way to classify birds based on its images. Based on further research, it can be concluded that convolutional neural networks have potential in achieving impressive results, and they can also adapt to handle the complexities inherent in bird image classification. In conclusion, the model did a decent job in classifying 10 common bird species, with accuracy at 0.75, macro average precision at 0.76, and macro average recall at 0.75 with 50 training epochs and an 80:20 train test split. This is significant since it is a potential direction where future improvements can be conducted such that the model will be able to identify a wider range of birds (with some tweaking and providing enough data) so it can serve as an alternative to human powered identification. This can potentially bring a new perspective in ornithology and help amateur birders better understand different bird species. Convolutional neural networks can revolutionize the field of avian identification, offering a cutting-edge solution that not only showcases its prowess in recognizing a diverse range of bird species.

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A Frontier in EBV Vaccine Research: mRNA-Based Immunization with gp350, gp42, and gL Glycoproteins

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Hailey Xi is a motivated and curious high school student at Collingwood School, Canada with a passion for immunology and genetics. She hopes to someday be at the forefront of tackling issues important to her such as cancer and autoimmune disease. In her free time, she loves painting, figure skating, and cafe-hopping.

Abstract

Epstein-Barr virus (EBV), an extremely common herpesvirus that affects 95% of the adult population, has been implicated in various medical conditions, including infectious mononucleosis, cancers, and autoimmune diseases, yet there is no working vaccine approved for it. Demonstrated by their success in combatting SARS-CoV-2, which became a pandemic-level health-threat in 2020, Messenger RNA (mRNA) vaccines offer a streamlined process that could expedite the development of an EBV vaccine. After providing an overview of mRNA vaccines and their applications, this paper discusses candidate EBV glycoproteins gp350, gp42, and gL for the development of a vaccine, selected based on the criteria of protein abundance, functional importance, stage of EBV infection, presence on the viral envelope, and role in immune evasion. The engineering process for these candidate mRNA vaccines involved the insertion of signal sequences, transmembrane domains, 5' and 3' untranslated regions, and poly (A) tails to ensure protein expression and localization. Potential next steps and their merits are discussed regarding mRNA synthesis. Immunofluorescence, Western blotting, and Enzyme-Linked Immunosorbent Assay ELISA) are suggested to visualize protein expression, confirm localization, and quantify protein levels, respectively. Subsequent steps and their obstacles are discussed, including in vitro testing on human cell lines, animal models, and human trials. This paper explores three candidate vaccines with the potential to reduce the prevalence of the elusive pathogen EBV and its associated diseases. Its findings lay the groundwork for developing mRNA vaccines targeting EBV-associated diseases, offering a promising avenue for research in the fields of preventive medicine and immunology.

Introduction

Currently, of all known human viruses, only approximately 10% have a working vaccine (Forni et al., 2022; Office of Infectious Disease and HIV/AIDS Policy, 2022). Messenger RNA (mRNA) vaccines have emerged as a groundbreaking innovation in the field of vaccinology. Most recently, the Nobel Prize was awarded to two scientists, Katalin Karikó and Drew Weissman, who made pivotal strides in mRNA synthesis. mRNA vaccines offer a promising approach to combat a wide range of infectious diseases, including those caused by complex pathogens like the Epstein-Barr virus (EBV). mRNA vaccines like the Moderna Spikevax vaccine and Pfizer BioNTech Comirnaty make up the majority of vaccines distributed in the wake of the SARS-CoV-2 pandemic from late 2020 to its declared end in 2023, with a campaign resulting in 13.51 billion doses administered globally as of August 5th, 2023 (Mathieu et al. 2023). The development of mRNA vaccines represents a paradigm shift in how immunization against infectious diseases is approached. Unlike traditional vaccines that rely on weakened or inactivated pathogens, mRNA vaccines utilize a revolutionary concept. In a much more streamlined and less costly development process, they provide the body with genetic instructions in the form of synthetic mRNA, enabling cells to produce harmless pieces of the target pathogen (Pardi et al., 2018).

The process of developing an RNA vaccine typically begins with the generation of the RNA encoding the antigen of interest. In vitro transcription, using a bacterial platform such as E. coli, is a common method used to synthesize the mRNA for the vaccine (Liang et al., 2000). This involves using a DNA template that encodes the target antigen. The DNA template contains a promoter region recognized by RNA polymerase, which initiates the transcription process. Promoters like the T7 promoter are commonly used for mass-producing mRNA, after which the RNA polymerase enzyme copies the DNA template, synthesizing the corresponding mRNA (Kang et al., 2023). This mRNA coding for antigenic proteins is encapsulated in lipid nanoparticles, facilitating its delivery into cells. Compared to viral vectors or DNA delivery, mRNA-based vaccines have a lower risk of integrating into the host genome. Additionally, mRNA acts more quickly since it only needs to reach the cytoplasm for translation, bypassing the need for nuclear transport. Upon translation of the mRNA, produced proteins prompt a robust and targeted immune response, harnessing the body's immunological memory by producing memory T and B lymphocytes. These memory T and B cells are effectively primed with a more rapid effector response and antibodies to efficiently recognize and fight the pathogen if encountered. Specifically, the proteins that mRNA vaccines code for primarily are extracellular proteins, particularly glycoproteins, proteins that have sugar molecules (glycans) attached to them. They are essential components of many biological processes, including cell signaling and immune recognition. Due to their accessibility on the cell surface, they are key markers that the immune system can readily recognize and respond to, ultimately conferring protection against the corresponding pathogen. mRNA vaccines have shown remarkable adaptability, making them suitable for addressing a broad spectrum of infectious diseases, from viral infections to bacterial pathogens (Pardi et al., 2018).

Epstein-Barr virus (EBV), a member of the herpesvirus family, is one of the most widespread human viruses—infecting 95% of adults worldwide—yet it has no clinically approved vaccine (Cohen, 2000). EBV has a double-stranded DNA (dsDNA) structure, with several main parts making up its 170 nanometers (nm): an outer lipid bilayer envelope, a central core, and an inner, irregularly shaped middle compartment (Cai et al., 2021). EBV infections are usually asymptomatic or present as mild illnesses, but this virus is also implicated in more complex and serious medical conditions. EBV's adaptability and complexity contribute to its diverse clinical manifestations, ranging from infectious mononucleosis (commonly known as mono) to its involvement in more severe disorders. One of the most notable aspects of EBV is its association with various types of cancer, including Burkitt lymphoma, nasopharyngeal carcinoma, and Hodgkin lymphoma; the World Health Organization (WHO) has categorized EBV as a class I oncogenic virus due to its role as a significant global health concern, attributed directly to roughly 200,000 newly diagnosed tumors each year across the world. This amounts to 1.5% of human cancer globally (Farrell, 2019). As recent evidence surfaces, EBV has also been implicated in autoimmune diseases, including multiple sclerosis (Bjornevik et al., 2022).

EBV has evolved sophisticated mechanisms to evade the immune system, persist in the host, and establish latent infections—where the virus lies dormant in host cells. EBV has a unique ability to promote uncontrolled cell growth by altering host-cell DNA, and with four latency phases, the virus can shut down certain immunogenic genes, allowing long-term persistence in host cells without detection. These distinctive characteristics make vaccine development tricky. Researchers are actively investigating the mechanisms underlying these connections, with the hope of uncovering potential therapeutic interventions. Though several attempts at clinical trials for EBV vaccines have been recorded, none have received approval and many face issues in efficacy or adjuvant selection (Cai et al., 2021). This is where newer mRNA vaccines come into play.

Methods

Table 1. Overview of selected candidate genes and their properties considered during selection.

Candidate Gene	Product	Genbank ID	Properties
BLLF1	gp350	QCG99665.1	The most abundantly expressed surface glycoprotein during both phases (most notably lytic) first viral attachment protein.
BKRF2	gL	UQK62613.1	Non-membrane bound part of the gH/gL glycoprotein complex. Essential for viral entry into the host cell via fusion of viral and plasma membranes.
BZLF2	gp42	QZL09798.1	Contributes to infection of B-cells (primary EBV reservoir) and acts as a tropism switch. Role in immune evasion by blocking T-cell receptors after fusion to the gH/gL complex ensures the virus is undetected. Extracellular protein.

Candidate Selection Considerations

Several criteria were used in selecting candidate EBV proteins, informed by the mechanisms that mRNA vaccines rely on to trigger an immune response as well as the primary goals for such a vaccine. These included protein abundance, functional importance, stage of EBV infection, presence of viral envelope, and role in immune evasion which are demonstrated in the product glycoproteins listed in Table 1. Each criterion deals with how a protein interacts with human host cells, including how often they are expressed extracellularly, which affects the likelihood of an immune response, and whether the virus can continue to proliferate without it. All of these factors must be considered in the creation of a vaccine prototype with high efficacy. A detailed explanation for each criterion follows below.

Abundance

The abundance of a candidate protein on the plasma membrane of EBV-infected cells can significantly impact its suitability as a vaccine target. Proteins that are heavily expressed during EBV infection are more likely to be exposed to the immune system and may elicit stronger immune responses (Salvatori, 2020). They are also more reliable targets that ensure, if successful, the vaccine can defend against most and not just some invading pathogens. As seen in Table 1. Gp350 was an attractive candidate for this reason; it is the most abundantly expressed glycoprotein during the lytic phase of the virus (Slabik, 2020). Examination of transcriptomic and proteomic data can provide insights into protein abundance.

Functional Importance

Consideration of the protein's role in EBV biology is crucial. Proteins that play essential roles in viral entry, immune evasion, or replication may be attractive candidates. This also prevents evolutionary vaccine resistance because the virus cannot adapt to function without said protein. For example, gp350 is involved in viral attachment to host cells, making it a key player in viral proliferation (Slabik, 2020). gL has a prominent role in viral entry and was therefore selected along with gp42 given its involvement in B-cell fusion and immune evasion mechanisms that make it a potential target to disrupt these strategies (Ressing, 2003).

Stages of EBV Infection

EBV undergoes both lytic and latent phases during infection. Proteins that are expressed during these phases may have different immunogenic properties. For example, proteins expressed during the lytic phase may be more readily recognized by the immune system, with a significantly higher frequency of CD8+ T-cells (Callan et al., 1998). It is less common to find reliably expressed proteins in the latent phase as the virus is not active, but gp350 holds promise due to its abundance in the lytic phase and its random expression in detectable amounts in the latent phase (Slabik et al., 2020).

Extracellular Expression

Proteins that are expressed extracellularly and exposed to the host immune system are what the mRNA vaccine mechanism relies on. This includes proteins like gp350, gL, and gp42 which interact with host cells during EBV attachment (Table 1).

Role in Immune Evasion

Proteins involved in immune evasion mechanisms and latency establishment, such as gp42 (Table 1), may be important for the virus's survival and can be attractive vaccine candidates, as without them miRNA production, the decreasing of immune recognition by CD8+ cells, and the decreasing of antiviral protein production would be disrupted.

Engineering the mRNA Vaccines

For each candidate protein, the amino acid sequences of EBV proteins gp350 (product of gene BLLF1), gp42 (product of gene BZLF2), and gL (product of gene BKRF2) were obtained from the NCBI Virus database in FASTA format. The same procedure was repeated for the SARS-CoV-2 surface glycoprotein.

Then, the protein structure prediction software InterProScan version 96.0 (referred to as InterPro in this paper) was utilized to identify signal sequences and transmembrane domains in the amino acid sequences. InterPro utilizes predictive models from databases including SignalP, employing bioinformatics algorithms such as TMHMM and Phobius, providing comprehensive information on protein sequences that can be used to inform the design process (Paysan-Lafosse et al., 2022).

The Moderna mRNA vaccine sequence was utilized as a model for designing the mRNA vaccines. To analyze the mRNA sequence of the Moderna vaccine model, SnapGene version 7.0.2 was employed to identify the locations of the 5' UTR, 3' UTR, and polyA tail in the model based on the sequence.

Next, the signal sequence and transmembrane domain were located within the SARS-CoV-2 Spike protein (e.g., obtained from InterProScan) and inserted into the respective N-terminus and C-terminus of the candidate protein's amino acid sequence where necessary. Lastly, the other elements of the mRNA vaccine model were inserted into the sequence. The design of the mRNA vaccine sequences for each candidate protein incorporated the following elements in order from 5' to 3':

1. 5' UTR sequence from the Moderna mRNA vaccine model
2. Open reading frame (ORF) of the candidate vaccine protein, which includes the engineered signal sequence and transmembrane domain, if applicable.
3. 3' UTR sequence from the Moderna mRNA vaccine model
4. Poly(A) tail

Results

Outlined are the design processes for each candidate protein based on Figure 1.

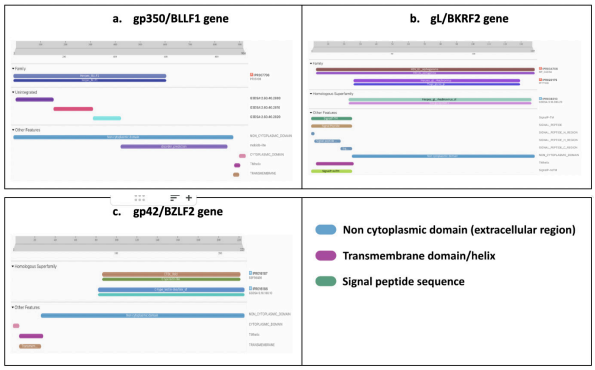

Figure 1. Interpro predicted glycoprotein expression, protein localization, and features. a) extracellular expression of amino acids 1-865, TM domain observed at the C-terminus region 870-892, N-terminus signal peptides absent. b) extracellular expression of amino acids 26-137, presence of N-terminus signal sequence 1-25, TM domain predicted for residues 4-26 (false positive attributed to a long stretch of hydrophobic amino acids), c) extracellular amino acids 28-223, TM domain predicted at region 7-29 (signal sequence present but not predicted in the figure due to lack of traditional signal sequence).

Further scrutiny and validation were warranted regarding Figure 1.c to confirm the accuracy of this prediction, particularly in the context of its potential role within the vaccine model. Kirschner et al. (2009) confirm that highly hydrophobic region 9-29 accounts for the transmembrane domain, as well as indicating gp42 is a type-II membrane protein. Therefore, it does not have a traditional signal sequence, as residues 9-29 serve to direct the insertion of the protein into the endoplasmic reticulum membrane.

Though in Figure 1.b Interpro appears to predict a transmembrane helix, upon further research Matsuura et al. (2010) indicate that gL has only a signal sequence and there is no transmembrane domain structure. The BKRF2 glycoprotein L was found to possess a signal sequence at the C-terminus with a hydrophobic stretch and no transmembrane helix. The software assessed the glycoprotein L for its propensity to form a transmembrane helix based on the presence of nonpolar/hydrophobic amino acids; however, such a helix formation was proved improbable. The system may not have been able to distinguish between a signal peptide and a transmembrane helix. Further analysis using a newer model of SignalP may be able to verify this (Peterson, 2011).

Engineering Signal Sequence and Modifying the ORF:

The gp350 protein was determined to lack a signal sequence. To ensure efficient protein synthesis and localization to the cell surface, a signal sequence from the Moderna mRNA vaccine model was incorporated. The first 18 amino acids from the Moderna vaccine model (known as the signal sequence) were inserted at the N-terminus of the BLLF1 mRNA. The original methionine (AUG) start codon of the glycoprotein was removed to maintain consistency with the signal sequence insertion.

Insertion of the Transmembrane Domain

To incorporate a transmembrane domain into the gL mRNA sequence, the transmembrane domain of the SARS-CoV-2 Spike protein was identified as amino acids 1214 to 1236. This stretch of 23 amino acids (from 1214 to 1236) was added into the ORF immediately before the stop codon. This addition involved inserting 69 bases corresponding to the amino acid sequence.

Incorporating the 5’ and 3’ UTRs and Poly(A) tail:

The 5’ untranslated region (UTR) from the Moderna mRNA vaccine model was added in front of the modified ORF for all candidate glycoprotein mRNA sequences, ensuring proper translation initiation. The 3’ UTR was appended at the end of the mRNA sequence to maintain the essential regulatory elements required for post-transcriptional control. The poly(A) tail, a chain of adenine nucleotides, was inserted after the 3’ UTR to improve stability and prevent RNA degradation.

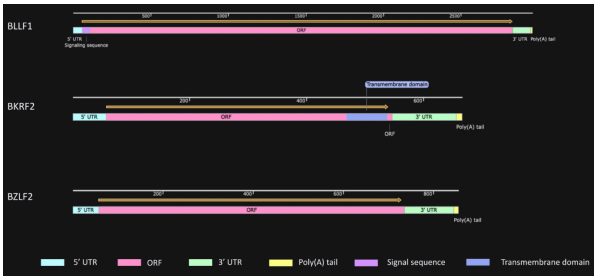

Figure 2. Graphical map of the engineered components of the vaccine from left to right. BLLF1 total 2957 bases, BKRF2 total 665 bases, BZLF2 total 854 bases

Discussion

As of now, a vaccine candidate for EBV has not made it past Phase III of the vaccine screening process or regulatory approval; however, with renewed interest in mRNA technology, a different approach harnessing mRNA vaccines may see success. As demonstrated by its use in streamlining an effective vaccine for SARS-CoV-2, mRNA technology can decrease the time and resources required to engineer new iterations for testing, a significant obstacle during the four decades since vaccine development began. To advance understanding and evaluate the efficacy of the proposed EBNA mRNA vaccine, it is essential to consider prospective methods being researched in the vaccine production and testing process. These methods are crucial for assessing whether the proposed mechanisms will effectively produce the desired immune response. Several testing approaches can be employed as next steps to examine various aspects of the vaccine development process.

RNA Generation

Optimizing mRNA synthesis is crucial for the successful development and production of RNA vaccines, which require the mass generation of mRNA, often in the form of in vitro transcription using bacteriophage RNA polymerase and PCR-amplified linearized templates or plasmids. One key consideration is the choice of promoter system used for in vitro transcription, which can significantly impact mRNA yield, purity, and stability. The T7 promoter system is commonly employed due to its high efficiency and specificity in driving transcription from a DNA template (Kang et al., 2023). However, alternative promoter systems such as SP6 and T3 should be considered, as each offers distinct transcriptional activity and regulatory control advantages.

Optimized RNA Modalities

Several alternative mRNA models are undergoing research for their lower-dose mRNA requirements, including self-amplifying mRNA (saRNA) and its structurally altered counterpart trans-amplifying mRNA (taRNA) (Rosa et al., 2021). saRNA involves inserting a viral replicase gene, typically, sequences from single-stranded RNA viruses like alphaviruses, and flaviviruses. When delivered to the cytoplasm, this type of mRNA produces high levels of the desired antigen without generating viral infectious particles, addressing safety concerns. In mouse models, a saRNA vaccine required a significantly lower dose compared to conventional mRNA vaccines to induce an immune response against H1N1/PR8 infection.

Trans-amplifying mRNA (taRNA) results from splitting self-amplifying mRNA into two templates: one containing the gene of interest and the other containing the replicase system. taRNA offers advantages over saRNA, including improved safety, versatility, and cost-effectiveness in manufacturing. Notably, taRNA has already demonstrated efficacy in protecting mice against influenza, inducing antibody production and providing protection.

mRNA Capping

Capping of in vitro transcribed (IVT) mRNA is essential for translation efficiency and intracellular stability (Ramanathan et al., 2016). This technique involves the addition of a cap structure to the mRNA's 5' end, promoting efficient protein synthesis. During the IVT reaction, substituting a portion of the guanosine triphosphate (GTP) substrate with a cap analog alongside ribonucleoside triphosphates (rNTPs) results in cap-1 mRNAs that trigger less immunogenicity in vivo (Rosa et al., 2021). While this method is faster and eliminates the need for a separate enzymatic reaction, it achieves an imperfect capping efficiency of approximately 60–80%. On the other hand, a separate enzymatic reaction using the vaccinia capping enzyme (VCC) and a methyl donor to cap the mRNA, achieves a higher capping efficiency of 100% (Rosa et al., 2021). However, this method requires an additional step and setup. Both methods may involve high production costs when considering large-scale manufacturing. To mitigate these costs, researchers may explore alternative expression systems such as yeast-based platforms, which offer lower production costs but may require additional optimization steps to achieve optimal mRNA yield and quality. A 2018 patent utilizes specific elements from the yeast Ty retrotransposon, enabling the production of RNAs, including mRNAs and long non-coding RNAs (lncRNAs), with features like a 3' polyA tail, a 5' methylguanosine cap, and potential methylation of adenine and cytosine residues (Pigeon et al., 2018). Although still requiring further research, this yeast-based platform allows cost-effective production of these RNAs in significant quantities, showing promise.

Uracil to Pseudouridine Replacement

It has been demonstrated that replacing uracil residues with pseudouridine (Ψ) can enhance the stability of in vitro transcribed RNA, reduce immunogenicity, and improve translation efficiency (Morais et al., 2021). Nucleotide modifications play a pivotal role in mRNA-LNP vaccine design. Unmodified mRNA molecules can trigger innate immune responses upon administration. To mitigate this, chemically modified nucleoside Ψ can be incorporated into the mRNA sequence. The choice of modifications should be guided by their impact on both the immune response and protein expression (Morais et al., 2021).

Testing for Protein Expression/ Localization

Immunofluorescence can be utilized to visualize the expression and localization of the EBNA protein within cells. Immunofluorescence involves using antibodies tagged with fluorescent molecules to bind to specific target proteins within the cell. When excited by a specific wavelength of light, the fluorophores' fluorescence allows visualization of the protein's location (Joshi & Yu, 2017). Cells are fixed, permeabilized to allow antibody penetration, and then incubated with primary antibodies against the target protein. After washing away unbound antibodies, cells are incubated with fluorescently labelled secondary antibodies that bind to the primary antibodies. Immunofluorescence allows tracking of the distribution of the target protein within the cellular context, providing insights into its subcellular localization and potential interactions with cellular components.

Western blotting is another technique that can be utilized, not for cellular localization but rather to confirm protein expression in cell lysates as it detects proteins based on their size and immunoreactivity. Protein lysates are separated by gel electrophoresis based on size and transferred onto a membrane (Yang et al., 2012). The membrane is then probed with antibodies against the protein of interest, followed by detection using chemiluminescent or chromogenic substrates. Post-imaging, the data can help confirm the expected expression of the intended proteins.

Enzyme-linked immunosorbent Assay (ELISA) uses antibodies linked with enzymes that react with a substrate to produce a detectable signal (usually colorimetric or chemiluminescent) proportional to the amount of target protein, as stated in StatPearls (Alhajj et al., 2023). ELISA is highly quantitative and can measure protein concentration accurately. Researchers can use it to assess the level of vaccine-encoded protein in samples, such as cell culture supernatants. Calibration curves and standardization are key considerations.

Further Testing and Limitations

Following verification of protein expression and localization, in vitro testing using human cell lines should be conducted to assess the stability, translational efficiency, and immunogenicity of the modified mRNA. These initial studies provide valuable insights into the performance of the vaccine candidate at the cellular level, helping to refine its design. In the vaccine development process what follows is usually animal model testing to evaluate the safety and immunogenicity of the mRNA vaccine candidate. It is important to monitor the immune responses of these animal models, including antibody production, T-cell activation, and cytokine profiles. These can verify the vaccine candidate's ability to induce strong immune responses against the virus and expose any adverse effects or inflammatory responses in the animal subjects. This would involve selecting appropriate animal models, such as mice or non-human primates to mimic human responses, preferably species that naturally are EBV hosts or are modified to interact with the virus as human cells do (Cai et al., 2021). Animal model selection is a key obstacle in mRNA vaccine development currently. The cotton-top tamarin was initially established as an experimental model for EBV infection and lymphoma development, first being used in 1985; however, the model's translatability to human EBV infection was limited (Escalante et al., 2022). Humanized mice, which develop lymphoma upon EBV infection, have also been employed, yet Escalante et al. note that their susceptibility to EBV infection and subsequent disease manifestation again differed from human EBV infection. Rabbits and Chinese tree shrews were found to be unreliable for the same reason as humanized mice; their epithelial cells were not infected by EBV, making it difficult to generalize for human testing. As of now, no ideal animal model has been designated for the testing of EBV vaccines.

If animal testing shows promising results, the candidate can then proceed onto ordered clinical trials on humans–from Phase I, administered to a handful of healthy volunteers, to Phase II with a larger group of participants including individuals at risk for EBV, and lastly a large scale Phase III diverse population trial (WHO, 2020). Despite efforts, the furthest a vaccine candidate for EBV has progressed is Phase II. Phase II of a prophylactic AS04 recombinant gp350 vaccine demonstrated a reduced incidence of infectious mononucleosis in the vaccinated group compared to the placebo group (Cai et al., 2021). However, the vaccine fell short of preventing initial EBV infection, its primary goal. mRNA vaccines hold promise in revitalizing these efforts to develop

an effective EBV vaccine by offering a versatile and potentially more efficient alternative to conventional vaccine strategies. As they can be rapidly designed and produced for numerous antigens, and their flexibility enables the exploration of different delivery methods and adjuvants, mRNA vaccines hold the potential to overcome challenges associated with traditional vaccine approaches.

Conclusion

With hundreds of researchers contributing to its development over several decades, mRNA vaccines are finally gaining recognition for their potential to solve various global health challenges where research with other methods has stagnated. With one such area being vaccination for EBV, an extensively studied virus for its role in various diseases, three protein targets show promise for immunization with new mRNA technology. Gp350, gL, and gp42 all have unique roles in EBV's complex biology and are expressed extracellularly, making them ideal candidates. By making several alterations to their genes to allow for uptake, protein synthesis, and stability, an mRNA vaccine can be created and tested with established methods such as immunofluorescence, Western Blotting, and ELISA. The versatility and speed of development associated with mRNA vaccines hold promise for revolutionizing the field of immunology and responding rapidly to emerging health threats, such as Epstein-Barr virus, fast-mutating pathogens like influenza, or even certain cancers.

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Musical Training and the Perception of Positive Music Listening Emotions as Medicine for the Brain

By Lillian Yeh

Author Bio

Lillian Yeh is a junior attending Boston University Academy. She has explored her love for music in various ways–nine years as a violist, playing in ensembles, occasionally composing for fun in her free time, conducting her school orchestra, and more. Lillian intends to further explore music as a healing mechanism whether that be through performing or research in college and beyond.

Abstract

Although much research has been conducted on the benefits of the music-listening experience and neural responses to music listening, no previous study has examined the potential congruency of the experience of listening to music and the perception of emotional responses to music listening. Two hundred individuals participated as respondents in a survey on the experience of music listening, its impact on mood, and perception of emotions associated with music listening. Survey participants were categorized as nonmusicians and musicians, or musicians with < 7 years of experience and musicians with > 7 years of experience. This study hypothesized that a greater percentage of musician respondents would associate music listening with positive emotions in comparison to nonmusicians due to benefits of musicianship on the brain as described in the literature. A Google Form survey was used to collect responses. Pie chart analyses of survey data revealed that, in comparison to nonmusicians, there was greater variation between musician responses to questions asking about the association of positive emotions (e.g. confidence, comfort) with listening to music, and that a greater percentage of musician respondents associated negative emotions (i.e. anger) with listening to music in comparison to nonmusicians. Furthermore, a smaller percentage of musicians with more years of experience associated listening to music with positive emotions (i.e. comfort) in comparison to musicians with fewer years of experience. These results add to previous studies that indicate music can improve well-being and that musicians generally have a more developed recognition of emotions.

Keywords: music, music cognition, neuroscience, cognitive science, musical emotions, psychology, phenomenology, healing

Introduction

Music is often understood as a universal language that can evoke emotions that words cannot. In recent years, music has been further recognized for its therapeutic value. Music is known to help alleviate stress and anxiety and release various "happy chemicals" in the brain (Boso, 2006). Lesser known may be the long-term social and emotional benefits that music education can have. Additionally, the phenomenology–the way individuals perceive experiences and the value that experiences hold (Smith, 2018)– of the music listening experience could potentially increase the benefits of music listening on the brain. Understanding the benefits of music and the perception of positive musical emotions on self-esteem, emotional management, and well-being of musicians could further reveal the importance of implementing musical training into education for its positive long-term impact on quality of life.

This paper primarily intends to answer the following question: What differences exist between musicians and nonmusicians in their perception of emotions elicited by listening to music, and what could these differences tell us about the effect of musicianship on emotional well-being?

The foundation of this research rests on literature about the mental and physical benefits of music listening and musical training, as well literature engaging the phenomenology of music, coupled with survey results (n=20) meant to elicit respondents' perception of the benefits of musical training on emotional intelligence.

Literature Review

Long before the development of the academic fields of psychology and neuroscience, music has been incorporated into various community and cultural practices for its value as a healing mechanism. Greek physicians used instrumental vibration to help with digestion, mental well-being, and sleep. In his book, De Anima, Aristotle wrote that flute music gave rise to strong emotions and could purify his soul (Meymandi, 2009). In the Old Testament of the Bible, David's harp is described as an instrument that had the ability to ward off evil spirits (I. Samuel, Chapter 16, Verse 14–23). Throughout history, music in various forms has been recognized as a way to evoke indescribable emotions, heal both those who perform and those who listen, and to bring people together.

More recent neuroscientific and psychological studies on the effect of music on the brain have begun to shed more light on the various mental and physical benefits of music experience, whether that be through listening or training.

Listening to music releases certain biochemical mediators, such as endorphins, endocannabinoids, dopamine and nitric oxide (NO), which could be helpful for emotional management in general, but also for managing neurological disorders through music therapy (Boso, 2006). The increase of dopamine that occurs when listening to music can benefit mental health and decrease stress (Váradi, 2022). Furthermore, listening to pleasant music activates parts of the brain associated with reward and pleasure (Koelsch, 2010).

However, listening to music may not only have mental benefits but physical benefits as well. The release of NO, a chemical that can eradicate bacteria and viruses, into the bloodstream through listening to pleasant music could potentially prevent bacterial or viral infections (Boso, 2006). In a study where surgical patients were asked to listen to music, music listening effected a decrease in pain and stress for the patients (Boso, 2006).

Interestingly, listening to and processing music does not only activate one hemisphere nor one specific region of the brain, but various cerebral structures combined (Warren, 2008; Blood, 1999). The network that processes musical emotions includes areas such as the insula and 'limbic system', which comprises the amygdala, hippocampus, and their cortical and subcortical connections (Warren, 2008).

Although various neural networks from both hemispheres process musical emotions, the regions activated may vary among individuals since personal experiences, culture, listening history, and more, can affect an individual's listening experience (Boso, 2006). For example, in Western music, happy and sad emotions are often associated with major and minor keys, respectively, one example of how culture impacts the perception and processing of music (Vuust, 2022).

While listening to music already has strong benefits for well-being, playing and interacting with music are even more effective in improving certain neural, cognitive, and even social mechanisms. For example, musical collaboration and dance are both constructive methods of creating strong social connections (Váradi, 2022). Additionally, musical communication improves recognition of verbal communication and human facial expressions, verbal memory, and focus (Váradi, 2022; François, 2015).

Music education has been shown to have a positive influence on emotional intelligence (Váradi, 2022). Additionally, music engagement can increase self-confidence, self-awareness, maturity, and learning motivation (Váradi, 2022). Through white matter modifications, musical training has been shown to strengthen connections between different areas of the brain (François, 2015). Musicians have also exhibited signs of change in most areas of auditory pathways (François, 2015). Furthermore, a study showed that musicians display better neural processing of speech sounds than nonmusicians, which may indicate that representation of sounds in the brainstem is more accurate in musicians than nonmusicians (François, 2015). Benefits of musical training appear from a young age and persist through adulthood, even if the period of training only lasts a few years long (François, 2015). The multitude of long-term positive emotional, intellectual, and social benefits of musical training indicate the importance of implementing music into education from a young age.

This paper hypothesizes that, according to the literature, if musicians are aware of or associate music playing and listening with its positive experience and benefits, then, in comparison to nonmusicians, musicians will elicit more positive emotions (e.g. happiness, confidence, comfort) while listening to music due to emotional and social benefits of musical training.

Methods

As an extension of reviewing the literature regarding the impact of music listening and training on the brain, 200 individuals of different age groups and cultural backgrounds were surveyed on their experience of music listening and/or musical training. Respondents were recruited through the author's personal connections, such as peers, friends, family, and more. This may explain why survey participants were largely between the age range of 13-34 and American citizens. Results were obtained by using a Google Form to collect responses and then analyzed using pie charts on Google Sheets. The survey asked questions meant to evoke the respondent's self-perception of their musical experience and emotions associated with listening to or playing music (see Appendix). Questions with other musical emotions during music listening (e.g. "Do you feel awe when you listen to music?") and questions specifically for musicians (e.g. "Do you feel more confident when you play music?") were also included in the survey for context in hopes that they would provide useful data. However, the survey questions this paper analyzes provided the most helpful information.

Results

It is first important to note that the majority of survey participants were between the ages of 13-34 (Figure 1), which may indicate that the survey results are more biased towards individuals in these more hormonal states. With a larger sample size and a more even spread among age ranges, survey results on music and association of emotions with music listening may differ from this survey's results.

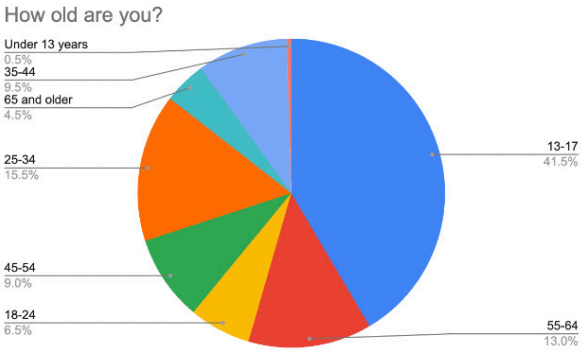

Figure 1. Responses to "How old are you?"

Additionally, the majority of survey participants were U.S. citizens, which may explain the highest percentage of music listening preference to be in the "pop" genre, as in "popular" music (Figure 2). With a larger sample size and a more even spread among various countries of citizenship, more disparity among music tastes might be observed.

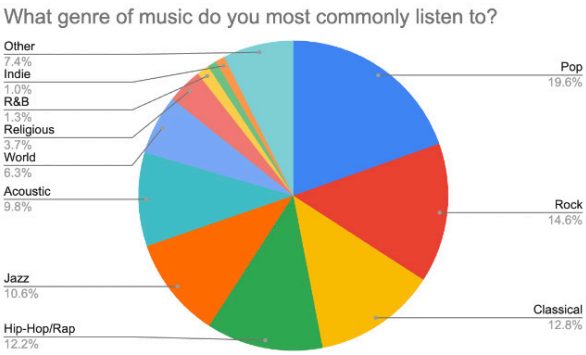

Figure 2. *Responses to "What genre of music do you most commonly listen to?" Survey participants were given the option to select as many music genres as they believed they enjoyed listening to.*

The vast majority of the 200 survey respondents replied with "Yes" when asked if they enjoyed listening to music and that they did so frequently (Figure 3), which may show that most people associate music listening with pleasure, as one would imagine that fewer people seek out pain over pleasure, though it is worth noting that sensation seeking isn't entirely uncommon (Sagioglou & Greitemeyer, 2020). If music listening is frequent and associated with pleasure, this may suggest that regardless of what specific emotions music listening may induce based on other factors (genre, repertoire, key, rhythm, etc.), the pleasurable experience of listening to music may generally have a beneficial effect on emotional wellbeing and mood.

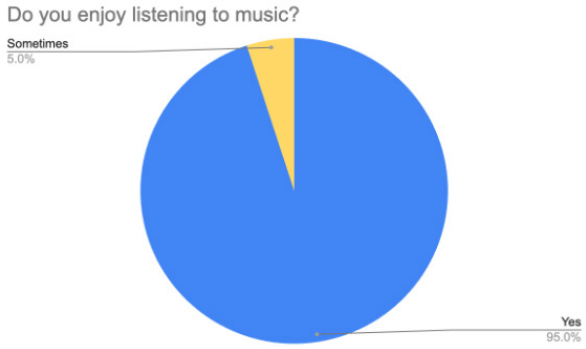

Figure 3. *Responses to "Do you enjoy listening to music?"*

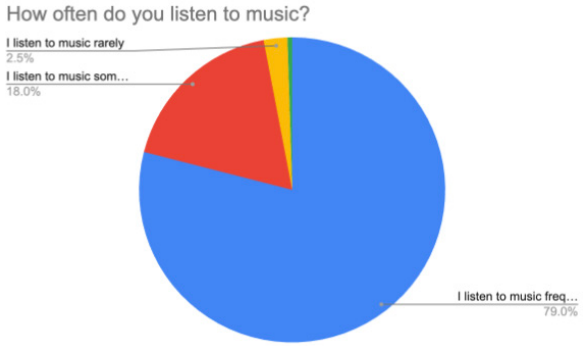

Figure 4. *Responses to "How often do you listen to music?"*

Furthermore, when asked what descriptors best captured the mood of music that individual survey participants listened to, more than 50% of respondents claimed that they listened to music that evoked positive emotions: "Happy and upbeat" or "Calming and soothing" (Figure 5). When asked how music listening generally affected their mood, a similar percentage of survey respondents found music listening to uplift their mood (Figure 6). This may indicate that a majority of people tend to favor listening to music with positive emotions that have the ability to uplift their mood. However, this fact does not discount the positive effects of listening to music that may be associated with more negative emotions, such as the "intense and complicated" or "sad and pensive" options. Regardless of whether the listener classifies a song or piece of music with positive (e.g. happy) or negative (e.g. sad) emotions, favored music induces more activity in the brain's reward circuits (Vuust, 2022).

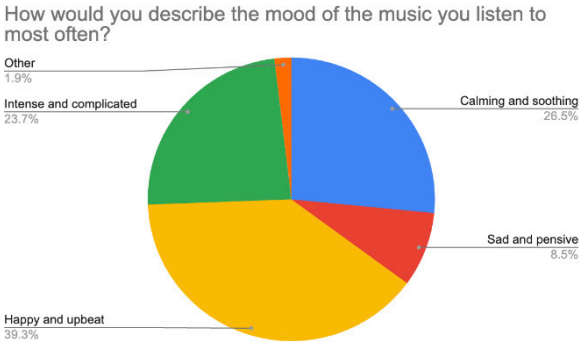

Figure 5. *Responses to "How would you describe the mood of the music you listen to most often?"*

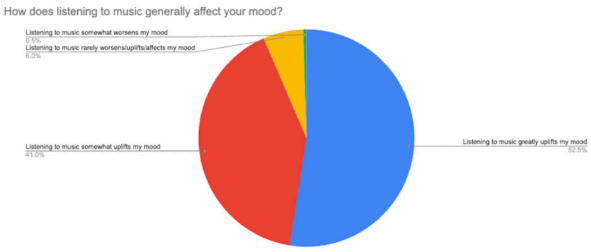

Figure 6. *Responses to "How does listening to music generally affect your mood?"*

When asked about musical emotions and responses to music listening, a majority (64.5%) of respondents claimed to feel more confident when listening to music and an even larger majority (73.5%) generally associated music listening with feelings of comfort (Figure 7, Figure 8). These results seem to be in support of the 93.5% majority who responded that listening to music greatly or somewhat uplifts their mood (Figure 6) in that music listening is perceived by most participants as a mechanism capable of having a positive effect on emotional well-being and mood.

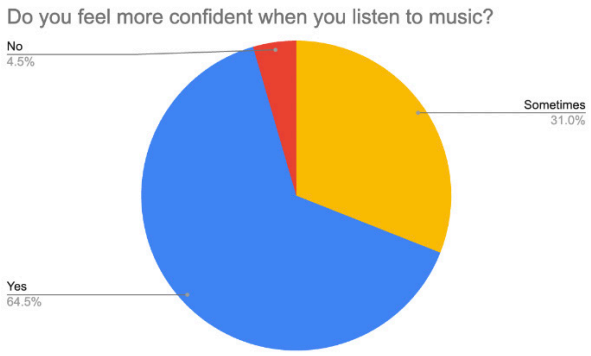

Figure 7. *Responses to "Do you feel more confident when you listen to music?"*

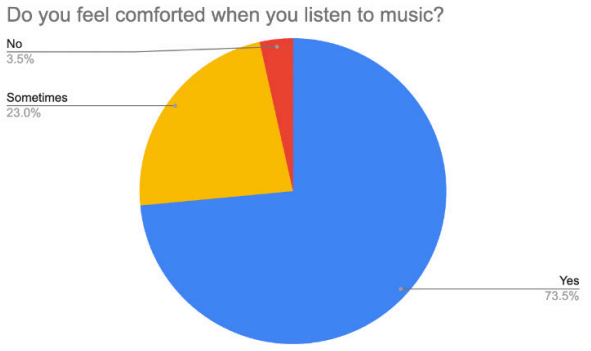

Figure 8. *Responses to "Do you feel comforted when you listen to music?"*

When comparing feelings of confidence associated with music listening between the group of nonmusician and musician respondents, however, no significant difference was observed (Figure 9). While it is expected that musicians may feel more confident when playing music that they have successfully played on their own before, minimal difference between the two groups' responses was recorded. The similarity between the two groups can be better understood if these results are attributed to an individual's general feelings of self-confidence. Although this would have to be further tested, it may be expected that even if the sample size was larger, and the ratio between nonmusicians and musicians was equal, there may not be much difference still because confidence is more difficult to measure due to its complexity in comparison to amygdala emotions; confidence is the result of interactions between different parts of the brain and, during music listening, may instead be linked to an individual's long-term self-esteem (Bang, 2022).

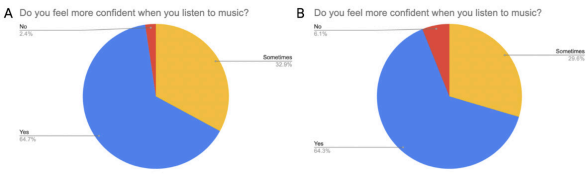

Figure 9. *Comparison of responses of nonmusicians (9A) to responses of musicians (9B) to "Do you feel more confident when you listen to music?"*

In contrast, when comparing feelings of comfort associated with music listening between nonmusicians and musicians, a slightly larger majority of musicians (74.8%) replied that they felt comforted by music listening in comparison to nonmusicians (71.8%) (Figure 10). However, among musicians, there was a 6.1% response of "No," while there were no negative responses among nonmusicians. This may be evidence of a different relationship between musicians and comfort than between nonmusicians and comfort. It could be the case that musicians internalize listening to music from a critical perspective, triggering competition and focus in the prefrontal cortex (Decety et. al, 2004; Trafton, 2014) or dopamine as a rewarding motivator (Love, 2015), where nonmusicians may feel something more like nostalgia, which involves self-reflection, autobiographical memory, regulatory capacity, and reward (Yang et al., 2022). Additionally,

it is unclear whether respondents interpreted the question as asking if the act of listening to music is comforting (attitude toward listening experience) or if music is capable of comforting them (attitude toward emotional self-regulation). In future studies, this question can be further adapted to elicit more useful information.

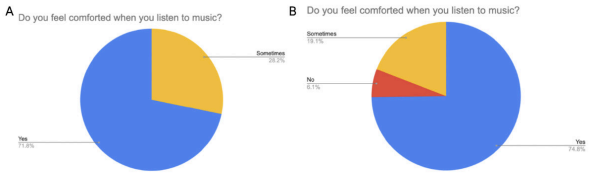

Figure 10. *Comparison of responses of nonmusician participants (10A) to responses of musician participants (10B) to "Do you feel comforted when you listen to music?"*

In a more in-depth analysis of musicians' responses to this question of "Do you feel comforted when you listen to music?," there was a greater percentage of "Sometimes" and "No" responses from more experienced musicians (> 7 years of experience) in comparison to less experienced musicians (< 7 years of experience) (Figure 11). This may indicate that more experienced musicians feel a broader variety of emotions than less experienced musicians or non-musicians due to more experience associating different emotions with playing certain pieces, which in turn transforms their music listening experience. For instance, if a musician had already performed a piece, then it may be expected that, while listening to the piece again, the piece elicits feelings of confidence in the musician because the musician is confident in their ability to play the piece. Thus, these results may convey that the more experienced musicians have interacted with music in a way that nonmusicians do not, the more likely they are to feel more case-specific emotions when listening to music, depending on the song, its melody, or genre.

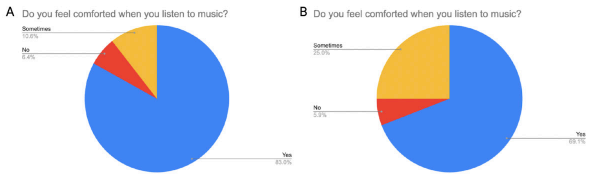

Figure 11. *Comparison of responses of musician participants with < 7 years of experience with musical training (11A) to responses of musician participants with > 7 years of experience with musical training (11B) to "Do you feel comforted when you listen to music?"*

Interestingly, when comparing feelings of anger associated with music listening between non-musicians and musicians, a majority of 81.2% of nonmusicians responded with "No" to feeling anger when listening to music, while a smaller majority of 63.5% of musicians responded with "No" to feeling anger when listening to music (Figure 12). Furthermore, while there were no "Yes" responses among nonmusicians, a 7.8% of musicians responded with "Yes" to feeling anger while listening to music. It makes sense that musicians have higher percentages of feelings of anger when listening to music if musicians have more activity in the amygdala in response to music listening, since general feelings of anger activate the amygdala (Dougherty, 2011). On the other hand, anger is a simple emotion, and it might be expected that the emotions felt by a musician listening to music are of a more complex nature, assuming they involve other brain activity in the areas responsible for not only memory but also understanding. The survey questions also lacked a differentiation between those who sought out music to quell anger and those for whom music caused anger. Future research should consider the language that would best elicit the information at issue.

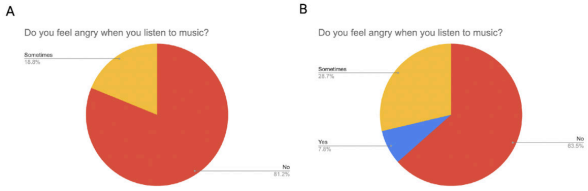

Figure 12. *Comparison of responses of nonmusicians participants (12A) to responses of musician participants (12B) to "Do you feel angry when you listen to music?"*

Discussion

The survey showed a strong correlation between music listening and positive emotions, and showcased differences between emotions perceived through the music listening experience by nonmusicians and musicians.

The paper's initial hypothesis that musicians, in comparison to nonmusicians, would produce more positive emotions during music listening due to the benefits of musical training was rejected by further analysis of survey results. While a majority of musicians still associated positive emotions with music listening (i.e. 64.3% of musicians responded that listening to music makes them feel confident and 74.8% of musicians responded that listening to music makes them feel comforted), musicians consistently associated a greater variation of emotions with music listening, including negative emotions, in comparison to non-musicians (i.e. 6.1% of musicians claimed they did not feel comforted while listening to music, while no nonmusicians claimed to not feel comfort while listening to music, and while 81.2% of nonmusicians replied that they did not feel anger while listening to music, a smaller majority of 63.5% of musicians replied that they did not feel anger while listening to music, with 7.8% of musicians even replying with "Yes" to feeling anger while music listening) and musicians with more years of experience (> 7 years of experience) exhibited more variation in emotions associated with music listening in comparison to musicians with less years of experience (< 7 years of experience) (i.e. when asked if they felt comfort during music listening, 83% of musicians with < 7 years of experience responded with yes, while a smaller majority of 69.1% of musicians with > 7 years of experience responded with yes). These outcomes show that it is not the case that musicians will feel more positive emotions while listening to music in comparison to non-musicians. Instead, these results may reveal that musicians develop stronger emotional intelligence, recognition of musical emotions, and increased specificity in their association of certain pieces or types of music with different emotions in comparison to nonmusicians if it is the case that musician's enhanced ability to recognize emotions, verbal communication, and facial expressions (Váradi, 2022) also applies to their ability to recognize emotions while listening to music.

Perceptions of preferred music listening tastes differed among survey participants. However, 93.5% of survey participants responded that music listening either greatly uplifted or somewhat uplifted their moods. Additionally, a 64.5% and 73.5% majority of survey respondents answered "Yes" when asked if they felt more confident and if they felt comforted when listening to music, respectively, indicating that generally, music listening is associated with positive emotions. These results parallel the literature which states that varying music taste preferences and emotions associated with different genres or 'moods' of music (e.g. happy, sad, intense) do not necessarily correlate to positive or negative feelings or responses in the brain (i.e. "happy" music does not necessarily induce positive emotions and "sad" music does not necessarily induce negative emotions); rather, preferred music directly activates the brain's reward circuits (Vuust, 2022).

Importantly, this survey must generally be understood as having a phenomenological approach. Aside from its factual questions, such as "How old are you?", most, if not all music listening related questions required survey respondents to reflect on their own perception of their music listening experience and emotions that they did or did not feel. It is not only important to understand the literature and the experience of music listening on the brain itself, but also perception of the music listening experience, which the survey aimed to achieve. Consciousness of positive feelings towards music listening coupled with the actual experience and release of biochemical mediators may theoretically further the benefits of music listening on an individual's mental health. If an individual believes or is aware that music listening is a positive experience, then it may be expected that their brain will respond positively when the individual listens to music they enjoy. This theory can be better understood through music tastes and how they function. If an individual enjoys a specific genre of music and is aware of their enjoyment of music from that genre, the brain's reward circuits will be activated if the individual listens to that genre of music that they like (Koelsch, 2010). Likewise, it may be expected that awareness of the mental and emotional benefits of music listening can increase the benefits of the music listening experience itself.

Conclusion

The notion of music listening being perceived by the listener as a positive experience, whether as a source of pleasure or of deep healing, has been affirmed by self-reflective survey response data combined with the literature of music on the brain. The fact that most survey respondents believe music to be greatly or somewhat uplifting to mood suggests

that music listening can be an effective mechanism for improving mental and emotional well-being, whether that be short or long-term.

Additionally, as discovered through the self-reflective nature of this survey, the perception of music listening as a positive experience may imply that music listening is associated with a pleasurable experience to some and therefore has even more of a beneficial effect when perceived as favorable, which a majority of survey respondents asserted.

Lastly, an observable difference between nonmusician and musician respondents as well as differences between less-experienced musicians (< 7 years of experience) and more-experienced musicians (> 7 years of experience) have indicated not only that it is possible musical training can increase recognition of emotions when listening to music, but also that the more years of experience that an individual has may further increase recognition of emotions when listening to music, and therefore be beneficial to emotional and social intelligence.

These results show the necessity of incorporating music into daily life in its many forms. When just listening to music, it has the power to benefit one's emotional state. When learning music, musicians may be able to increase emotional awareness through pure listening. The literature has additionally illustrated the many ways in which music works both as a healing mechanism and a positive influence on emotional awareness, and, in that way, previous literature supports the survey results in this study. The author's hope for this paper is that it further illustrates the power of music to reach places of the mind that words, when only spoken, can not. Music should be further recognized and implemented into policies in areas like education and mental health treatment for its profound and priceless impact.

Limitations

One limitation of this research is the demographics and sample size of survey respondents. As previously mentioned, a majority of survey respondents (63.5%) were in the 13-34 age range, which indicates that the survey may have been more biased towards individuals in more hormonal states. Additionally, the majority of survey respondents were U.S. citizens, which may explain survey results for music taste revealing "pop" music as the most popular response. Having a larger sample size that includes a wider range of age, nationality, and background demographics could help in attaining a broader variety of perspectives.

Another limitation of the survey was the phrasing of the survey questions. For example, it is possible that while one survey respondent interpreted the question "Do you feel sad when you listen to music?" as asking if listening to music is sad or if music elicits a feeling of sadness within them. In the future, having more clear and specific questions could help to avoid misinterpretation of the questions by survey respondents and also in attaining accurate respondent data.

Lastly, as a part of the self-reflective approach that this survey took, and because it has already been established that there is a difference between an experience and one's perception of that experience, survey results may not be fully accurate because it asks individuals to reflect on their perception of the music listening experience without acquiring any experimental data about the neuroscientific process that occurs in their brain when listening to music. While this paper argues that an individual's perception of music listening as a positive experience furthers the benefits of the "real" experience of listening to music, it is important to recognize this survey-based analysis as a useful, but limited, method of understanding the effect of music listening on the brain.

Future Studies

Future studies could touch on the following questions posed by the survey research:

1. What differences are observed between neural activity in a musician's brain versus a nonmusician's brain while listening to music?

2. What discrepancies and similarities are there between the perception of emotions elicited through music listening and the brain's actual emotional response during music listening?

3. What differences are there between the psychological, emotional, social, or physical benefits of music education for an adolescent versus as an adult?

4. How would responses vary across different respondent demographics?

Acknowledgments

I thank my mentor, Mr. Carlo Nicolau, for providing me with endless support throughout and for the many inspiring conversations along the way. I would also like to thank Mrs. Avi Hegland-Fisher for guiding me through the extensive ebb-and-flow of research and writing.

Appendix

Survey Questions

Survey Questions for All Survey Respondents (Including Musicians)

1. How old are you?

2. What is your nationality (citizenship)?

3. What is your highest education level?

4. If you are employed, in which industry do you work?

5. If you are a student, what do you study? (If you are in high school or below, or beyond undergraduate/graduate/subspecialties, please put "Not applicable")

6. How often do you listen to music?

7. What genre of music do you most commonly listen to? Check all that apply.

8. Do you enjoy listening to music?

9. How would you describe the mood of the music you listen to most often?

10. How does listening to music generally affect your mood?

11. Do you feel more confident when you listen to music?

12. Do you feel nostalgic when you listen to music?

13. Do you feel comforted when you listen to music?

14. Do you feel angry when you listen to music?

15. Do you feel sad when you listen to music?

16. Do you feel awe when you listen to music?

17. Do you feel afraid when you listen to music?

Survey Questions for Musicians

1. When did you start playing your instrument?

2. How long have you played an instrument?

3. How would you describe the mood of the music you play most often?

4. Do you enjoy playing music?
   Do you feel more confident when you play music?

5. Do you feel nostalgic when you play music?

6. Do you feel comforted when you play music?

7. Do you feel angry when you play music?

8. Do you feel sad when you play music?

9. Do you feel awe when you play music?

10. Do you feel afraid when you play music?

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Deriving and Verifying a Community Vitality Index through a Machine Learning Model Based on House Price Data

By Mark Li

Author Biography

Mark Li is a junior at Avon High School in Avon, CT. He is currently the captain of the AHS Coding Club and the founder of the Steel City Codes Hartford Region. He is interested in STEM and social sciences, having qualified for AIME, the USPHO Semifinal, and the USACO Gold Division. He is researching how to enhance test traceability with large language models. Additionally, Mark is involved in community service and serves as an advisor at the Hartford Community Fund. He aspires to use technology to help communities in need, fostering sustainable development and equitable opportunities for all.

Abstract

Recognizing the complexity and limitations of the approach to produce a traditional Multi-dimensional Community Index (MD-CVI) as well as high cost and time-intensive, the study explores another approach that establishes a machine-learning model to derive a community index by leveraging contemporary house prices. This method has several significant advantages over traditional methods, providing a more efficient and reliable way to assess community well-being. The model produces a dynamic Community Vitality Index (CVI) that quickly captures changes within a community and enhances the MD-CVI's sophistication by selecting and combining any geographic regions generated by clustering algorithms, employing machine learning model and house sold price reduces human errors from questionnaires, and potentially improves accuracy. The study also exemplified and verified the model via house data from Minnesota, Texas, and Connecticut, spanning the last five years. Subsequently, comparing the house-price-based CVI with traditional MD-CVIs reveals a consistent alignment in their community index rankings. The conclusion is that the house-price-based CVI, as second research, is a viable proxy and a benchmark for a traditional MD-CVI, indicating an innovative approach for the stakeholders, including the government, education institutions, health and welfare organizations, etc. in assessing community well-being and making informed policy decisions regarding the flow of public funding of community-based projects. This research has the potential to significantly impact policy decisions, ensuring that public funding is directed to the communities that need it most.

Keywords: Real-Time Community Vitality Index, Multi-Dimensional Community Index, House-Dependent Factors, Location-Dependent Factors, House Price, Census, and Machine Learning

Introduction

A Community Vitality Index (CVI) provides a comprehensive overview of community well-being. (Curtis et al., 2012). Governments, non-profit organizations, researchers, and even private companies have used various community indexes to assess and measure a community's vitality and allocate funding accordingly. A traditional multi-dimensional CVI (MD-CVI) typically involves collecting data from multiple aspects of a community, such as demographics, employment, and Census. Traditional CVIs rely on collecting surveys and Census information updated once every decade, and CVIs are adjusted annually based on extrapolation instead of actual community changes. The process is complex, resulting in significant delays in CVI updating, thereby limiting the MD-CVI's ability to capture urgent matters in community dynamics. To address the discreteness of a traditional MD-CVI, this study introduces a machine-learning model to derive a community index from house prices, which reflects the combined influence of various factors affecting the real estate market and the community's overall well-being simultaneously.

Two categories of factors influence house prices: those directly linked to the physical house structure, referred to as "house-dependent factors," and those tied to the overall health of a community, referred to as "location-dependent factors." The study formulates an index for evaluating the impacts of location-dependent variables, representing the community vitality index. Numerous academic studies have demonstrated the influence of location-dependent factors on house prices. Communities offering a high quality of life, excellent schools, healthcare, and low crime rates tend to draw more residents. The high demand for housing in such communities can impact property prices. A study by Florida State University shows that a 10% increase in violent crimes within a neighborhood reduces house values by 6% in Miami-Dade County, Florida. (Goncalves, 2009) Attractive community amenities can positively impact the value of real estate. "Homes adjacent to natural resources like parks and open spaces hold an 8%-20% higher value than comparable properties." (Wolf, 2018). Rising housing prices suggest a community has a healthy economy, including a low unemployment rate, steady incomes, and a flourishing business environment, a critical component of overall community well-being. Therefore, the house-price-based index can serve as a proxy for the MD-CVI and will remedy the deficiencies of the traditional MD-CVIs, such as formidable data collection, inconsistent variables, coarse granularity, and static out-of-date data.

Materials and Methods

A house price is the cumulative impact of house-dependent and location-dependant factors. The relationship can be represented as the formula:
P = f (house-dependent factors) + g (Location-dependent factors) + e

Where P is the house price, f(x) is the cumulative impacts of house-dependent factors, g(x) is the cumulative impacts of location-dependent factors, representing the unprocessed CVI, and e is the error.

This study employs a proportioning algorithm to determine the optimal distribution of price value between the proto-CVI and the regression of the house-dependent factors concerning the least regression R2 value. The resulting CVI can be derived through the price split, as illustrated below:

Cumulative impacts of Location-dependent factors (CVI) = Price – Cumulative impacts of House Dependent Factors - Error

$$\sum \frac{|O_i - E_i|^2}{|E_i|}$$

The significance of the correlation is calculated through the Chi-Square test. Oi represents the vector of observed values, and Ei represents the vector of expected values.

2.1 Data Source and Two Overarching Parts of the Regression Model

Data Source: This study uses nearly 100,000 housing data fetched from the Redfin crossing Southern, Eastern, and Northern regions of the US.

House-dependent Factors: Square Footage, Square Footage of Heated Area, Lot Size, Number of

Rooms, Number of Bedrooms, Number of Bathrooms, The Number of Garages, Whether the house has a pool, Flooring material, External Siding material, Heating fuel type.

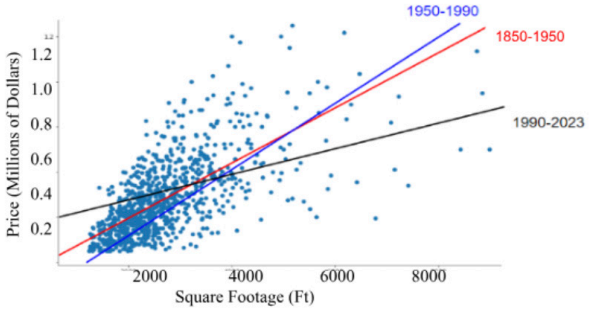
Location-dependent Factors: Crime Rate, Police Count, Number of Nearby Highways, Number of Nearby Local Roads, and Number of Nearby Service Roads.

The dataset was split into binary and non-binary variables, and categorical variables were converted into a series of binary variables.

2.2 Model Development

This study uses a hierarchical regression model (Price Determination Model ~PD-Model) to calculate housing prices and the CVI. It processed the continuous numeric, categorical, binary, and variables separately. Two primary factors, square footage and the segmented build year, were initially added as independent variables. The correlation is 0.6792.

Figure 1. *Year Partitioned Comparison of Sq. Footage and House Price*



The graph depicts the year-segmented relationship. It shows a direct relationship between square footage and housing price, indicating the use of regression.

Afterward, adding more factors into a multiple linear regression model forms a circular cluster, resulting in a reduced R2 value of 0.5381, indicating increased coherence among the model's variables. To address the data circulation issue, HDBSCAN and K-Means++ were applied to cleanse the datasets. K-means was paired with K-means++ to find the optimal number of clusters by location. They also identified outliers via the longitude and latitude of houses and clusters to control location-dependent factors. For Hartford County, location clustering graphed by MatPlotLib is shown below.

Figure 2. Housing Clusters in Hartford County, CT

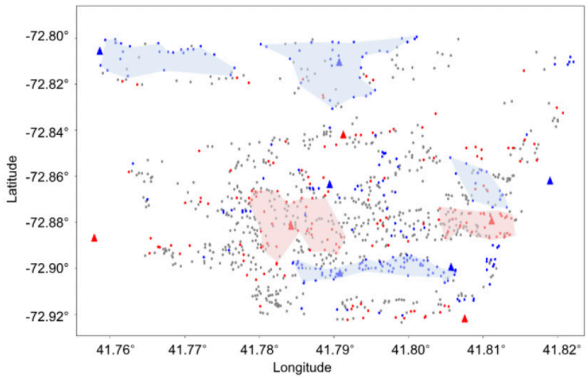


Figure 2 visualizes the regions where the community index is calculated, reflecting low and high house prices. K-means++ identified six high-priced, five low-priced, and ten medium-priced clusters. Red denotes house prices below $350,000, and blue indicates above $750,000. The shaded regions represent actual clusters of houses. Triangles represent clusters of houses.

In outlier detection clustering, HDBSCAN used a distance threshold between two neighborhood data points. If the shape of clusters is elliptical, the accuracy and the R2 value decrease significantly. To obtain the accuracy and reliability model, a clean function was created to remove outlier data in the three steps below to improve the accuracy to 0.7302.

1. HDBSCAN clustering produces a membership score for each data point. All data points with a membership score of 0.7 or higher were excluded, creating a controllable outlier removal system;

2. Linear regression analysis estimates the coefficient for each variable in the housing dataset;

3. The slope values defined two parallel hyperplanes, and the y-intercept was adjusted to encompass 65% of the data within the range of hyperplanes; other data was dropped.

Next, the result is adjusted for inflation as housing prices have increased by 30% since 2019. The inflation rate is obtained from the average price change. Finally, by weighting the proportions, 71.42% of the price was allocated to the house-dependent factors and 28.58% to the location-dependent factors (implying the CVI). The calculated CVI was normalized into the final index, subtracting N to make variance across different CVIs more apparent: Normalized CVI = Unprocessed Community Index - N

Results

The table below lists all the independent variables, coefficients, and confidence for house-dependent factors used in the regression analysis of location-dependent variables. The coefficients describe the strength of correlation and, thus, the importance of each house-dependent factor contributing to housing price and the ranking of the importance of location-dependent variables. The margin for statistical significance is 0.1 or less. The Confidence value used is a P-value from Chi-Square analysis. Categorical and Binary variables are handled separately in the regression model.

Table 1: *House Dependent Variables and Coefficient (* is Statistically Significance)*

House Dependent ~**Numerical Variables**		Coefficient	Confidence
Square Footage		2618*	0.088
Square Footage of Heated Area		149*	0.075
Lot Size		125*	0.018
No. of Rooms		1724*	0.047
No. of Bedrooms		1392	0.715
No. of Bathrooms		1102	0.692
House Dependent ~**Binary/Categorical Variable**		Coefficient	Confidence
Has a Pool?		19983*	0.045
Flooring	Has Hardwood Floor?	19276*	0.098
Exterior Siding	Wood or Other	-912	0.158
	Brick or Stone	15407	0.466
Heating Utility	Natural Gas or Oil	93	0.539
	Electric power	-463	0.572

Table 2: Location Dependent Variables and Coefficient

Location dependent Variable			Coefficient	Confidence	
				Individual	Combined
Location dependent Factors	Accessibility	No. of Nearby Highways	-5161	0.654	0.238
		No. of Nearby Local Roads	4353	0.476	
		No. of Nearby Service Roads	1043	0.142	
	Crime	Crime Rate Normalized(x1000)	-4.76	0.276	0.194
		Police Count	-102	0.445	
	Public Participation		92.4	0.120	

In a multivariate regression model, the factors can be displayed as such, where n is the number of variables, w is the list of all factor coefficients, y is the dependent variable, and n an independent variable:

$$C + \sum_{i=1}^{n} x_i \cdot w_i = y$$

The independent variables with the most significant magnitude of weightings impact the dependent variable the most. By extension, if a list of various terms (xi) is plugged into a multivariate regression, the xi terms with the most significant coefficient magnitude will have the strongest correlation overall. The above formulation can be used to determine the importance of the variables and, by extension, suggest a ranking system to measure how important each variable is to community vitality given the housing-based CVI.

The values in the Coefficient column in Table 2 ranked from most to least important were Accessibility, Crime Rate, and Public Participation sequentially. The correlation comparison produces a ranking of the least and most important factors towards community vitality. The government or a social welfare organization can establish a cutoff threshold to filter out a portion of funding applications and grasp the priority of applications, thereby mitigating the scenario faced by Flint, Michigan. Allocating government spending is fraught with oversight. Flint was overlooked in competitive federal grants since it could not maintain non-federal funding during a downturn in public health, civic participation, and employment, among other factors. (Jeff Arkin) By plugging the factor CVIs into the ranking system in this paper, a set of coefficients describing the importance of each factor is produced, allowing Flint to identify the most critical issues and enable

the community to apply for federal aid grants that effectively address their most pressing needs.

3.1 Verifying the accuracy of House-price-based CVI compared to traditional MD-CVI

The following figures compare the house-price-based CVI with traditional MD-CVIs for the towns of Greater Hartford County. This ensures that the CVI by PD-MODEL is reliable and the results are consistent with the values of conventional MD-CVIs.

Figure 3. *Scaled House-Price-Based CVI and Economic Innovation Group DCI*

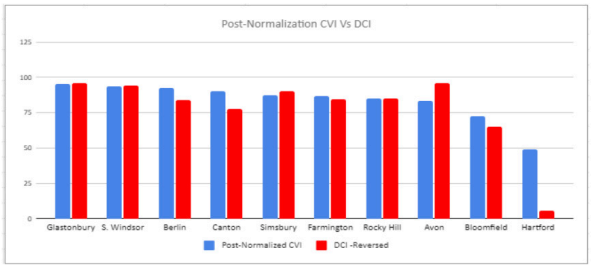


Figure 3 compared the house-price-based CVI with the Distressed Communities Index (DCI) developed by The Economic Innovation Group, a bipartisan public policy think tank. (Economic Innovation Group, 2017) The scale on the left describes the post-normalization scaled house-price-based CVI and the scale on the right represents the DCI.

Figure 4. *House-price-based CVI and DataHaven Community Well-being Index*

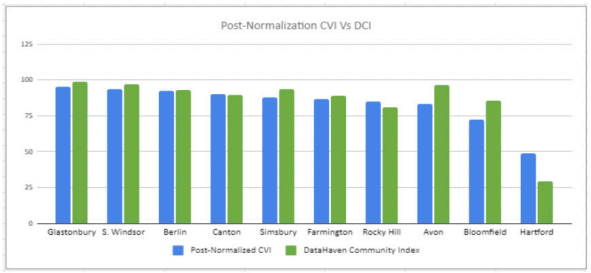


Figure 4 compared the house-price-based CVI with the Community Well-being Index developed by DataHevan. The two figures show that the town ranking of the house-price-based CVI consistently aligns with the town ranking in the two traditional MD-CVIs.

Figure 5. *Comparison of School Ranking, Scaled house-price-based CVI and DCI.*

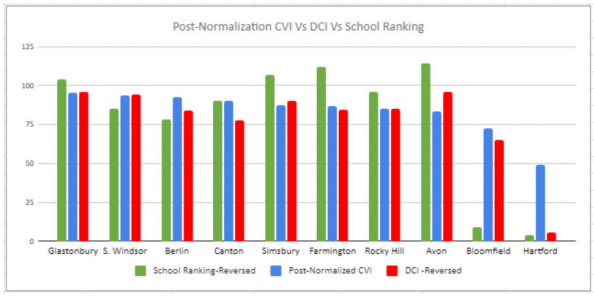
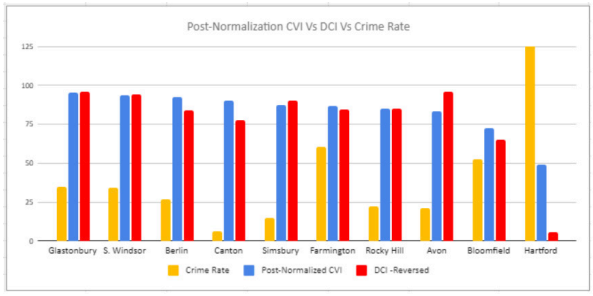


Figure 5 shows that school quality correlates well with the CVI, with both indexes coinciding with the school rankings. The school ranking, DCI, and normalized CVI are scaled to fit in one graph.

Figure 6. *Comparison of Crime Rate, Scaled house-price-based CVI, DCI*



There is a slight trend in terms of the crime rate. The crime rates are similar in communities with a higher vitality index or lower DCI. However, crime rates in areas with high DCI or low vitality index are much higher. Hartford was not included due to its exceptionally high crime rate and DCI preventing scaling of the other crime rates. Note: The data for Hartford/NE Hartford overshoots the graph. The crime rate was obtained from Census Information.

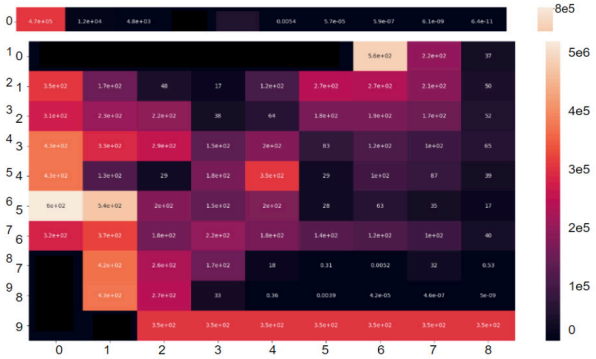
3.2. Exemplification

The figures below showcase PD-MODEL being applied to other metro areas. They depict the average house price of each grid square by region

of Zipcode combinations. Light colors indicate high prices, while dark colors represent low prices. The similarity and high accuracy enable the utilization of PD-MODEL for any community. It will produce a community region and a valid CVI for it.

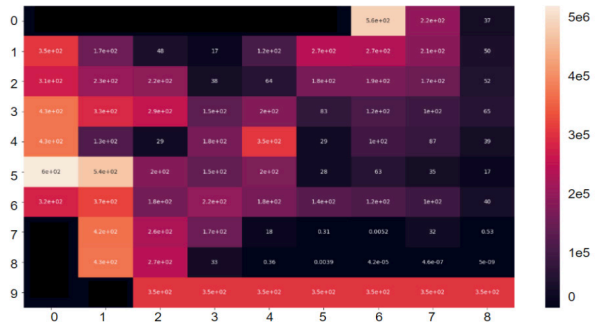
Figure 7. *Heatmap of average housing prices (Greater Hartford County, CT)*

The high-valued house cluster is at (2,1) because the high-valued region at (4,0) pulls the center to (2,1).
Figure 8. Heatmap of average Texas housing prices (Plano and Houston, TX)



High-valued house cluster is at (1,8).

Figure 9. *Heatmap of average Minnesota housing prices (Plymouth and Minnetonka, MN)*



High-valued house clusters concentrated around (0, 5) and (6,0)

Discussion

The study validated the model based on single-family house prices in suburban areas, where the abundant data increases the model's accuracy. In rural areas where the house price data may not reach a specific density, sparse data can make it difficult for the models to generalize effectively and capture the underlying patterns in the data. In urban areas, different features, such as renting homes, proximity to public transportation, amenities, and population density, may influence the community index differently compared to suburban areas. Therefore, the model must be fine-tuned to accommodate the data pattern in rural or urban areas.

The initially stated goal of the house-price-based CVI model is to provide a synthesized view of various factors affecting the real estate market and the community's overall well-being through a new methodology, showing its advantage in simplicity, accessibility, and real-time monitoring. It may not capture different communities' nuances or unique characteristics and dynamics. In future studies, we endeavor to enhance the conceptual model to address these issues. The work is underway.

PD-MODEL computes the CVI results using data from each house within the zip code area. As data for individual houses was unavailable within census tracts, the CVI wasn't standardized based on them. Nonetheless, this model remains applicable to census tracts, provided they can link and furnish addresses for individual houses.

As each CVI determination region becomes geographically smaller, the effects of sparsely distributed outliers become more significant. For example, even though crime rates usually tend to concentrate on specific "Crime Hotspots," isolated instances of crime still occur in areas with very low concentrations. In a particular case, a region with an outlier crime rate can disproportionately negatively impact the vitality index. Consequently, important factors with sparse distribution may introduce inaccuracies when using smaller areas and data subsets.

Conclusion

This paper adopts an agglomerative hierarchical regression model to derive a community vitality index from house sales information. It examines its close correlation with other existing multi-dimensional community well-being indicators. The house-price-based CVI reflects the collective impacts of the indicators showing a community's well-being.

The house-price-based CVI can be updated based on the latest house sales data, and the community can immediately show its ever-changing dynamics before the census data. It can provide real-time insights into the spatial distribution of economic well-being during economic and social volatility. The level of details in the house sales information determines the CVI's granularity, such that the CVI's flexibility for both small and large areas allows users to create their search criteria on either a city, a county, or a geographic region controlled by zip code combinations. The house-price-based CVI is not intended to offer a complete and definitive view of a community but a new perspective different from traditional multidimensional CVIs. It should be used as a proxy for conventional multidimensional CVIs. Policymakers, organizations, and researchers can use it as a benchmark to verify the effectiveness of traditional multidimensional CVIs and different community-based funding allocations. The PD-CVI model functions as a validation tool, specifically evaluating human intervention within the MD-CVI to refine its value further. I hope this work can attract more curiosity and encourage participation in the ongoing effort to improve our understanding of the community's vitality to identify areas of need.

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The Dream of St. Ursula by Carpaccio: What it Reveals About Late 15th Century Female Spirituality

By Nina Zhang

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Abstract

In June of 2023, the National Gallery of Art in Washington D.C and the Palazzo Ducale in Venice concluded an extremely rare exhibition on Carpaccio's art. Carpaccio's art has rarely left Venice, as his most important works are too large or too fragile. This exhibition, the first exhibition of Carpaccio's art outside Italy, has slowly reinvigorated interest in Carpaccio's works. Though often overshadowed by his contemporaries, Giovanni Bellini, Giorgione, and Titian, Carpaccio is the most effective in conveying the realistic Venice in 1500. (Butterfield, 2023) This paper takes Carpaccio's most renowned piece of work, the Cycle of Saint Ursula, to investigate the extent of female power in the household and the religious sphere, referencing historical sources and analyzing the contents of St. Ursula's room. This paper argues that women in Venice in the late 15th and early 16th centuries were restrained rather than empowered by intertwined responsibilities in the domestic and spiritual spheres.

Keywords: Vittore Carpaccio, Saint Ursula, The Cycle of Saint Ursula, The Dream of St. Ursula, Venice, Quattrocento, Cinquecento, Venetian Art, Feminist interpretation, Female Spirituality, The Golden Legends

The Dream of St. Ursula by Carpaccio: What it Reveals About Late 15th Century Female Spirituality

The Dream of St. Ursula by Carpaccio is an oil painting created in 1490 as part of the series Cycle of Saint Ursula for the Venetia Chapel Scuola di Santa Orsola. Now displayed at the Galleries of the Academy of Venice, the narrative cycle highlights the significant events of St. Ursula's life. Unlike the other panels that depict the landscapes, in this particular panel, the Dream of St. Ursula, Carpaccio invites the viewer into the interiors of a spacious room, enhanced by uniform lighting. The floors, walls, and ceilings of the room are modestly decorated with delicate furnishing. On the left, St. Ursula rests serenely on her bed, which, with its tall bed posts, takes up almost the entirety of the room. St. Ursula faces the door on the right, from which an angel walks in amid rays of golden light that illuminate the room.

To give a brief overview of the tale of St. Ursula, according to the Golden Legend, a compilation of the stories of Saints from c. 1290. St. Ursula was born a Christian princess of Britain, daughter of Maurus (or Notus). As a young girl, she was distinguished by "her virtuous life, her wisdom, and her beauty", and was famed for her holiness and purity and her always delightful speech. (Ryan & Duffy, 2012, p. 642) It is said that "Lovelier woman there was not alive." (Ruskin, 1912, sec. 12) The words of praise were then so wildly circulated, in no time they reached the ears of the King of Anglia, who, pleased by Ursula's supposed perfection, entreated with lavish gifts and malicious threats to have Ursula betrothed to his son. Though her father King Maurus was reluctant upon the request, with Ursula's consent he gave his blessings. It was, however, based upon conditions that Ursula herself proposed, which the King of Anglia readily agreed upon. The conditions are as follows: both the King of Anglia and his son are to be baptized, while Ursula would be allowed a three-year pilgrimage accompanied by a thousand virgins. As the marriage was settled, Ursula set off on her pilgrimage. In her trip, Ursula spread the Christian faith to her followers and to wherever she set foot. She passed through Cologne, Basel, and Rome, where the Pope joined the party too. Unfortunately, her spiritual influence threatened the Roman commanders Maximus and Africanus, who sent word to Julius, the commander of the Huns, to slaughter the procession at Cologne. Hence, the virgins, the accompanying bishops, and the newly arrived—Ursula's husband, mother-in-law, and sister-in-law-- were butchered by pagans and martyred at Cologne. (Ryan & Duffy, 2012, pp. 642–645)

The Golden Legend's account of St. Ursula was most likely roughly similar to what Carpaccio understood of St. Ursula's tale, since from 1470 to 1530, The Golden Legend was also one of the most widely reproduced books in Europe. (Fordham University Medieval Sourcebook: The Golden Legend (Aurea Legenda), n.d.) Yet, Carpaccio took his liberties to modernize St. Ursula, a princess from the early Middle Ages, supposedly martyred 238 AD, by depicting her as a pious young girl in upper-class 15th-century Venice, as one would infer from the interior design of St. Ursula's room. (Ryan & Duffy, 2012, p. 645) The two window frames on the opposite wall show Venetian architectural tendencies in the Renaissance to reintegrate Roman classical forms, merging these inspirations into Venetian structural elements. The upper portion of the frame is round with a large radius, while the lower portion is in the form of a pilaster, whose capital is a stylized and compressed ionic column. The painting similarly includes Renaissance Venetian stylistic innovations of the period. Notice that the windows are pedimented with glass. The practice is newly introduced to Venetian architecture in the late 15th and early 16th centuries. Similarly, the bed in which St. Ursula rests is also uniquely Renaissance Venetian. Structured in light and sturdy iron, decorated with a cloth canopy, and raised at the base by painted chests; it frequently reappears in recorded 15th-century Venetian inventories (Brown, 1997, p. 117). In addition, St. Ursula's room is dotted with expensive furniture signifying her status. Like most aristocratic Venetian homes, the ceiling is coffered, and the tile floors are covered with luxurious carpets imported from the east. (Brown, 1997, p. 230)

Carpaccio's artistic decision to modernize St. Ursula may raise some eyebrows. Some may even question if that was truly Carpaccio's intention. It was. The Cycle of St. Ursula spearheaded the artistic style popular in the 1500s which Patricia Fortini Brown termed the "eyewitness style". Unlike medieval fantastical styles that also fascinated the public with mystique, the eyewitness style's purpose

is to "create believable portrayals of sacred events through a naturalism of execution and an attention to the details of figures and setting" (Morse, 2007, p. 153). Carpaccio practices both styles, and his painting Saint George and the Dragon perfectly encapsulates the former. (Fig.5) However, in this case, Carpaccio makes the deliberate choice to paint in the "eyewitness style" to, firstly, emphasize the actuality of St. Ursula's life events by placing them in a Renaissance Venetian setting familiar to his audience, and second, underline her virtue through according to Venetian standards of female religious piety. Therefore, while it is a religious work of art, an ode to the sanctity of St. Ursula, it also incorporates the style of a genre painting. With an "objectivity that reminds one of Vermeer", Carpaccio portrays scenes from Venetian private life, to reflect the ideal, the canon of Christian virtue for 15th century Venetian women. (The Dream of St Ursula by CARPACCIO, Vittore, n.d.)

Like many Renaissance painters, Carpaccio fully exposes the interiors of St. Ursula's room in stunning realism, which was made possible by his skillful portrayal of space and detail. The spaciousness of the room is conveyed through Carpaccio's meticulous use of linear perspective, rendered by the rigid orthogonal lines depicted as the clear-cut edges of St. Ursula's bedroom. To reveal as much of the room's contents as possible, he makes some adjustments to the room's perspective, zooming out and shifting the vanishing towards the upper left. By this Carpaccio was able to depict, with greater detail, St. Ursula on the left and furniture next to the walls and on the floor. Due to his adjustments to perspective, all objects in the room are reduced to a small scale, dwarfed by the height of the bedroom ceiling, yet with Carpaccio's crisp style and accuracy, the viewer can recognize objects with no less clarity. For instance, at first glance, one immediately notices the decorative undulations of St. Ursula's bedposts, despite them being extremely thin. (Fig. 1) As a result, many scholars (many of whom I have cited in this essay) have referenced this painting in discussing Venetian domestic norms, due to the fact many items in the room can be easily identified. I have also referenced many items previously in identifying the room as Venetian and will continue citing them in discussion of Carpaccio's representation of Venetian Christian piety.

The first and most important item in the room is attached to the walls behind St. Ursula's bed: a religious painting for private devotion. (Fig. 3) Often referred to as fornmenti in Venice, devotional paintings are usually portraits of Madonna and Child, hung with a votive candle or lamp in front and a metal container filled with holy water underneath. (Morse, 2007, pp. 166, 168) The significance of the fornmenti lies in its function as an "unofficial focal points for religious meditation", much like a private altar. (Morse, 2007, p. 168)

As the devotional painting creates one space for religious meditation, books create a second one. Venice was an important center of book production at the time, with Books of Hours, the Divine Office, Breviaries, Psalters, missals, hagiographic literature, and the Bible being the most popular. (Morse, 2007, p. 166) In the far-right corner, in what seems like a reading space, we find a three-legged stool next to a table, both covered in crimson cloth. Books are scattered on the table, along with an hourglass. Next to it is a cupboard, which, with its doors ajar, reveals books, some organized and stacked neatly, some flipped open to indicate Ursula's studies.

The placement of religious paintings and religious books within a domestic setting is a sign that Venetian understanding of the religious piety of women extends to secular spaces. Religious objects are juxtaposed with lighthearted forms: a white dog crouched by the bed, and two blue slippers scattered by the bedside that St. Ursula had probably taken off before climbing into the sheets. Carpaccio emphasizes the importance of persistent devotion not only by showing two religious spaces in one room, but also by showing them in use: the votive candle is lit in front of the devotional painting, and the books are left on the desks after a session of reading. Carpaccio's emphasis on consistent devotion most likely found its roots in the writing of authorities at the time, who took "the monastic ideal as a model for domestic spiritual behavior." (Morse, 2007, p. 170) For instance, Décor puellarum, printed in 1471 Venice, outlines a spiritual routine for young girls, which involves a series of prayers and chores that last throughout the day. (Morse, 2007, p. 170)

The above-mentioned objects reveal another religious expectation for 15th-century Venetian women: women were not just expected to own unfailing piety, there are also demanded to be dependable wives and mothers. In Venetian terms,

motherhood entails the responsibility of maintaining moral households and raising virtuous Christian children, which is primarily executed by the display of religious items acting as the "paradigm".(Morse, 2007, pp. 179, 180) St. Ursula, not yet a mother, is shown to offer moral and spiritual guidance to her husband instead, who, according to legend, converts to Christianity under her influence. Carpaccio highlights St. Ursula as a moral guide to her husband, appealing to his Venetian audience. He does so by including him in her pilgrimage with the virgins and her attendants, contradicting the account of The Golden Legends. (Morse, 2007, p. 110)

Carpaccio's depiction of the virgin also provides us with an abundance of information about Venetian understanding of Christian virtue for women. (Fig. 4) We find St. Ursula covered in a crimson red carpet, which captures the viewer's attention. St. Ursula lies stiffly, her limbs straight under the neatly spread bedsheets. Her physical form is concealed to deprive her of any sensuality or attraction. Little skin is shown except her face and her right upper arm, which are pallid in contrast with the vibrant red of the sheets, creating a sense of purity. St. Ursula's face is illuminated by the light coming in from the door, her head sunken within the smooth, unruffled pillows, her cheek resting on the palm of her right hand. With her eyes closed, her expression is serene and tranquil with sleep, but with her lips compressed she is solemn. Her figure is so thin, so fragile, rendering her almost childlike. Employing The Dream of St. Ursula as a symbol in his novel Il Fuoco in the 19th century, D' Annuzio underlines, correctly, the childlike qualities of St. Ursula in this painting: "Infantia is the simple word that radiates morning freshness around the head of the sleeping saint…..Chaste and naïve". (Meyers, 2013, p. 187) Thus, it could be inferred that the Venetian interpretation of Christian virtue for women consists of childlike innocence but not childish imprudence, chastity, and reserve.

The Golden Legends has presented St. Ursula as a woman of independence and charisma who was incredibly influential. Not only was she an advisor to her father, as a princess she was not a powerless pawn in the grander scheme of things, but an autonomous individual who made her own decisions on marriage and even drafted the terms for it. Being a proactive leader of a thousand virgins and a successful advocate of the Christian faith comes to show her leadership and authority as a woman. The historical St. Ursula would not have appealed to Renaissance Venetian conventions, since her virtue is of a very different kind compared to Renaissance Venetian expectations for female virtue, which Carpaccio certainly takes into account when communicating her piety and devotion to his audience. Through analyzing the deliberate choices of Carpaccio in The Cycle of St. Ursula, and this panel in particular, we find the implementation of feminine virtue is restricted to domestic spheres in Renaissance Venice, their influence confined to her husband and her children. In traditional scenes where St. Ursula asserts her dominance in the public sphere, her presence is arbitrarily dimmed. In public spaces, instead of being illustrated in proactive leadership positions she is prescribed in The Golden Legends, she is shown as a "passive object of others". (Rodini, n.d., p. 98) Only in the dream scene is she finally the prominent figure, because according to Venetian standards, it's where female virtue belongs—within enclosed boundaries of the home.

In conclusion, Carpaccio adapts the story of St. Ursula from The Golden Legends to align with Venetian values of virtue. Thus, by analyzing the cycle, The Dream of St. Ursula in particular, we were able to reveal the religious expectations Venetian society held of women in the late 15th and early 16th centuries. Venetian society expected women to be consistent in their religious practices, frequently worshiping and reading throughout the day. They were tasked with offering religious guidance to their families: their husbands and their children by setting up religious items throughout the house. Female virtue was defined by innocence and chastity because they were expected to be pure but still aware of and compliant with strict Christian decrees. Lastly, Venetian women were presumed to exercise their virtue only within their households, under the dominion of their male supervisors, whether that be her father or husband.

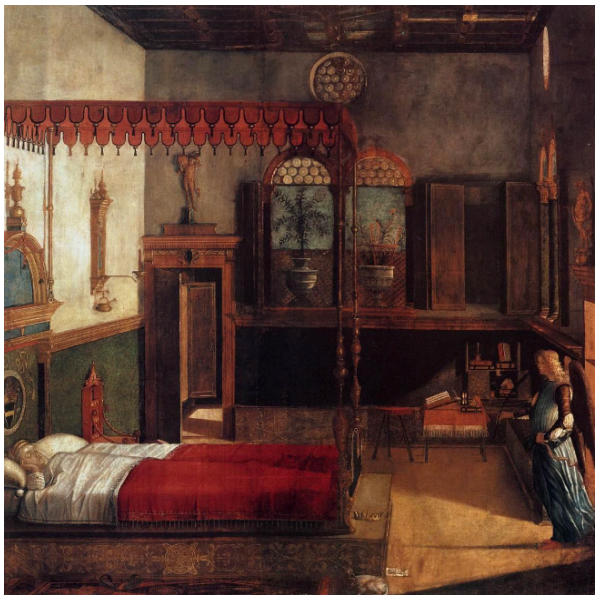
Figure 1 The Dream of St. Ursula by Carpaccio in full


Figure 2 The Dream of St. Ursula detail


Figure 3 The Dream of St. Ursula detail

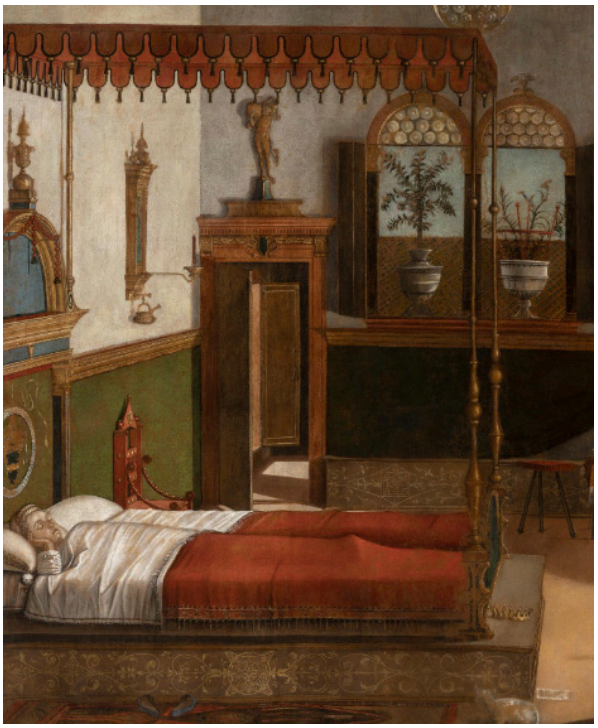
Figure 4 The Dream of St. Ursula detail

Figure 5 Saint George and the Dragon by Carpaccio

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Ideology - Partisanship Alignment and Quality of Democracy: A Correlational Study

By Hengrui Zhu

Author Biography

Hengrui Zhu is a junior at BASIS International School Park Lane Harbour in Guangdong China. His interests include Philosophy, Ethics in Society, and Public Policy. Currently, he is studying moral methodology in meta-ethics and normative ethics, and, based on his study of why things matter, pursuing arguments in applied ethics in informing us of what we owe each other and therefore how we should live our lives.

Abstract

This paper identifies whether a correlation exists between the extent to which a democracy is programmatic and the quality of its democracy. In order to achieve the objective, the research will:

1. Develop an indicator for the Programmatic Score of democracies.

2. Assess if there exists a significant correlational relationship between the programmatic score of countries and their respective quality of democracy.

This paper devises the Programmatic Score of democracies as an indicator of the extent to which voters vote based on their ideology, instead of other factors such as socio- economic and racial status.

To achieve objective 1, the paper uses Wave 7 of the World Value Survey to determine the proportion of the voting population that votes for the party and the ideological composition of the voters of the party. To achieve objective 2, the paper determines the quality of democracy to be Freedom House's Freedom Score of the country, with countries rated 70 or above characterized as democracies.

Keywords: programmatic, ideology, voting, quality of democracy, economic incentive, issue-voting, non-economic issue, party representation, geographical clustering, multi-party

Ideology-Based Voting and Quality of Democracy: A Correlational Study

Although written records of partisanship, or political factions, can be dated back to Plato's mention of the political factions of Classical Athens in his Republic, modern political parties are considered to have emerged in late 18th century Europe (Conservative Party of the United Kingdom) and the United States of America (Democratic Party) that extended politics to the general public, where the concept of the electorate is conceived and civil democracies featuring more competition began.

By the early 19th century, Western European politics, in countries like Sweden, Belgium, Switzerland, Germany, and France, began to be increasingly centered around parties divided by the liberal-conservative dichotomy, a phenomenon intensified by the 1848 revolutions. The early 20th century saw the emergence of the socialist party disrupt the ideology-dependent division of political parties in Europe.

There exists mainly two possible motivations for one to vote for a party — one's ideological standing matching that of the party's, or one being economically incentivized to vote for the party. For example, one's views on issues such as abortion and LGBTQ+ rights may align with a party's policies, causing one to, thus, vote for the party. On the contrary, one might vote for a party with policies on issues, such as abortion, that are opposite to one's views because the party provides him with economic incentives, such as preferable tax policies. The extent to which a country is programmatic is the extent to which the voters of the country vote based on ideology, which is not limited to non-economic issues. For example, a voter might ideologically support the government in helping the poor, while resent that the money is coming out of his bank account. In a scenario in which two countries have the same number of such voters, the country with more votes for the party that proposes government support policies would be considered more programmatic. In a world in which economic incentives always trump ideology, the democracy with better voter representation is hypothesized to be more programmatic. For example, there exists democracy A and democracy B in world W, in which the only non-economic issue is the justifiability of abortion, and the only economic issue pertaining to ideology is the fairness of redistribution. In democracy A, there exists only two parties, Party A1 and Party A2. Party A1 is anti- abortion and anti-redistribution, while Party A2 is pro-abortion and pro-redistribution. If a voter is of relatively lower socio-economic status, the person would most likely be pro- redistribution (Brown-Iannuzzi et al., 2017). Also assume that the person is anti-abortion. If the person is more programmatic than 0.5, he would more likely vote for Party A1. If the person is less programmatic than 0.5, he would more likely vote for party A2. This paper aims to investigate whether there exists a correlation between a democracy's Programmatic Score and its quality of democracy as the first step to a series of research to establish a causal relationship between a democracy's Programmatic Score and its quality of democracy and investigate whether it is the difference in extent of representation or qualitative differences between voters of different countries (e.g. voters of democracy A tend to vote based on ideology than voters of democracy B) that accounts for some countries having a higher programmatic score than others. If qualitative differences between voters of different countries are found to account for differences in Programmatic scores of countries, future research could set out to find the reason.

Literature Review

Research has established that higher socio-economic status is negatively correlated with (Andersen & Curtis, 2015; Brooks & Brady, 1999) support for redistribution. Interestingly, lottery winners were shown to be more hostile towards redistributive politics than non-lottery winners (Doherty et al., 2006). Research has also established that subjective socio-economic status causes differences in redistributive preferences and ideology, such as considering inequality as fair or unfair (Brown-Iannuzzi et al., 2017). Research has found a lack of significant correlation between socio-economic status and non-economic issues, such as abortion (Spaeth & Powers, 1984).

The Left-Right labeling mechanism, since its inception after the French Revolution, has formed a code of communication between politicians, parties, media, and voters and served as an instrument to help voters understand the political realm as labels and guides to navigate and orient citizens through a mass of political messages and shaping attitudes and choices. This mostly occurred in countries where the establishment of democracy was not suspended by various forms of fascism and totalitarianism, including extra-European countries like Australia and Canada. Over time, the left and right have offered citizens of multiparty polities a compass either to organize their knowledge and locate themselves in a political arena made up of "us and them." Stability and comprehensiveness have allowed "left" and "right" to serve as devices to simplify citizens' choices and to affirm their political identity within and beyond the borders of national polities.

Time and the media have allowed "left" and "right" to take the features of stable postures towards politics that distinguish people one from another. Ultimately, "left" and "right" have become common heuristics across countries for tracing the manifold political offers of parties to more basic political views, and thus to summarize, distinguish, and compare the various political platforms of governments and of their oppositions. For example, one might first learn that certain policies, such as a high level of government intervention in the economy and a "pro-choice" stance on abortion, is categorized as "left", which then helps him navigate through the stances of parties, simplified by the media as "left", "right", or "centrist". One might also be socially primed to attribute normative values to these labels. For instance, the Black U.S. population, although no less ideologically diverse than other ethnicities, overwhelmingly vote democrats, many of whom normatively viewing the "left" as good and the "right" as bad (Dombroski, 2020).

Overall, there is little existing literature on the extent to which ideological voting relates to quality of democracy.

Methodology

This section presents the method with which the extent to which voters of a country vote based on ideology is determined.

Quality of Democracy and Analyzed Countries

This paper first determines the quality of democracy to be assessed with the Global Freedom Scores by Freedom House (or Freedom House Score), and only qualifies countries with a Freedom House Score of 70 or above as a democracy. A country will be analyzed if and only if it: 1) it has been rated with a Freedom House Score equal to or above 70 throughout 2017-2022 (the time-frame of Wave 7 of the World Values Survey) and 2) data of some of its parties' economic-left-right scale is available on V-Dem.

Table 1
List of Analyzed Countries

Country	Freedom House Score
Sweden	100
Finland	100
Norway	100
New Zealand	99
Canada	98
Netherlands	97
Denmark	97
Switzerland	96
Uruguay	96
Japan	96
Portugal	96
Slovenia	95
Australia	95

Country	Freedom House Score
Germany	94
Estonia	94
Taiwan	94
Iceland	94
Chile	94
Austria	93
United Kingdom	93
Cyprus	92
Spain	90
Slovakia	90
Italy	90

Country	Freedom House Score
Lithuania	89
France	89
Latvia	88
Greece	86
Argentina	85
Croatia	84
Mongolia	84
United States of America	83
Romania	83
South Korea	83
Poland	81
Ghana	80
South Africa	79
Brazil	72
Colombia	70
Ecuador	70

Programmatic Score

To capture the extent to which voters of a country vote based on ideology rather than other factors, the paper devises the concept of "Programmatic Score", which can range from 0 (no votes are based on ideology) to 1 (all votes are based on ideology). A country's Programmatic Score is the sum of the Programmatic Score of its parties; the formula for which is "Percentage of Programmatic Voters out of all voters" * "Percentage of voters of the

party over the total voting population". The second half of the formula takes the size of the party into consideration (i.e.., a country with a sizable party having a Programmatic Score of 0.9 and a miniature party having a Programmatic Score of 0.1 should have a higher Programmatic Score than a country with a miniature party having a Programmatic Score of 0.9 and a sizable party having a Programmatic Score of 0.1).

To determine the Programmatic Score of a party, this paper first determines its size, then determines the ideological position of the party on the left-right scale.

The size of the party is the percentage of voters of the party over the total voting population, calculated with the following procedure:

1. On World Values Survey, select wave, which, if the availability of V-Dem data permits (I.e., at the time of writing, the most up-to-date V-Dem data is 2018), would preferably be the most recent (which, at the time of writing, would be Wave 7 (2017-2022)). As "percentage of voters of the party over the total voting population" is wave-contingent, wave-switching will obscure accurate observation. Thus, it is advised to use the same wave for all parties in a country. If there are significant shifts in the ideological position of the party, it is advised to exclude the party from analysis.

2. Select country. The country must both have a Freedom House score of equal to or above 70 and Economic-Left-Right data of its parties must be available on V-Dem.

3. In "Survey Questions", search "Which party would you vote for if there were a national election tomorrow" and click "Show".

Figure 1
Response of Question Q223 — "Which party would you vote for if there were a national election tomorrow" on World Values Survey, Wave 7.

Q223.- Which party would you vote for if there were a national election tomorrow

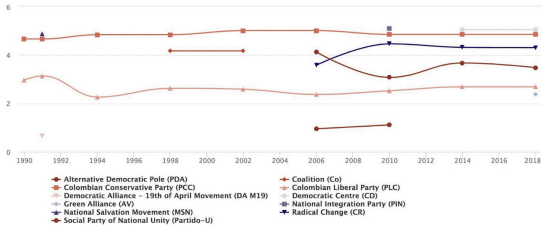
Cross by
-- None selected --

	Number of cases	%/Total	Cumulative %
No right to vote	61	4.0%	4.0%
I would cast a blank ballot; White vote	204	13.4%	17.4%
COL: Colombian Conservative Party	112	7.4%	24.8%
COL: Colombian Liberal Party	211	13.9%	38.7%
COL: Social Party of National Unity	83	5.5%	44.1%
COL: Radical Change	44	2.9%	47.0%
COL: Partido Independiente de Renovación Absoluta	10	0.7%	47.7%
COL: Green Alliance	75	4.9%	52.6%
COL: Alternative Democratic Pole	56	3.7%	56.3%
COL: Progressive Movement (Colombia)	31	2.0%	58.4%
COL: Democratic Center Party	179	11.8%	70.1%
No answer	454	29.9%	100.0%
(N)	(1,520)	100%	

Selected sample: Colombia 2018 (1520)

4. Because the Programmatic Score concerns only the extent to which voters vote based on ideology, only voters should be considered, and thus responses with "No right to vote", "I would cast blank ballot; White vote", and "No answer" should be eliminated, thus changing the number of total responses (N).

Figure 2
List of Parties of Colombia on V-Dem



Furthermore, only include parties that have data available on both World Values Survey and V-Dem. In the case of Colombia, for example, the Colombian Conservative Party will be analyzed, while the Progressive movement will not.

Figure 3
Side-by-side: World Values Survey data before and after excluding non-voters and parties without available data

Base=1520; Weighted results	Number of cases	% of Population
No right to vote	61	4%
I would cast a blank ballot; White vote	204	13.40%
COL: Colombian Conservative Party	112	7.40%
COL: Colombian Liberal Party	211	13.90%
COL: Social Party of National Unity	83	5.50%
COL: Radical Change	44	2.90%
COL: Partido Independiente de Renovación Absoluta	10	0.70%
COL: Green Alliance	75	4.90%
COL: Alternative Democratic Pole	56	3.70%
COL: Progressive Movement (Colombia)	31	2%
COL: Democratic Center Party	179	11.70%
No answer	454	29.90%
	Total: 1520	Total: 100%

	Number of cases	% of Population
COL: Colombian Conservative Party	112	7.40%
COL: Colombian Liberal Party	211	13.90%
COL: Social Party of National Unity	83	5.50%
COL: Radical Change	44	2.90%
COL: Green Alliance	75	4.90%
COL: Alternative Democratic Pole	56	3.70%
COL: Democratic Center Party	179	11.80%
	Total: 760	Total: 50.1%

To determine Recalculated %Total of each party, divide the party's Number of cases by the Recalculated (N). The cumulative % should remain 100%.

Table 2

Recalculated (Valid) Percentages of the Voting Population who votes for analyzed Colombian parties

	Number of cases	% of Population	Valid % of Population
COL: Colombian Conservative Party	112	7.40%	14.77%
COL: Colombian Liberal Party	211	13.90%	27.74%
COL: Social Party of National Unity	83	5.50%	10.98%
COL: Radical Change	44	2.90%	5.79%
COL: Green Alliance	75	4.90%	9.78%
COL: Alternative Democratic Pole	56	3.70%	7.39%
COL: Democratic Center Party	179	11.80%	23.55%
	Total: 760	Total: 50.1%	Total: 100%

After determining the size of the party, the paper now determines the ideological composition of the voters of a party by the following procedures.

On World Values Survey, cross "Which party would you vote for if there were a national election tomorrow" with "Left-Right political scale" and select "Show Row% (exclude DK/NA)". This paper categorizes voters who identify with 1-2 as left, 3-4 as center- left, 5-6 as center, 7-8 as center-right, and 9-10 as right.

Table 3

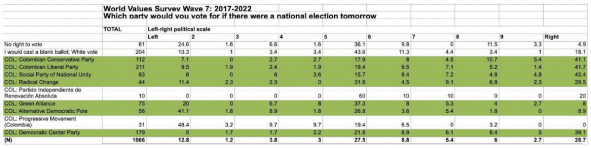
Raw response of "Which party would you vote for if there were a national election tomorrow" crossed with "Left-Right Political Scale" for Colombia on World Values Survey, Wave 7

World Values Survey Wave 7: 2017-2022
Which party would you vote for if there were a national election tomorrow

	TOTAL	Left-right political scale									
		Left	2	3	4	5	6	7	8	9	Right
No right to vote	61	24.6	1.6	6.6	1.6	36.1	9.8	0	11.5	3.3	4.9
I would cast a blank ballot; White vote	204	10.3	1	3.4	3.4	43.6	11.3	4.4	3.4	1	18.1
COL: Colombian Conservative Party	112	7.1	0	2.7	2.7	17.9	8	4.5	10.7	5.4	41.1
COL: Colombian Liberal Party	211	9.5	1.9	2.4	1.9	19.4	9.5	7.1	5.2	1.4	41.7
COL: Social Party of National Unity	83	6	0	6	3.6	15.7	8.4	7.2	4.8	4.8	43.4
COL: Radical Change	44	11.4	2.3	2.3	0	31.8	4.5	9.1	6.8	2.3	29.5
COL: Partido Independiente de Renovación Absoluta	10	0	0	0	0	60	10	10	0	0	20
COL: Green Alliance	75	20	0	6.7	8	37.3	8	5.3	4	2.7	8
COL: Alternative Democratic Pole	56	41.1	1.8	8.9	1.8	26.8	3.6	5.4	1.8	0	8.9
COL: Progressive Movement (Colombia)	31	48.4	3.2	9.7	9.7	19.4	6.5	0	3.2	0	0
COL: Democratic Center Party	179	5	1.7	1.7	2.2	21.8	8.9	6.1	8.4	5	39.1
(N)	1066	12.8	1.2	3.8	3	27.5	8.8	5.4	6	2.7	28.7

Table 4

Analyzed response of "Which party would you vote for if there were a national election tomorrow" crossed with "Left-Right Political Scale" for Colombia on World Values Survey, Wave 7, highlighted in green



World Values Survey Wave 7: 2017-2022
Which party would you vote for if there were a national election tomorrow

	TOTAL	Left-right political scale									
		Left	2	3	4	5	6	7	8	9	Right
No right to vote	61	24.6	1.6	6.6	1.6	36.1	9.8	0	11.5	3.3	4.9
I would cast a blank ballot; White vote	204	10.3	1	3.4	3.4	43.6	11.3	4.4	3.4	1	18.1
COL: Colombian Conservative Party	112	7.1	0	2.7	2.7	17.9	8	4.5	10.7	5.4	41.1
COL: Colombian Liberal Party	211	9.5	1.9	2.4	1.9	19.4	9.5	7.1	5.2	1.4	41.7
COL: Social Party of National Unity	83	6	0	6	3.6	15.7	8.4	7.2	4.8	4.8	43.4
COL: Radical Change	44	11.4	2.3	2.3	0	31.8	4.5	9.1	6.8	2.3	29.5
COL: Partido Independiente de Renovación Absoluta	10	0	0	0	0	60	10	10	0	0	20
COL: Green Alliance	75	20	0	6.7	8	37.3	8	5.3	4	2.7	8
COL: Alternative Democratic Pole	56	41.1	1.8	8.9	1.8	26.8	3.6	5.4	1.8	0	8.9
COL: Progressive Movement (Colombia)	31	48.4	3.2	9.7	9.7	19.4	6.5	0	3.2	0	0
COL: Democratic Center Party	179	5	1.7	1.7	2.2	21.8	8.9	6.1	8.4	5	39.1
(N)	1066	12.8	1.2	3.8	3	27.5	8.8	5.4	6	2.7	28.7

After determining the ideological stance of the voters of the party, determine the ideological stance of the party. There are no indicators that classify a party's ideological position specific to issue. For example, if Party A proposes a high level of state intervention in the economy, and Party B proposes highly progressive taxation, there are no indicators that can tell them apart ideologically, which is why the left-right scale has been historically prominent as a compass of political navigation.

The idea of the Programmatic Score, or PS, is that, if a voter identifies to be on the left of the scale, and if the party is on the left of the scale, then the voter would be programmatic if he votes for the party or other parties on the left of the scale. An objection to this method would be to say that the voter is programmatic only if he votes for the party that he CONSIDERS to be on the left. But the merit to abandoning the subjective identification is that it reflects that some countries might be more programmatic because the parties are more ideologically distinct or clear to the voter, and thus improving the accuracy of identification.

The main drawback of only having an economic-left-right indicator is that it identifies some programmatic voters as non-programmatic. For instance, in Germany, if Thomas is economically conservative and socially liberal, which aligns with the policy of the Free Democratic Party, he would most likely place himself as a centrist. While the FDP would be characterized by V-Dem as rightist. Thomas should be considered programmatic if he votes for the FDP, but would not be, with this paper's methodology. V-Dem characterizes a party on a scale of 0 (left) - 6 (right), assigning, for example, the Columbian Conservative Party a score of 4.854, while World Values Survey characterizes a party on a scale of 1-10.

Convert V-Dem scores to the World Values Survey scale by performing 1+3/2*V-Dem Score = Left-Right Score of the party. For instance, to determine whether the Colombian Conservative Party is on the left, center, or right, multiply 4.854*3/2+1 to convert the V-Dem six-point scale to the World Values Survey ten-point scale, which equals to 8.281, which this paper considers center-right for being closer to 8 than to 9.

Table 5

Ideological Positions of, Percentages of Population Who Votes For, and Ideological Positions of Voters Of parties of Colombia

Parties	V-Dem Characterization Converted to WVS Scale (V-Dem*3/2+1	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right
Colombian Conservative Party	Center - Right 8.281	14.77%	7.2%	6.4%	31.7%	24.6%	30.1%
Colombian Liberal Party	Center-Left 4.9105	27.74%	6.5%	7.2%	30.5%	25.8%	30.3%
Social Party of National Unity	Center-Left 6.07	10.98%	6.7%	4.8%	39.9%	21.2%	27.4%
Radical Change	Center-Right 7.590	5.79%	5.6%	11.2%	55.6%	11.1%	16.7%
Green Alliance	Center 4.554	9.78%	2.8%	16.7%	50%	11.1%	19.5%
Alternative Democratic Pole	Left 2.668	7.39%	20%	17.8%	44.5%	6.6%	11.1%
Democratic Centre	Right 8.5795	23.55%	6.7%	3.9%	30.7%	14.5%	44.1%
			1-2	3-4	5-6	7-8	9-10

After determining the ideological stance of the voters of the party and the ideological stance of the party, determine the extent to which the voters of a party are programmatic. This paper defines the programmatic ideological composition of voters of a party as the two positions closest to the categorized ideological position of the party. For example, voters who identify as center and center-right of a party with a V-Dem economic-left -right score of 6.5 would be considered programmatic voters of the party, while the rest are considered non- programmatic.

Table 6

In blue, Percentage Of Programmatic Voters Out of Total Voters of Party for every analyzed party of Colombia

Parties	V-Dem Characterization Converted to WVS Scale (VDem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right
Colombian Conservative Party	Center - Right 8.281	14.77%	7.2%	6.4%	31.7%	24.6%	30.1%
Colombian Liberal Party	Center 5.032	27.74%	6.5%	7.2%	30.5%	25.8%	30.3%
Social Party of National Unity	Center 6.223	10.98%	6.7%	4.8%	39.9%	21.2%	27.4%
Radical Change	Center-Right 7.4635	5.79%	5.6%	11.2%	55.6%	11.1%	16.7%
Green Alliance	Center 4.5535	9.78%	2.8%	16.7%	50%	11.1%	19.5%
Alternative Democratic Pole	Center-Left 2.668	7.39%	20%	17.8%	44.5%	6.6%	11.1%
Democratic Centre	Right 8.5795	23.55%	6.7%	3.9%	30.7%	14.5%	44.1%
			1-2	3-4	5-6	7-8	9-10

The Programmatic Score of a party is then calculated by multiplying the "Percentage of the Voting Population who votes for the Party" with the "Percentage of Programmatic Voters out of all the voters of the Party". The Programmatic Score of the democracy is the sum of the Programmatic Score of each of its parties.

Table 7.1

Programmatic Scores of parties of Colombia and Colombia

Parties	V-Dem Characterization Converted to WVS Scale (VDem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
Colombian Conservative Party	Center - Right 8.281	14.77%	7.2%	6.4%	31.7%	24.6%	30.1%	0.081
Colombian Liberal Party	Center 5.032	27.74%	6.5%	7.2%	30.5%	25.8%	30.3%	0.1046
Social Party of National Unity	Center 6.223	10.98%	6.7%	4.8%	39.9%	21.2%	27.4%	0.0671
Radical Change	Center-Right 7.4635	5.79%	5.6%	11.2%	55.6%	11.1%	16.7%	0.039
Green Alliance	Center 4.5535	9.78%	2.8%	16.7%	50%	11.1%	19.5%	0.065
Alternative Democratic Pole	Center-Left 2.668	7.39%	20%	17.8%	44.5%	6.6%	11.1%	0.0279
Democratic Centre	Right 8.5795	23.55%	6.7%	3.9%	30.7%	14.5%	44.1%	0.138
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.52

The Colombian Conservative Party is characterized as center-right and has a Programmatic Score of 0.081. The Colombian Liberal Party is characterized as center and has a Programmatic Score of 0.1046. The Social Party of National Unity is characterized as center and has a Programmatic Score of 0.0671. Radical Change is characterized as Center- Right and has a Programmatic Score of 0.039. Green Alliance is characterized as center and has a Programmatic Score of 0.065. Alternative Democratic Pole is characterized as Center- Left and has a Programmatic Score of 0.0279. Democratic Centre is characterized as right and has a Programmatic Score of 0.138. Colombia has a Programmatic Score of 0.52.

Results

The analyzed parties, their respective V-Dem characterization, the percentage of the voting population that votes for the party, the ideological standings of the voters of the parties, and the Programmatic Score, of each of the 40 countries are as follow:

Table 7.2

Programmatic Scores of analyzed Parties of Argentina and Argentina

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
ARG: Citizen's Unity, Cristina Fernandez de Kirchner	3.3265	38.85%	9.8%	27%	40.1%	14.2%	9%	0.014
ARG: Justicialist [Peronist] Party, Daniel Scioli, Florencio Randazzo	4.852	2.35%	7.3%	4.3%	51.5%	36.8%	0%	0.013113
ARG: Front for Victory	3.3265	20.08%	2.8%	9.2%	51.3%	21.9%	14.8%	0.12148
ARG: Republican Proposal, María Eugenia Vidal	7.273	10.95%	1.5%	9.2%	43.3%	28.9%	17.2%	0.07906
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.32

Table 7.3
Programmatic Scores of analyzed Parties of Australia and Australia

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
AUS: Australian Labor Party	3.751	37.30%	9.4	25.4	55.7	5.8	3.6	0.303
AUS: Liberal Party	6.7315	43.18%	3.4	5.8	50.8	28.6	11.4	0.343
AUS: Australia Greens	2.287	15.78%	22.1	31.5	40.9	4.7	0.8	0.0845
AUS: Australian Democrats	3.697	0.069%	37.4	0	62.6	0	0	0.0004
AUS: One Nation Party	7.5385	3.668%	0	5.4	47.5	24.6	22.5	0.0173
								Cumulative: 0.75

Table 7.4
Programmatic Scores of analyzed Parties of Austria and Austria

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
AUT: Freedom Party of Austria	7.3201	21.18%	2%	6%	31.7%	48.4%	12.1%	0.1697
AUT: Social Democratic Party of Austria	5.1655	31.76%	16.3%	37.9%	41.1%	4.2%	0.4%	0.2509
AUT: Austrian People's Party	6.583	32.61%	2.4%	7%	60.4%	27.5%	2.6%	0.2866
AUT: The Greens – The Green Alternative	4.1815	10.93%	28%	51.5%	20.1%	0.5%	0%	0.07826
AUT: NEOS – The New Austria	7.852	3.503%	4.5%	35.4%	46%	14.1%	0%	0.0049
								Cumulative: 0.79

Table 7.5
Programmatic Scores of analyzed Parties of Brazil and Brazil

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
Brazilian Democratic Movement	Right 8.281	19.9%	16.3%	7.7%	37.5%	10.6%	28%	0.056
Workers' Party	Center 4.91	48.57%	19.6%	11.6%	35.5%	7.3%	25.9%	0.1724
Brazilian Social Democracy Party	Center 6.07	14.52%	20.5%	12.2%	39.1%	10.9%	17.3%	0.0726
Democratic Labour Party	Center 4.393	5.99%	13.4%	14.9%	26.7%	16.7%	28.3%	0.0065312
Brazilian Labour Party	Center-Right 6.823	1.57%	0%	0%	66.7%	20.1%	13.3%	0.0042021
Communist Party of Brazil	Left 2.668	0.63%	37.6%	24.8%	37.6%	0%	0%	0.0039312
Brazilian Socialist Party	Left 3.735	5.06%	16%	18%	32%	28%	6%	0.0253
Socialist People's Party	Center 4.822	0.63%	28.5%	43%	0%	28.5%	0%	0.002709
Democrats	Right 8.166	2.20%	20.9%	12.6%	0%	8.3%	58.3%	0.014652
Progressives	Right 8.107	0.63%	25%	0%	50%	0%	25%	0.001575
Brazilian Republican Party	Center 7.63825	0.63%	0%	0%	60.2%	0%	39.8%	0.0025074
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.362

Table 7.6
Programmatic Scores of analyzed Parties of Canada and Canada

Canada

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
CAN: Liberal Party	4.014	33.57		28.1	39.7			0.23
CAN: Conservative Party	7.249	29.09			41	37.7		0.23
CAN: New Democratic Party	2.661	21.87	22.7	22.17				0.098
CAN: Bloc Quebecois	5.8825	8.02			47.2	13.6		0.049
CAN: Green Party	4.6495	7.46		22.9	43.6			0.050
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.66

Table 7.7
Programmatic Scores of analyzed Parties of Chile and Chile

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
CHL: Independent Democratic Union	8.5555	12.43781094533%	0	5.4	2.8	68.2	23.6	11.42%
CHL: National Renewal	7.5835	25.37%	1.2	18.9	17	40.9	22	15.96%
CHL: Christian Democratic Party	5.8495	11.44%	2.6	22.9	71.5	2.9	0	8.51%
CHL: Party for Democracy	4.582	17.91%	3.5	64.2	30.2	2.1	0	16.91%
CHL: Socialist Party of Chile	3.7705	18.91%	12	57.9	16.7	4.4	8.9	14.11%
CHL: Communist Party of Chile	2.686	10.95%	46	49.2	2.5	0	2.4	10.42%
CHL: Political Evolution	6.001	1.99%	13.4	0	86.6	0	0	1.72%
CHL: Democratic Revolution	2.887	0.995%	24.1	29.5	46.3	0	0	0.53332%
								Cumulative: 0.8

Table 7.8
Programmatic Scores of analyzed Parties of Croatia and Croatia

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
HRV: Croatian Democratic Union	6.5515	38.26%	1.1%	3.1%	20.4%	20%	55.3%	0.1546
HRV: Croatian People's Party – Liberal Democrats	5.4685	1.52%	8.3%	28.6%	54%	9%	0%	0.01259
HRV: Croatian Peasant Party	2.923	5.03%	13.7%	8.8%	28.3%	46.6%	6.6%	0.011
HRV: Croatian Social Liberal Party	5.638	1.37%	4.8%	23%	55.4%	16.8%	0%	0.0099
HRV: Croatian Party of Rights	8.13	3.35%	0%	2.6%	18.5%	26.8%	52.1%	0.026
HRV: Croatian Party of Pensioners	4.170	4.12%	19.8%	7.6%	61.4%	7.3%	3.8%	0.028
HRV: Istrian Democratic Assembly	3.8965	3.51%	22.7%	39.4%	29.6%	4%	4.3%	0.024
HRV: Social Democratic Party of Croatia	4.423	32.32%	39.3%	26.6%	27.4%	4.4%	2.3%	0.175
HRV: Bridge of Independent Lists	6.784	10.52%	9%	7.2%	51.9%	26%	6.1%	0.082
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.52

Table 7.9
Programmatic Scores of analyzed Parties of Cyprus and Cyprus

Cyprus

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
CYP: Progressive Party of Working People	4.498	36.28%	77.6%	17.2%	5.2%	0	0	0.0813
CYP: Democratic Rally	7.798	53.59%	1.2%	0	4.7%	34.9%	59.3%	0.5048
CYP: Movement of Social Democrats	4.555	8.861%	0%	28.5%	71.5%	0	0	0.08861
CYP: Citizens' Alliance	5.5945	1.266%	0	0	100%	0	0	0.01266
								Cumulative: 0.69

Table 7.10
Programmatic Scores of analyzed Parties of Denmark and Denmark

Denmark

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
DNK: Social Democrats	3.86	32.57%		38.2	34.8			0.24
DNK: Danish Social-Liberal Party / Radical Liberal Party	5.63	7.73%		36.5	46.9			0.064
DNK: Conservative People's Party	7.49	5.37%			22.1	63.9		0.046
DNK: Socialist Peoples Party	2.94	6.15%	16.8	62.8				0.049
DNK: Danish Peoples Party	5.05	13.99%		12.3	37.6			0.070
DNK: Liberal Party	7.12	21.27%			23.5	50.5		0.157
DNK: Red-Green Alliance	1.53	8.10%	63.2	21.1				0.068
DNK: [New] Liberal Alliance	8.62	4.86%				45	20.8	0.032
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.73

Table 7.11
Programmatic Scores of analyzed Parties of Ecuador and Ecuador

Ecuador

Parties	V-Dem Characterization Converted to WVS Scale (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
PAIS Alliance	3.457	74.15%	17.8%	14.5%	36.7%	12.7%	18.5%	0.4
ECU: Patriotic Society Party	5.394	1.92%	6.2%	18.7%	37.5%	6.2%	31.3%	0.0114
ECU: Partido Renovador Institucional Acción Nacional	7.486	2.60%	4.3%	4.3%	47.8%	30.4%	13%	0.0214
ECU: CREO movement	7.381	16.14%	6.7%	12.7%	45.6%	16.4%	18.7%	0.101
								Cumulative: 0.53

Table 7.12
Programmatic Scores of analyzed Parties of Estonia and Estonia

Estonia

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
EST: Estonian Centre Party	4.3015	34.48%	14.9	14.6	56.3	8.7	5.5	0.245
EST: Estonian Reform Party	7.447	34.65%	1.7	2.8	41.6	39.8	14.3	0.2821
EST: Estonian Greens	5.884	5.66%	6.4	2.8	72.6	18.3	0	0.05145
EST: Union of Pro Patria and Res Publica	7.2925	8.06%	0	6.7	37	43.1	13.1	0.0452972
EST: Social Democratic Party – Moderates	3.733	13.38%	4.5	36.8	46	7.8	4.9	0.1108
EST: Estonian Free Party	7.1545	3.77%	0	14.5	59.2	26.3	0	0.032
								Cumulative: 0.77

Table 7.13
Programmatic Scores of analyzed Parties of France and France

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
FRA: French Communist Party	2.122	9%	54%	27.1%	18.9%	0%	0%	0.073
FRA: Socialist Party	3.246	50%	13.6%	51.6%	31.4%	3.2%	0.3%	0.326
FRA: National Front	5.941	22.2%	3.8%	3.1%	32.7%	23.2%	37.1%	0.124
FRA: Unbowed France	1.7335	18.8%	27.8%	46.1%	21.3%	4.2%	0.7%	0.139
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.66

Table 7.14
Programmatic Scores of analyzed Parties of Finland and Finland

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
FIN: Social Democratic Party of Finland	3.685	17.28		33.7	37.5			0.123
FIN: Agrarian Union / Centre Party	5.599	18.47			43.3	43.5		0.1603
FIN: National Coalition Party	7.906	22.14				51.6	32.7	0.1866
FIN: Left Alliance	2.3665	8.94	55.7	32.1				0.078
FIN: Swedish People's Party	7.6255	0.4965				43.3	44.1	0.00043
FIN: Green League	4.3825	18.77		45.9	31.9			0.146
FIN: Christian Democrats / League	6.199	2.7805			36.2	51		0.024
FIN: The Finns Party	6.3535	11.12214			32.2	33.9		0.074
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.79

Table 7.15
Programmatic Scores of analyzed Parties of Germany and Germany

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
DEU: Christian Democratic Union of Germany; Christian Social Union in Bavaria	6.49	36.30%	3.8	14.5	60.4	18.2	3.2	0.285
DEU: Social Democratic Party	4.324	21.64%	10.5	48.4	36.3	4	0.8	0.183
DEU: Free Democratic Party	7.255	8.46%	3.1	11.3	68	16.5	1	0.071
DEU: Alliance 90/ The Greens	4.4995	16.84%	11.4	57.5	28.5	2.6	0	0.145
DEU: Alternative for Germany	6.064	6.54%	0	5.4	37.3	44	13.3	0.0532
DEU: The Left	1.7665	10.21%	37.6	47	13.7	1.7	0	0.0864
								Cumulative: 0.82

Table 7.16
Programmatic Scores of analyzed Parties of Germany and Germany

Parties	V-Dem Characterization Converted to WVS Scale (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
National Democratic Congress	4.1275	41.64%	15.1%	16.9%	39.8%	13.5%	14.5%	0.1657
GHA: New Patriotic Party	6.4645	53.55%	20.5%	13%	24.6%	20.8%	21.2%	0.243
GHA: Convention People's Party	3.1135	4.81%	16.4%	20.8%	21.7%	25.5%	15.6%	0.018
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.43

Table 7.17
Programmatic Scores of analyzed Parties of Greece and Greece

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
GRC: New Democracy	7.0555	51.47%	0.5%	0%	27.5%	53.5%	18.5%	0.417
GRC: Communist Party of Greece	1.7185	14.22%	40.5%	43.4%	14.8%	1.5%	0%	0.119
GRC: Coalition of the Radical Left	3.6655	26.23%	16.6%	56.5%	22.1%	2.6%	2.3%	0.206
GRC: People's Association / Golden Dawn	7.7845	8.09%	0%	0%	10.6%	14.4%	74.9%	0.0722
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.81

Table 7.18
Programmatic Scores of analyzed Parties of Iceland and Iceland

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
ISL: Progressive Party	5.5285	11.27%	1.5	5.4	64	24.7	4.3	0.0999649
ISL: Independence Party	8.092	31.14%	1.1	2.2	13.4	55.8	26.5	0.2563
ISL: Social Democratic Alliance	4.1125	12.60%	14.8	43.7	38.9	2.7	0	0.1041
ISL: Left-Green Movement	5.482	23.87%	26.2	57.8	14.2	1.7	0.2	0.17186
ISL: Bright Future	5.4895	3.19%	1.6	36.8	50.4	11.3	0	0.00278168
ISL: Pirate Party of Iceland	6.859	10.91%	10.5	40.1	43.3	5.8	0.4	0.0535681
ISL: Centre Party	5.4745	7.01%	5.9	5.5	60.9	14.7	13.1	0.0465
								Cumulative: 0.74

Table 7.19
Programmatic Scores of analyzed Parties of Japan and Japan

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
JPN: Liberal Democratic Party	7.645	56.19%				41.1	20.5	0.346
JPN: Clean Government Party / New Komeito	4.558	5.18%		3.2	54.9			0.03
JPN: Japan Communist Party	2.2075	6.52%	25.6	38.5				0.042
JPN: Social Democratic Party / Old Japan Socialist Party	3.202	1%	16.7	33.4				0.00501
JPN: Japan Innovation Party	7.6315	12.71%				21.1	6.5	0.0351
JPN: Constitutional Democratic Party of Japan	4.18	18.39%		48.12	33.7			0.15
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.61

Table 7.20
Programmatic Scores of analyzed Parties of Mongolia and Mongolia

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
MNG: Mongolian People's Party	4.282	34.93%	14.5%	11.1%	40%	25.4%	9%	0.178
MNG: Democratic Party	5.4685	28.22%	8.3%	7.7%	36.9%	32.7%	14.3%	0.1259
MNG: Mongolian People's Revolutionary Party	2.923	11.51%	9.7%	8.8%	28.3%	46.6%	6.6%	0.086
MNG: Civil Will–Green Party	5.638	25.35%	4.2%	5.8%	44.7%	33.2%	12.3%	0.1975
			0-2	3-4	5-6	7-8	9-10	Cumulative: 0.59

Table 7.21
Programmatic Scores of analyzed Parties of Poland and Poland

Parties	V-Dem Characterization Translated to World Value Survey (3/2*V-Dem+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
POL: Polish People's Party	4.9075	9.62%	7.6%	10.1%	52.6%	22.8%	6.9%	0.0605
POL: Democratic Left Alliance	4.398	11.86%	34%	26.4%	35.1%	0%	4.6%	0.00729
POL: Law and Justice	4.554	26.28%	2.8%	4%	32.5%	27.3%	33.5%	0.0959402423 7
POL: Civic Platform	6.10225	39.18%	5.7%	15%	52.1%	15.7%	11.4%	0.2656
POL: Palikot's Movement	5.1085	13.06%	12.2%	25.2%	50.2%	12.5%	0%	0.0984724
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.53

Table 7.22
Programmatic Scores of analyzed Parties of Portugal and Portugal

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
PRT: Left Block	2.695	18.21%	26.5	53				0.145
PRT: Socialist Party	4.69	79.32%		28	58.3			0.685
PRT: Social Democratic Centre - Popular Party	7.792	2.47%				33	0	0.008151
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.84

Table 7.23
Programmatic Scores of analyzed Parties of Romania and Romania

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
ROU: National Peasant Party Christian Democrat	6.79	0.8968%	0%	0%	0%	0%	100%	0
ROU: Democratic Alliance of Hungarians in Romania	6.18	23.32%	9.2%	4%	60.1%	13.2%	13.5%	0.171
ROU: Greater Romania Party	6.427	8.061%	18.4%	0%	62.4%	9.8%	9.4%	0.0291
ROU: Social Democratic Party	4.03	21.09%	27.8%	13.3%	34.8%	10.4%	13.7%	0.1014
ROU: The Conservative Party	6.766	1.34%	22.7%	27,4%	49.8%	0%	0%	0.0067
ROU: People's Party – Dan Diaconescu	5.7145	21.98%	13.1%	4.5%	41%	27.2%	14.2%	0.1499
ROU: National Union for the Progress of Romania	4.216	1.34%	47.2%	0%	31.6%	0%	21.2%	0.0042
ROU: National Liberal Party	7.087	17.49%	8.9%	10.9%	49.5%	12.4%	18.3%	0.108
ROU: Civic Force	7.6765	4.49%	11.6%	0%	44.3%	13.2%	30.9%	0.0198
								Cumulative: 0.59

Table 7.24
Programmatic Scores of analyzed Parties of Slovakia and Slovakia

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
SVK: Communist Party of Slovakia	1.3655	1.79%	18.4%	31.9%	17.5%	26.3%	5.8%	0.0090037
SVK: Christian-Democratic Movement	7.333	8.71%	0%	9.2%	36.8%	31.4%	22.6%	0.0594
SVK: Slovak National Party	6.3475	8.47%	2.5%	21.3%	47.4%	24%	4.7%	0.0605
SVK: Party of the Hungarian Community	6.025	4.30%	0%	23.9%	54.1%	16.1%	5.9%	0.0302
SVK: Green Party – Green Alternative	3.2515	2.74%	3.9%	14.5%	43.6%	30.2%	7.9%	0.00504
SVK: People's Party Our Slovakia	5.9395	7.40%	2.8%	15.2%	40.8%	38.3%	3%	0.059
SVK: Most–Hid	3.997	6.44%	1.3%	15.6%	53.7%	22.9%	6.5%	0.045
SVK: Ordinary People and Independent Personalities	6.688	12.17%	1%	3.8%	48.9%	33%	13.2%	0.0996723
SVK: Freedom and Solidarity	7.759	13.01%	0	28%	48.3%	6.3%	17.5%	0.031
SVK: We are Family	5.1775	7.28%	1.7%	8%	33.2%	34.5%	22.6%	0.00912
SVK: Direction – Social Democracy	3.814	27.68%	22.8%	35.7%	32.2%	7%	2.4%	0.1879
								Cumulative: 0.62

Table 7.25
Programmatic Scores of analyzed Parties of Slovenia and Slovenia

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
SVN: Democratic Party of Pensioners of Slovenia	3.24	0.12	4.8	17.6	64.9	6.7		0.027
SVN: Slovenian People's Party	7.31	0.042			50.7	12.6	19.1	0.027
SVN: Slovenian National Party	6.26	0.025		11.8	36.8	8.9		0.011
SVN: Slovenian Democratic Party	8.70	0.2189				40.6	17.4	0.127
SVN: Social Democrats	3.79	0.284		33.2	38.4			0.203
SVN: Positive Slovenia	4.00	0.023		26	39			0.015
SVN: New Slovenia – Christian Democrats	7.98	0.08				39.7	16.8	0.045
SVN: The Modern Centre Party	5.42	0.11		34.6	44.1	6.3		0.087
SVN: United Left	1.64	0.089	36.9	49.3				0.077
SVN: Party of Alenka Bratušek	5.42	0.011		44	40.2			0.0093
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.78

Table 7.26
Programmatic Scores of analyzed Parties of Spain and Spain

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
ESP: United Left	2.245	19.15%	52.9%	34.7%	12.3%	0%	0%	0.1678
ESP: United We Can	2.503	36.17%	37.3%	45.7%	12.2%	4.1%	0.8%	0.3
ESP: Valencian Compromise	3.054	1.702%	0%	100%	0%	0%	0%	0.01702
ESP: Citizens	6.6775	42.98%	0.8%	9.9%	60.4%	27.8%	1.2%	0.379
								Cumulative: 0.86

Table 7.27
Programmatic Scores of analyzed Parties of Switzerland and Switzerland

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
CHE: Social Democratic Party of Switzerland	2.64	29.49%	20.5	51.3				0.212
CHE: Christian Democratic People 's Party	5.90	16.04%			55.2	20.8		0.122
CHE: Swiss People 's Party	9.09	30.37%				50	19.1	0.21
CHE: Green Party of Switzerland	2.64	9.01%			26.5	2		0.026
CHE: Green Liberal Party of Switzerland	6.64	9.23%			41.2	6.7		0.044
CHE: Conservative Democratic Party of Switzerland	7.04	5.58%			50	32.5		0.049
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.66

Table 7.28
Programmatic Scores of analyzed Parties of Taiwan and Taiwan

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
TWN: Nationalist Party	7.2655	41.45%	20.4%	29.9%	42.9%	4.3%	4.9%	0.195644
TWN: Democratic Progressive Party	5.098	32.51%	31.1%	29%	36%	1.6%	2.4%	0.21
TWN: New Power Party	3.3835	6.606%	28.3%	42.7%	28.1%	0.8%	0%	0.047
TWN: People First Party	7.1725	1.42%	32%	52.3%	15.7%	0	0	0.0022294
TWN: Non-partisan & Non-Partisan Solidarity Union	7.0345	17.96%	31.1%	31.6%	36%	0.7%	0.8%	0.0659
								Cumulative: 0.52

Table 7.29
Programmatic Scores of analyzed Parties of Uruguay and Urugua

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
URY: Colorado Party	6.7135	8.37%	1.3	4.8	16	22.7		0.032
URY: National Party	7.1125	34.44%			32.2	15.8	0.165	0.165
URY: Broad Front	3.998	50.75%		26.1%	20.9%			0.239
URY: Open Cabildo	8.527	6.45%				33	31.1	0.041
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.48

Table 7.30
Programmatic Scores of analyzed Parties of Latvia and Latvia

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
LVA: Harmony Center	4.219	23.36%	4.5%	22.1%	38%	24.9%	10.5%	0.14
LVA: KPV LV	6.2605	2.422%	6.4%	10.8%	53.2%	29.6%	0%	0.02
LVA: New Conservative Party	6.2605	7.44%	6.6%	13.9%	29.2%	25%	25.4%	0.04
LVA: Development/ For!	6.478	10.21%	2.8%	6.9%	38.7%	37.8%	13.8%	0.078
LVA: National Alliance	6.8965	10.381%	1.3%	3.5%	20.7%	45.4%	29.1%	0.069
LVA: Union of Greens and Farmers	5.581	22.84%	9.6%	8.3%	50.3%	22.4%	9.3%	0.166
LVA: New Unity	7.1515	13.67%	0%	7.4%	37.3%	35.8%	19.5%	0.0999
LVA: Latvian Association of Regions	6.3955	4.33%	0%	2.9%	60.8%	27.8%	8.5%	0.038
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.69

Table 7.31
Programmatic Scores of analyzed Parties of Lithuania and Lithuania

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
LTU: Social Democratic Party of Lithuania	2.122	24.62%	20.1%	17.4%	43.4%	16.5%	2.6%	0.0923
LTU: Lithuanian Liberal Union	7.5085	6.615%	2.6%	7.8%	48.8%	28.4%	12.4%	0.0511
LTU: Labour Party	5.3935	9.38%	9.6%	7.5%	49.7%	26.4%	6.9%	0.0714
LTU: Lithuanian Peasant [Popular/ Greens] Union	5.1625	21.08%	3.7%	10.7%	54%	27.4%	4.1%	0.172
LTU: Order and Justice	5.45	8.31%	4.8%	17.9%	55.8%	19.4%	2.1%	0.0612
LTU: Homeland Union – Lithuanian Christian Democrats	6.865	30%	52.4%	20.9%	24.3%	37.4%	0%	0.1851
								Cumulative: 0.63

Table 7.32
Programmatic Scores of analyzed Parties of South Korea and South Korea

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
KOR: Liberty Korea Party - Grand National Party	1.8235	49.11%	3.9%	13.8%	35.4%	33.4%	13.4%	0.087
KOR: Democratic Party	1.231	38.28%	11.4%	33.1%	36.2%	15.9%	3.5%	0.1703
KOR: Advancement Unification Party - Liberty Forward Party	1.657	5.04%	11.1%	27.2%	29.2%	25.3%	7.1%	0.0193032
KOR: Democratic Labor Party	1.0975	7.56%	16.1%	36.7%	35.9%	7.5%	3.9%	0.0399
								Cumulative: 0.317

Table 7.33
Programmatic Scores of analyzed Parties of New Zealand and New Zealand

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
NZL: ACT New Zealand	8.31	2.00				50	35.7	0.01714
NZL: Green Party of Aotearoa New Zealand	2.71	9.13	31.2	48.4				0.0727
NZL: New Zealand Labour Party	4.32	43.37		43.8	32.2			0.3296
NZL: New Zealand National Party	6.96	43.37			25.6	48		0.3192
NZL: New Zealand First Party	5.19	2.14		6.7	66.6			0.01569
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.74

Table 7.34
Programmatic Scores of analyzed Parties of South Africa and South Africa

Parties	V-Dem Characterization Converted to WVS Scale (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
ZAF: African National Congress	Center-Left 3.685	74.40%	4.3%	11.1%	33.8%	36.1%	14.7%	0.334
ZAF: Democratic Alliance	Center-Right 6.784	18.07%	10.5%	11.7%	46.6%	21.9%	9.2%	0.124
ZAF: Inkatha Freedom Party	Center-Right 6.589	1.00%	0%	0%	41.9%	54.1%	4%	0.0096
ZAF: Economic Freedom Fighters	Left 1.564	2.13%	0%	9.2%	50.7%	26.7%	13.5%	0.0020
ZAF: Congress of the People	Center 4.753	0.88%	4.9%	4.4%	39.9%	38.8%	11.9%	0.0038984
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.4734

Table 7.35
Programmatic Scores of analyzed Parties of Italy and Italy

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
ITA: Go Italy	7.4725	12.67%	0.7%	0%	19.8%	57.5%	21.9%	0.101
ITA: North League	8.499	25.74%	1.1%	2.7%	15.7%	52.6%	28%	0.2075
ITA: Democratic Party	4.3975	26.23%	18.4%	41.3%	32.7%	4.9%	2.7%	0.1941
ITA: Union of the Centre	5.917	1.081%	0%	14.9%	44.9%	40.2%	0%	0.0093
ITA: Five Star Movement	6.0535	29.86%	5.7%	17.3%	44.5%	26.1%	6.5%	0.2108
ITA: The People of Family	7.4575	0.4912%	0	0	80.7%	19.3%	0	0.004912
ITA: Brothers of Italy	8.221	3.93%	0	0	21.2%	50.6%	28.3%	0.031
								Cumulative: 0.76

Table 7.36
Programmatic Scores of analyzed Parties of UK-Great Britain and UK-Great Britain

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
GBR: Conservative and Unionist Party	7.957	38.25%	1.4%	4.4%	38.6%	44.2%	11.4%	0.21267
GBR: Labour Party	2.536	46.41%	15.4%	33.9%	41.2%	7.4%	2.1%	0.2288
GBR: Liberal Democrats	5.1835	10.55%	1.6%	31.6%	59.5%	6.7%	0.5%	0.0961105
GBR: Independence Party	8.449	4.7815%	0%	10.3%	63.7%	22.3%	3.7%	0.0124319
								Cumulative: 0.55

Table 7.37
Programmatic Scores of analyzed Parties of the United States of America and the United States of America

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
USA: Republican Party	7.758	43.58%	2.3%	5.8%	29.8%	34.9%	27.3%	0.271
USA: Democratic Party	4.324	56.42%	24.5%	32.1%	33.5%	6.8%	3%	0.383
			0-2	3-4	5-6	7-8	9-10	Cumulative: 0.65

Table 7.38
Programmatic Scores of analyzed Parties of the Netherlands and the Netherlands

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
NLD: Christian Democratic Appeal	6.904	6.65	0	9.5	42.8	44.4	3.2	0.058
NLD: People's Party for Freedom and Democracy	7.417	28.69			25	61.4		0.248
NLD: Democrats 66	5.610	19.83		47.4	32.5			0.158
NLD: Party for Freedom	7.4725	11.50			33	38.5		0.082
NLD: Green Left	3.52	10.97	33.7	55.8				0.098
NLD: Socialist Party	1.993	9.49	26.7	48.9				0.072
NLD: Labour Party	4.45	12.87		55.7	23.8			0.102
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.82

Table 7.39
Programmatic Scores of analyzed Parties of Norway and the Norway

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
NLD: Christian Democratic Appeal	6.904	6.65	0	9.5	42.8	44.4	3.2	0.058
NLD: People's Party for Freedom and Democracy	7.417	28.69			25	61.4		0.248
NLD: Democrats 66	5.610	19.83		47.4	32.5			0.158
NLD: Party for Freedom	7.4725	11.50			33	38.5		0.082
NLD: Green Left	3.52	10.97	33.7	55.8				0.098
NLD: Socialist Party	1.993	9.49	26.7	48.9				0.072
NLD: Labour Party	4.45	12.87		55.7	23.8			0.102
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.82

Table 7.40
Programmatic Scores of analyzed Parties of Sweden and the Sweden

Parties	V-Dem Characterization Converted to WVS (V-Dem*3/2+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
NLD: Christian Democratic Appeal	6.904	6.65	0	9.5	42.8	44.4	3.2	0.058
NLD: People's Party for Freedom and Democracy	7.417	28.69			25	61.4		0.248
NLD: Democrats 66	5.610	19.83		47.4	32.5			0.158
NLD: Party for Freedom	7.4725	11.50			33	38.5		0.082
NLD: Green Left	3.52	10.97	33.7	55.8				0.098
NLD: Socialist Party	1.993	9.49	26.7	48.9				0.072
NLD: Labour Party	4.45	12.87		55.7	23.8			0.102
			1-2	3-4	5-6	7-8	9-10	Cumulative: 0.82

Analysis

Overall, there exists a strong, positive correlation between a democracy's Programmatic Score and its quality of democracy.

Figure 4
Statistical Analysis on Freedom House Score and Programmatic Score

```
corr ProgrammaticScore FreedomHouseScore
(obs=40)

             | Progra~e Freedo~e
-------------+------------------
Programmat~e |   1.0000
FreedomHou~e |   0.6921   1.0000


. regress FreedomHouseScore ProgrammaticScore

      Source |       SS           df       MS      Number of obs   =        40
-------------+----------------------------------   F(1, 38)        =     34.94
       Model |  1211.02516         1  1211.02516   Prob > F        =    0.0000
    Residual |  1316.94984        38  34.6565747   R-squared       =    0.4790
-------------+----------------------------------   Adj R-squared   =    0.4653
       Total |    2527.975        39  64.8198718   Root MSE        =     5.887

------------------------------------------------------------------------------
FreedomHouseScore | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
------------------+-----------------------------------------------------------
ProgrammaticScore |   36.24983   6.132283     5.91   0.000     23.83567    48.66398
            _cons |     66.3348   4.064864    16.32   0.000     58.10591    74.56369
------------------------------------------------------------------------------
```

The null hypothesis is rejected ($p<0.001$), and the correlation is therefore statistically significant. Every 1 point increase in the Programmatic score corresponds with a 0.69 increase in the Freedom House score and predicts a 0.36 increase in Freedom House score.

Figure 5
Lowess Smoother of Scatterplot of Freedom House Score (y-axis) vs. Programmatic Score (x- axis)

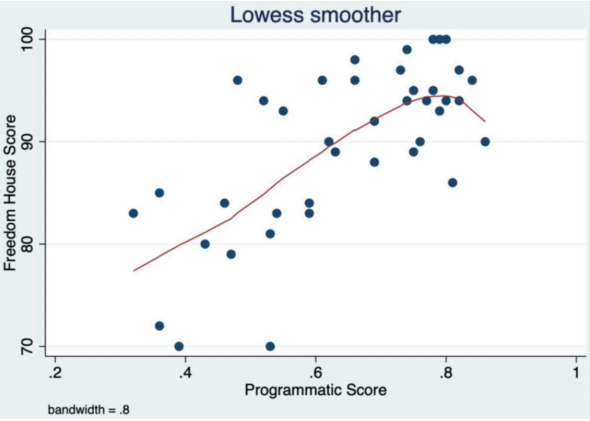


Figure 6
Map of Europe, color-coded by memberships in alliances

Democracies within a certain range of Programmatic Scores tend to cluster — Spain and Portugal with the highest scores (86, 84), followed by the three Scandinavian countries of Sweden, Norway, and Finland (80, 79, 78), then the Netherlands, Germany, and Austria (82, 82, 79), then Switzerland and France (66, 66), then Latvia and Lithuania (69, 63) , then, Slovakia, Romania, Poland, and Croatia (62, 59, 53, 52). Asian countries and regions, I.e., Japan, Mongolia, Taiwan, and South Korea (61, 59, 52, 32) tend to receive lower programmatic scores despite being rated disproportionally higher on Freedom House Score. Except for Chile (80), South American, as well as African countries, tend to score lower than European countries, none of which with scores above 55.

Conclusions

There exists a strong, positive correlation between the Programmatic Score of democracies and their respective quality of governance — that is, democracies in which the voter votes based on their ideology, or, as an alternative explanation, democracies with more comprehensive representation of the voters' ideology without compromising

economic incentives, are more likely to be better in terms of personal autonomy (e.g. restrictions to foreign travel), individual and organizational rights (e.g. freedom of expression and belief, and peaceful protest), political rights (e.g. safeguards against corruption), rule of law (e.g. due process in civil and criminal matters), pluralism and participation (e.g. freedom from undue obstacles to the rise and fall of parties), electoral process (e.g. free and fair elections), and government functioning (e.g. the extent to which freely elected head of government and national legislative representatives determine the policies of the government) than democracies in which the voter's ideology does not significantly influence their voting decision, or democracies with less comprehensive representation.

Limitations and Future Scope

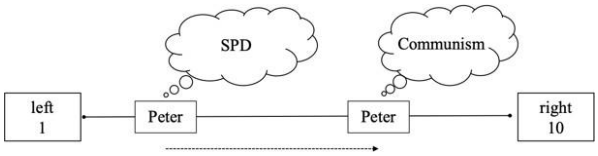
Methodologically, this paper is limited in that the paper employs the democracy's Freedom House Score as the only indicator of quality of democracy. The sole indicator of a party's left-right position is economic and is sourced only from V-Dem reports that do not necessarily reflect fluctuations during the 5-year period delineated by World Value Survey reports. For example, V-Dem may only provide data of a party's left-right position in 2018 in a country, which is surveyed in 2019 by World Values Survey, and thus may ultimately be insufficient in the timeliness of the data. Furthermore, World Value Survey's sample size can arguably be limited, as the question employed by the paper mostly samples less than ten thousand people, often with data of some parties' voters' ideological composition with a sample of less than ten people. The paper also does not account for the tendency of the surveyed to regard 5 (when asked on a scale of 1-10), as the center, a perception that would potentially skew the ideological composition of voters of a party to the left. There are methods that factors both the economic and the social in determining a party's position, but they require manual data gathering and computation for each specific party, which was not feasible given the time frame, but is a viable option for future studies.

Additionally, the paper does not conduct mathematical data analysis to determine the Programmatic score with models that would capture the deviation of the composition of the voters' ideology from the ideal composition more accurately than manual calculation that accounts only for proximity and does not factor t the extent of deviation in the programmatic score. For example, for a party that has been rated by V-Dem with a 6.789 to be rated with a Programmatic Score of 100, 100% of the Party's voters would need to identify as center or center-right. The methodology of this paper, however, will rate such a party with 50% of its voters being Centrists and the rest being Far-Lefts or Far-Rights (not to mention that the two groups are treated the same) with the same programmatic score with such a party with 50% of its voters being Centrists, and the rest being center-lefts. In other words, not only were different levels of deviation from the ideal ideological composition of voters of a party not mathematically modeled, they were not weighted except for the number of categories allowed being two instead of one. Future studies could weigh deviations by numerically considering different deviations as impacting the Programmatic Score differently. For example, for a centrist party, calculate its Programmatic Score by the formula 1- "deductions from deviation". A vote from a far-left or far-right voter would be weighed as 1, while a vote from a center-left or center-right voter would be weighed as 0.5. The exact numerical values in weighing can be modeled similarly to that of a logistic function.

This paper does not investigate the potential impacts the wording of the World Values Survey has on the responses of the surveyed. For example, instead of "Progressive" and "Conservative" or "Liberal" and "Conservative", World Values Survey instead uses the terms "Left" and "Right". In countries like Australia, Chile, Germany, Italy, and Spain, left-right ideological self-placement predicted voting better than the liberal-conservative self- placement, while the reverse occurred in the United States and in Poland (Caprara & Vecchione, 2018).

This paper does not address whether the subjective self-identification on the political left-right scale accurately reflects the voter's objective ideological position.

Figure 8
Possibly Differing Concepts of "Left" and "Right" of a Voter of Germany



The concepts of "left" and "right' differ significantly by individual. Unlike the accuracy and clarity of a party's policies, a lack of standard in identifying oneself as left or right does not entail the country being less programmatic. For example, depending on Peter's definition of "left" and "right", the exact same behavior can be classified as programmatic or non-programmatic.

This paper cannot escape the problem of score inconsistencies between different years of Freedom House reports due to changes in methodology, and thus obstructs valid comparison. The paper is limited also in that the sample size of democracies with lower Freedom House scores may be argued insignificant, for there are only four countries with a Freedom House score from 79 to 70 and with a V-Dem Economic Left-Right score.

The paper does not address the problem that a political left-right scale may not capture the differences in policies between parties, and thus may falsely attribute redundancy to a democracy. For example, this paper will identify that Party A and Party B in Country C are both be rated with an economic left-right score of 2 by V-Dem, but cannot address that Party A will implement highly progressive taxation, while Party B will implement highly subsidized healthcare. Although both are rated as equally progressive, the Centrist, or even the Conservative voter, would be more inclined to vote for Party B, and thus resulting in Party B having a lower Programmatic Score than Party A, not to mention that the social-ideological standing of the party is completely ignored, which, if graded on a scale of 1-10, would still face the same problem that numbers do not capture policies. Furthermore, the methodology of this paper also allows no spill-overs. For instance, Party A and B were rated by V-Dem to both have an economic left-right score of 1. Party A has more progressive voters than Party B (with 2000 progressive voters and 1000 centrists, and 500 conservatives), but the latter (with 1000 voters, all progressive) may still have a higher Programmatic Score than Party A, despite the fact that all progressive voters voted either for Party A or Party B. The methodology also generalizes party positions from 5-significant-digits scores provided by V- Dem into the categories of "Left", "Center-Left", "Center", "Center-Right", and "Right", the boundaries between which can be argued to be arbitrary.

Future studies could, based on analysis of factors such as political polarization, number of effective parties, and governmental constitution, establish the main factors behind the formation of clear party identities and distinctions, such as the cause of a lack of redundancy in ideology of parties in a democracy. Studies could also investigate whether factors such as the flexibility of parties in switching ideologies, socio-economic level of development of a democracy, and the elimination of socio-economic incentives in affiliation with parties are prerequisites to ideology-based voting. Future studies may also expound on reasons behind a potential causal relationship between Programmatic Score and Quality of Democracy. For example, does ideology-based voting increase political stability, participation, and representation? Do voters prefer ideology-based voting over socio- economic-based voting?

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Appendix A

Why some countries are more programmatic than others: three theories

Table 8

Freedom House Score, Programmatic Score, Worldwide Wealth Inequality Ranking, Gini coefficient of analyzed countries

Country (Freedom House Score)	Freedom House Score	Programmatic Score	Wealth Inequality Ranking	Gini Coefficient
Sweden	100	0.80	165	27.6
Finland	100	0.79	156	26.8
Norway	100	0.78	167	25
New Zealand	99	0.74	142	36.2
Canada	98	0.66	112	33.3
Netherlands	97	0.82	159	29.2
Denmark	97	0.73	154	27.7
Switzerland	96	0.66	162	33.1
Uruguay	96	0.48	58	40.2
Japan	96	0.61	116	32.9
Portugal	96	0.84	143	32.8
Slovenia	95	0.78	164	24.4
Australia	95	0.75	107	34.3
Germany	94	0.82	126	31.7
Estonia	94	0.77	132	30.8
Taiwan	94	0.52	111	33.6
Iceland	94	0.74	155	26.1
Chile	94	0.8	29	44.9
Austria	93	0.79	158	30.2
United Kingdom	93	0.55	94	35.1
Cyprus	92	0.69	129	31.2
Spain	90	0.86	153	34.3
Slovakia	90	0.62	166	23.2
Italy	90	0.76	150	35.2
Lithuania	89	0.63	128	35.3
France	89	0.75	163	32.4
Latvia	88	0.69	127	34.5
Greece	86	0.81	152	33.1
Argentina	85	0.36	41	42.3
Croatia	84	0.52	134	28.9
Mongolia	84	0.59	120	32.7
United States of America	83	0.54	47	41.5
Romania	83	0.59	100	34.8
South Korea	83	0.32	128	31.4
Poland	81	0.53	137	30.2
Ghana	80	0.43	36	43.5
South Africa	79	0.47	1	63
Brazil	72	0.36	17	48.9
Colombia	70	0.39	7	54.2
Ecuador	70	0.53	106	47.3

Figure 7
Statistical Analysis of Programmatic Score and Wealth Inequality

```
. corr ProgrammaticScore WealthInequality
(obs=40)

             | Progra~e Wealth~y
-------------+------------------
Programmat~e |   1.0000
WealthIneq~y |   0.6625   1.0000


. corr ProgrammaticScore GINI
(obs=40)

             | Progra~e     GINI
-------------+------------------
Programmat~e |   1.0000
        GINI |  -0.5371   1.0000
```

There exists a negative correlation between a country's Programmatic Score and its wealth inequality. In a country of higher wealth equality, one is less likely to aspire to be wealthier than others than in a country of higher wealth inequality (Côté et al., 2015). Thus, in a country of higher wealth equality, one is more likely to vote based on ideology instead of economic incentive. For instance, the reason why one votes for a party with progressive policies in a country of higher wealth equality is more likely ideological than economically incentivized.

This paper anticipates two other theories as to why some countries are more programmatic than others: culture and representation. The culture theory states that it seems conceivable that the typical American would view material possession as an effective approach to happiness more than the typical Scandinavian, and thus might be more influenced by economic incentives when voting. Pressure to conform to social norms is also likely higher in the US than in places like Germany. For instance, while 87% of Black voters identify as Democrats in the United States, only 29% of Black democrats identify as liberals. In a survey by the American National Election Study in 2012, when asked about which party they identify with, Black respondents were more likely to report they were a Democrat when they were with a black interviewer (96.4%) than a nonblack interviewer (83.9%) or an online survey (85%).
The representation theory states that voters of some countries don't inherently vote based on ideology more than voters of other countries. Instead, some countries are programmatic than others because they are either more comprehensive in representation, or provide no meaningful, economically incentivizing alternatives.

Suppose there exists democracies A, B, and C in world W, in which the only non- economic issue is abortion, and the only economic issue is redistribution. In democracy A, there exists only two parties: A1 is anti-abortion and anti-redistribution, A2 is pro-abortion and pro-redistribution. In democracy B, there exists four parties: B1 is anti-abortion and anti- redistribution, B2 is anti-abortion and pro-redistribution, B3 is pro-abortion and anti- redistribution, while B4 is pro-abortion and pro-redistribution. In democracy C, there exists two parties: C1 is pro-abortion, anti-redistribution, C2 is anti-abortion and anti-redistribution.

Jack is anti-abortion and has a PS of 0.5. Jack is of relatively lower socio-economic status, thus he would most likely be pro-redistribution. If Jack lives in democracy A, Jack would vote for A1 half of the time, and A2 half the time. Living in democracy B, he would vote for B4 100% of the time. Living in Democracy C, he would vote for C2 100% of the time. Although Jack maintains his PS, democracies B and C are more programmatic than A because they either have more comprehensive representation or provide no competing alternatives for the voter.

Table 9
Analyzed parties of Sweden, color-coded by ideological proximity

Parties	V-Dem Characterization Translated to World Value Survey (0/2*V-Dem+1)	Valid Percentage of Population who Votes for the Party	Left	Center-Left	Center	Center-Right	Right	Programmatic Score
Center Party	Center - Right (6.50)	3.26%	0%	0%	42.2%	33.8%	23.9%	0.024776
Fascist People's Party of Swede	Center-Right (6.99)	6.52%	0%	4.3%	42.1%	51.1%	2.6%	0.061
The Christian Democrats	Center-Right (7.69)	2.55%	9.9%	0%	24.1%	51.4%	14.7%	0.017
The Green Party	Center (4.903)	13.75%	12.3%	49%	28.6%	5.9%	4.2%	0.1067
Moderate Party	Center-Right (8.20)	33.30%	1.4%	1.5%	12.7%	55.5%	28.9%	0.281
Swedish Social Democratic Party	Center-Left (4.09)	29.23%	18.7%	50.1%	24.6%	5.2%	1.3%	0.218
The Left Party	Center-Left (3.096)	6.92%	58.8%	33.3%	6.3%	1.6%	0%	0.064
Sweden Democrats	Center -Right (7.399)	4.48%	2%	13%	50.8%	6.9%	26.4%	0.026
			1-2	3-4	5-6	7-8	9-10	Cumulative: 79.8%

The high Programmatic Score of Sweden, for instance, might be explained by its comprehensive representation of diverse ideologies on non-economic issues by parties of ideological proximity on economic issues. For example, it is possible that while the Christian Democrats and the Sweden Democrats are both economically conservative, the former is socially conservative and the latter is economically liberal. A relatively affluent voter is more likely anti-redistribution, and thus would most likely choose the non-economic-ideology- fitting party between the Christian Democrats or the Sweden Democrats.