# UMBC REVIEW

JOURNAL OF UNDERGRADUATE RESEARCH

2021 *Vol. 22*


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UMB
JOURNAL OF UNDER
REV

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**Image 1.**
*Two socially-distanced students walk through UMBC's Common's underneath a row of flags.*

# EDITOR'S INTRODUCTION

# Welcome to the 22nd volume of the UMBC Review: Journal of Undergraduate Research!

Over the last two decades, this journal has showcased the incredible research done by undergraduate students on campus. Despite the challenges and limitations imposed by this turbulent time due to the global pandemic, structural racism and political unrest in the U.S., our authors continue to conduct thoughtful research on issues of critical significance. We are proud to present ten research papers across a plethora of disciplines that epitomize the inclusive excellence of our campus.

The research published in this edition of the *UMBC Review* reflects some of the most pressing issues and lessons learned of the past year. We have ordered each piece thematically, in line with the experiences of our community during the ongoing pandemic, as we reevaluate and reposition ourselves to find connection, adapt to unprecedented circumstances, and confront a pandemic and civil unrest that highlight the power imbalances and inequity rampant in our society. Authors **Copenhaver**, **Shendy**, and **McVicker** explore connectivity in varying contexts, from mathematics to food webs. **Hooper** and **Davis** explore the notion that with connectivity can come power dynamics, whether in theater or in the rhetoric surrounding immigrant communities. **Mbagna Nanko, Park**, and **Hyatt** navigate themes of control, structure, and stability, as our community finds itself adapting to the combination of the novel coronavirus and inequity that has been with this country since its inception. Finally, **Driver** and **Rodriguez** discuss recent trends in music, which enabled so many people to find comfort and security during this tempestuous time. Each of the following papers offers new insight that advances their respective fields and society as a whole.

**Image 2.**

*Three Socially distanced students meet outside the Administration Building, having a casual converstation.*

## Meet the Authors!

**Ashley Copenhaver** uses artificial neural networks to characterize the connectivity of insulin secreting cells.

**Tahia Shendy** analyzes the discourse surrounding virtual influencers to understand how identity and authenticity are challenged and crafted in response to social media's ever-increasing influence.

**Kelly McVicker** investigates the impact of urbanization on food web dynamics in environments at the interface between land and river.

**Caitlyn Hooper** analyzes the impact of intimacy direction in theater and its impact on power dynamics.

**Cassie Davis** investigates nativist rhetoric, rhetoric that specifically underscores an us-versus-them sentiment between native Americans and immigrants through articles in the New York Times.

**Ryan Mbagna Nanko** uses high resolution microscopy to analyze the structure and properties of novel materials that could be the future of nano-electronics.

**Hye Jin Park** proposes a connection between parenting styles in immigrant communities and a child's self-regulation skills.

**Ben Hyatt** uses stability theory and matrix analyses to optimize control schemes for connected autonomous vehicles.

**Sarah Driver** analyzes the social and domestic impact of the parlor piano in the 19th century.

**L. Alexandra Rodriguez** looks at the racial politics of Lil Nas X's "Old Town Road" with a historical framework.

The UMBC Review publishes undergraduate research of the highest quality. Each paper underwent rigorous peer review from off-campus faculty and professionals, who evaluated the authors' contribution to their respective disciplines. Additionally, the authors worked through several rounds of revision with the editors to further refine their paper. The end result is the professional research you see here. We hope you will take part in and enjoy this journey of discovery.

# ACKNOWLEDGEMENTS

Faculty advisors play an essential role in the process of creating ideas and publishing research at UMBC. We'd like to thank the following faculty advisors for providing guidance and support to our student authors throughout the publication process:

**Dr. Brad Peercy**
**Dr. Chris Hawn**
**Dr. Charissa Cheah**
**Dr. Deepa Madan**
**Dr. Jinglai Shen**
**Dr. Melissa Blair**
**Dr. Rebecca Adelman**
**Dr. Tamara Bhalla**
**Ms. Susan Stroupe, MFA**

We would also like to thank our off-campus peer reveiwers. We are particularly grateful for the time they spent to review undergraduate research, and for the expertise they provided which aided us in our process.

**Dr. Bonnie Miller**
**Dr. David Walters**
**Dr. Elizabeth Morgan**
**Dr. Katelyn Stauffer**
**Dr. Kim Shively**
**Dr. Leo Chavez**
**Dr. Lili Du**
**Dr. Michael Richardson**
**Dr. Olivia Mather**
**Dr. Pranay Goel**
**Dr. Richard Bertram**
**Dr. You Jung Seo**
**Ms. Victoria Ferrari**

Finally, we would like to thank the on and off campus proofreaders. We are grateful to these individuals for their diligent review of each paper.

**Ms. Elaine MacDougall**
**Ms. Janet McGlynn**
**Dr. John Sinnigen**
**Dr. Jonathan Finkelstein**
**Dr. Leslie Morgan**
**Dr. Marilyn Demorest**
**Dr. Arthur Johnson**
**Dr. Diane Lee**
**Ms. Fritz Roads**

**Image 3.**
*Two students pictured with True Grit, UMBC's well-loved doggy mascot.*

## Further Acknowledgements

Thank you to the following for their financial support of the UMBC Review and their commitment to undergraduate research:

**Dr. Freeman Hrabowski –**
President of UMBC
**Dr. Katherine Cole –**
Vice Provost and Dean of Undergraduate Acadmeic Affairs
**Dr. April Householder –**
Director of the Undergraduate Research and Prestigious Scholarships
**The Office of the President**
**The Office of the Provost**

Finally, we would like to thank our own advisors for their time and guidance, and especially fort their support in helping us develope and publish this edition of the UMBC Review:

**Dr. Molly Ayn Jones-Lewis –**
Editorial Advisor, Department of Ancient Studies
**Professor Karol Keane –**
Design Advisor, Department of Visual Arts

We invite you to enjoy the 22nd Volume of the UMBC Review!

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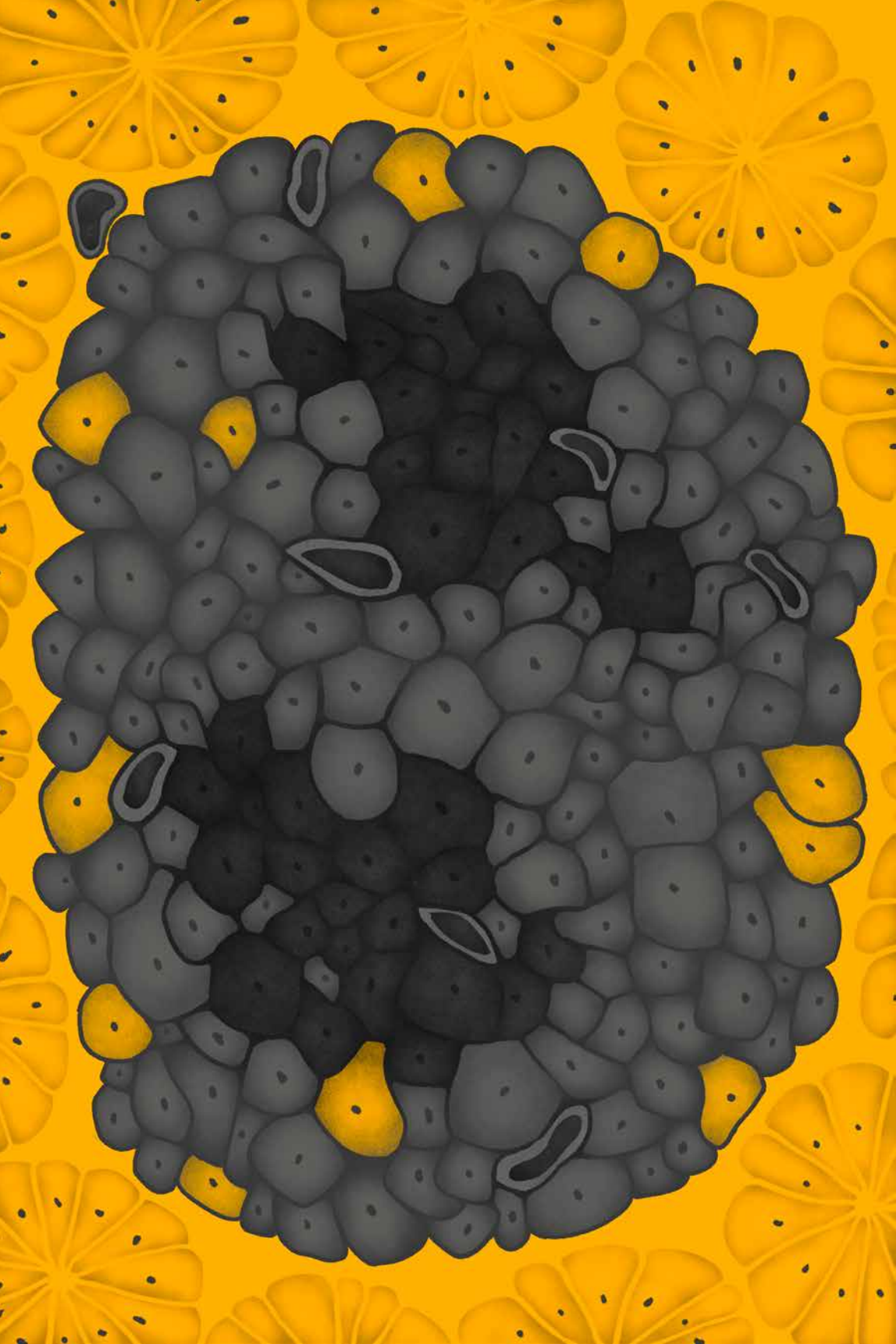
# Understanding Connectivity of Pancreatic Beta Cells through Artificial Neural Networks

Ashley Copenhaver



# Ashley Copenhaver

**Ashley Copenhaver graduated from UMBC in May 2020 with dual degrees in Mathematics and Biological Sciences. During her undergraduate career, she was a memberof the Honors College, a merit scholar, and partook in three software engineering summer internships at Google. Ashley began her PhD in Neuroscience at UMBC in fall 2020 where she hopes to integrate mathematics and biology. Her career goals after earning her PhD involve teaching students and studying neurodegenerative diseases.**

**Ashley would like to thank her research mentor Dr. Brad Peercy for his immense support and guidance throughout this research project. Additionally, she thanks Dr. Janita Patwardhan for being an amazing mentor in mathematics and aiding in the production of simulation data for this project.**

“

The use of mathematics to better understand biological problems is fascinating to me. I grew up with a passion for mathematics and a dream of becoming a neurosurgeon. My first year at UMBC was spent fulfilling pre-medical requirements and speaking to surgeons in the area. It wasn't until my second year that I decided to explore opportunities that would enable me to apply mathematics to the field of biology. In fall 2017, I began working on biomathematical research with Dr. Brad Peercy. We were studying the oscillatory behavior of pancreatic beta cells which are involved in insulin secretion. My research took an interlude over the summer while I worked on a machine learning project at my second software engineering internship with Google. This opportunity gave me the chance to take a few courses on understanding the mathematics of machine learning. I brought these ideas back to Dr. Peercy and we developed an application of neural networks for understanding pancreatic beta cell function. By bringing these new techniques into pancreatic beta cell studies, we can easily predict when a pancreatic islet has a switch cell and learn what cell characteristics are important for making these predictions.

**-Ashley Copenhaver** ”

**Image 1.**
A graphical depiction of The islet of Langerhans affected by Diabetes.

## Abstract

The islet of Langerhans consists of hundreds of beta cells (β -cells) whose synchronization is key to the proper secretion of insulin from the endocrine component of the pancreas. Experiments have suggested the existence of a type of β-cell in the islet, called the hub cell, which controls islet synchronicity. If silenced, the hub cell appears to desynchronize the islet. Simulations based on the experimental data have not confirmed the proposed high functional connectivity of hub cells. Instead, numerical exploration has shown the existence of a similar β-cell, termed the switch cell, which can control the activity of the islet but is not characterized by high functional connectivity. We used artificial neural network techniques to identify islets containing switch cells based upon cell characteristics and cell-coupling values. We began with a two-cell network using three parameters to identify a switch islet. Our network accurately predicted switch islets using both homogeneous and heterogeneous coupling values. We moved on to test a three-cell network and will continue to scale up to a network with 57 or more cells. The network can be used to discover what biophysical features are important for defining islets with switch cells.



*Keywords: insulin, glucose, hub cells, numerical exploration, neural network, islets & switch cells.*

# Introduction

The release of insulin in response to elevated blood glucose levels is of utmost importance for human health. Impairment of this process causes high blood glucose levels, which is one common symptom of diabetes mellitus. Diabetes mellitus affects 34.2 million Americans, or 10.5% of the American population[1]. Current treatments target the molecular pathways of insulin secretion, although factors such as cell network connectivity and cell physiology are not fully accounted for. Further studies into other factors contributing to the insulin secretion mechanism may allow for discovery of new treatments for diabetes[2].

The islets of Langerhans in the pancreas house multiple types of endocrine cells that cooperate to produce hormones, such as insulin, which regulate glucose levels in the bloodstream. Pancreatic beta cells (β-cell) are the predominant cell type in the islets of Langerhans. These cells control the release of insulin in response to elevated blood glucose levels[3]. The molecular pathway for insulin secretion is defined by key mechanistic steps, such as the closure of ATP-sensitive $K^+$ ($K_{ATP}$) channels, plasma membrane depolarization caused by positively charged ions like $Na^+$, and the opening of voltage-gated $Ca^{2+}$ channels[4]. Although most of the molecular pathway for insulin secretion has been characterized, there seems to be another component which contributes to this mechanism of synchronized insulin release from the islet: the physical arrangement and functional connectivity of pancreatic β-cells.

Recent studies have shown that individual β-cells are functionally different, to the extent that some subsets of β-cells, termed 'hub' cells, are able to drive the behavior of others[2]. Scientists found experimental evidence for hub cells by using a dual optogenetic and photopharmacology strategy to stimulate hub cells and silence, or stop activity in, other cells. The silencing of hub cells caused the islet to become desynchronized in its response to glucose, while stimulation of hub cells allowed the synchronized response to resume[2]. These unique characteristics of hub cells to control the islet synchronization suggest that hub cells are a major contributing factor to insulin secretion.

The experimental data produced by Johnston et al. was used to create a simulation of a network of β-cells[5]. The simulation was unable to determine the existence of a type of β-cell with characteristics of the hub cell described by Johnston et. al[2]. Instead, a similar subset of β-cells, termed switch cells, were identified. Unlike hub cells, switch cells are not typically the most functionally connected cells. Additionally, when switch cells are present, the functional connectivity of the network of cells does not follow a power law distribution as suggested by Johnston et al.[2]; Patwardhan was unable to reproduce desynchronization of the islet due to power law functional connections and hub cell silencing[5]. Even with these differences in network

functional connectivity distribution and cell functional connectivity level, the switch cells in the simulations were still able to influence islet behavior. The switch cell's ability to control islet activity makes them an interesting target to study for future diabetes treatments.

In this paper, we develop an artificial neural network that uses cell characteristics to distinguish between islets with at least one switch cell (switch islets) and islets lacking a switch cell (non-switch islet). The network was trained using features such as cell characteristics and cell coupling values. We observed whether the network could differentiate patterns to make correct predictions by calculating the accuracy of each training and testing session. Evaluation of these measures demonstrated that the important features for determining the existence of a switch cell are KATP and cell coupling values. The network described in this paper uses two or three cells. However, it was designed to be scaled up for use with a more biologically relevant number of cells[4]. Most of the results presented in this paper use simulation data for a two-cell islet so that we can present a visualization of the classification being learned by the network. Comparison of the accuracy values for networks trained with two and three-cell islets showed that the three-cell case misclassified islets more often.

# Methods

Artificial neural networks (ANNs) are useful for identifying complex patterns in large datasets. The neural network discussed in this paper is designed to find patterns in pancreatic β-cell characteristics and cell coupling values to identify switch islets.

## Simulation Data

The most important part of a neural network is the data being used to train and test the network. We used artificial data based on realistic biological values to optimize the network parameters. To train and test the network, we used data obtained from simulations run by Patwardhan[5]. These simulations were based on cell equations (1) and (2) which describe the behavior of the two cells:

$$\frac{dx_1}{dt} = f(x_1;\ gkatp_1) - g_{c12}(V_1 - V_2), \tag{1}$$

$$\frac{dx_2}{dt} = f(x_2;\ gkatp_2) - g_{c12}(V_1 - V_2), \tag{2}$$

where $x_i$ is the vector state variable of beta cell, I, with first component voltage, $V_i$, and dynamics are given by the vector function f. Specific forms of the model can be found in Patwardhan[5], and similarly described in Sherman[9]. To fit with our description of

switch cells, we only considered synchronized networks of cells, meaning the cells were firing action potentials at the same time.

We first collected data based on a two-cell islet. The $K_{ATP}$ ($g_{KATP}$) values for both cells and the coupling ($g_c$) value between the cells were used as the inputs for the ANN. The coupling value between the two cells, which represents the strength of the connection between the two cells, was held constant for the first test of the network. The output of the network was classified into switch islet or non-switch islet categories. Islets that had at least one switch cell present were categorized as switch islets (S = 1), while islets without any switch cells were categorized as non-switch islets (S = 0). Information was stored in the following format: ($g_{KATP1}$, $g_{KATP2}$, $g_c$, S). An example dataset used for training is (120.66, 127.35, 13.326, 1). We then transitioned to heterogeneous coupling values, which increases the complexity of the prediction problem because each coupling value has a different boundary for determining switch cells. Eventually, we progressed on to data for a three-cell islet with two cell-cell connections, giving us only two g¬c values for this scenario. An example of this data is: (137.09, 130.04, 115.92, 7.4679, 4.4491, 1) in the format ($g_{KATP1}$, $g_{KATP2}$, $g_{KATP3}$, $g_{c1,2}$, $g_{c2,3}$, S). Note that before use in training, these $g_{KATP}$ values and $g_c$ values were divided by their mean distribution value, 130 and 50, respectively, for better learning.

## Structure of the Artificial Neural Network

When designing this ANN, we kept simplicity in mind to focus on which input features were most important to the network. For this reason, we created a feedforward neural network with a single hidden layer and used backpropagation as described by Higham and Higham[6]. A diagram of the network used for a two-cell islet is shown in **Figure 1**.

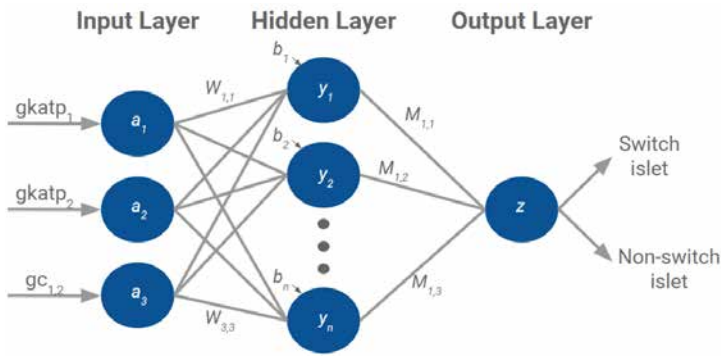



**Figure 1.**
A diagram of the structure of the fully connected Artificial Neural Network used for a two-cell islet. Three input values were used which represent the $K_{ATP}$ ($g_{KATP}$) values of both cells and the coupling value ($g_c$) between the cells. The network was designed to make a binary prediction: switch islet or non-switch islet.

Our simple network consists of three layers: input layer, hidden layer, and output layer. For the two-cell islet problem, our input layer has three nodes representing three features of the islet: $g_{KATP}$ of cell one ($g_{KATP1}$), $g_{KATP}$ of cell two ($g_{KATP2}$), and the coupling value between the cells ($g_{c1,2}$). The number of nodes (n) in the hidden layer is 20. Because we have defined this problem as a binary classification problem, our output layer has only one node which gives a value between zero and one. A value close to zero is a predicted non-switch islet whereas a value close to one is a predicted switch islet.

## Network Training

We train the network by performing a forward and backward pass. Predictions are made in the forward pass and the error in those predictions are used to update the weight and bias values in the backward pass. Completion of the forward and backward pass is a single iteration.

The features we use to train the network, $g_{KATP1}$, $g_{KATP2}$, and $g_{c1,2}$ in the two-cell case, are passed to the input layer. Our network is fully connected, so every node in the input layer, $a_j$, is connected to every node in the hidden layer, $y_i$, and so on. We define a weight term for each connection between an input node and a hidden node. These weights are stored in a weights matrix, $W$, for faster calculations. To help the model fit the data, we also assign bias, b, terms to each hidden node.

We calculate the hidden layer nodes (4), followed by the output layer node (5) in the forward pass. The sigmoid activation function (3) is used due to the nonlinearity of our problem[6] and because it ranges from 0 to 1,

$$\sigma(x) = \frac{1}{1+e^{-x}}. \tag{3}$$

This activation function is applied to the weights matrix and bias vector associated with the hidden layer to calculate the value of each hidden node, $y_i$,

$$y_i = \sigma\left(\sum_j W_{ij} a_j + b_i\right). \tag{4}$$

As we move from the hidden layer to the output layer, we calculate the value of the output node, $z$, in a similar manner,

$$z = \sigma\left(\sum_i M_{1i} y_i + b\right). \tag{5}$$

Where $M_{1j}$ is the corresponding weights matrix with only one column and b is a single value according to the single output node. This set of calculations, (4) and (5),

completes the forward pass, where we now have an output node value, which gives us our prediction of a switch or non-switch islet.

To evaluate the performance of the network, we compare predicted output values with actual output values using a cost function (6). Our cost function is a root mean squared error (RMSE) function defined as,

$$C(x) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\frac{1}{2}\|y(x^i) - F(x^i)\|_2^2}, \tag{6}$$

where n refers to the number of datasets being used to train the network, $y(x^i)$ is the target output, and $F(x^i)$ is the predicted output. This cost function gives an output value between 0 and 1. We used MATLAB's built-in feedforward neural network with heterogeneous coupling simulation data to compare the accuracy of the RMSE cost function and the cross entropy (CE) cost function which is more typically used for classification problems. We trained and tested the network 100 times for each cost function and found that RMSE had an accuracy of 94.76% ± 1.05, while CE had an accuracy of 94.87% ± 0.97. We use RMSE for the calculations in this paper.

The backpropagation step is employed to update the weight and bias values of the layers for proper network learning. This step implements the stochastic gradient descent algorithm as described by Higham and Higham[6]. This algorithm begins at the output layer and moves backwards to the input layer, calculating partial derivatives of the cost function with respect to either the weight or bias[6,8]. For each layer l, the values of the weights are updated by the following rule,

$$W^{[l]} = W^{[l]} - \eta\frac{\delta C}{\delta W^{[l]}}, \tag{7}$$

where C is our cost function and $\eta$ is the learning rate of the network. The learning rate determines the step-size that we take toward the local minima[8]. Bias values are similarly updated,

$$b^{[l]} = b^{[l]} - \eta\frac{\delta C}{\delta b^{[l]}}. \tag{8}$$

Once each layer has updated weight (7) and bias (8) values, the backpropagation step is finished, and the network has completed a single iteration. The network continues learning until all the user-specified iterations are completed on all the training data.

### Network Testing

The network is trained on 3,000 unique datasets for the specified number of iterations and then undergoes a testing phase with 2,000 new datasets. To analyze the performance of the network, we calculate the accuracy (A) of the network. This calculation considers the true negatives (TN), true positives (TP), false negatives (FN), and false positives (FP) as dictated by the results of the testing phase. A TP is when both the actual and predicted output values are switch islet and a TN is when both the actual and predicted output values are non-switch islet. In contrast, a FP is when the predicted output was a switch islet when the actual output should have been a non-switch islet. Similarly, a FN is when the predicted output was a non-switch islet when the actual output should have been a switch islet. The accuracy measure is calculated by summing the true positives and true negatives, and then dividing by the total number of testing datasets. Multiplying this value by 100 gives a percentage indicating the accuracy, with 100% representing the most accurate network. Computing the accuracy values allows us to compare the ability of the network to learn different sets of data.

## Results and Discussion

We used various sets of simulation data to challenge the robustness of the ANN that we created. The network was able to make accurate predictions for both two and three-cell islet scenarios that used $g_{KATP}$ and $g_c$ input values.

### Optimal Network Hyperparameters and Training Set Size

Before training the network with data collected from simulations, we experimentally found the optimal network hyperparameter values for learning rate ($\eta$) and iteration number ($i$) to ensure that the network can have maximal accuracy[7]. These parameters were used to initialize the network. Additionally, we chose to optimize the training set size ($T$) to reduce program runtime and the amount of time spent collecting simulation data without sacrificing high accuracy. Our optimal values were those associated with the highest average accuracy values.

Since there is not yet a precise methodology for choosing hyperparameters[7], we tested different combinations of values for the learning rate ($\eta$) and iteration number ($i$) hyperparameters as well as training set size ($t$). We used artificial data that was not collected from simulations to train and test the network. This artificial data was created by randomly generating two $g_{KATP}$ values, and then considering the boundary lines to record the target output. For simplicity, we assumed homogeneous coupling values and used only two inputs: $g_{KATP1}$ and $g_{KATP2}$.

The network was trained and tested three times for every combination of n, i, and T values, which were [1, 0.5, 0.1, 0.05, 0.01, 0.005], [100, 200, 300, 400, 500, 1000], and [1000, 2000, 3000, 4000], respectively. For all t tested, the values n=0.1 and i=200 provided the highest average accuracy values. Using these n and i values, we compared the accuracy measures for different t as shown in **Table 1**. The optimal size was found to be t=3000 because it had the highest accuracy. This guided our decision to use 3,000 datasets for training and 2,000 datasets for testing future networks.

| Training Set Size (t) | Average Accuracy (%) |
|---|---|
| 1000 | 94.4% |
| 2000 | 98.95% |
| 3000 | 99.4% |
| 4000 | 98.55% |

**Table 1.**
Comparison of accuracy values for different training set sizes. The accuracy values are an average of three different training and testing sessions for the network. The same datasets were used in all scenarios.

Identifying an optimal data set size before continuing with further tests minimized time and effort. Obtaining simulation data was a very manual, time-consuming process carried out by Dr. Patwardhan[5]. By discovering the number of datasets required for successful network training, we could collect the necessary datasets (3,000 for training and 2,000 for testing) at the same time. We only used homogeneous coupling when discovering an optimal data set size and assumed that heterogeneous coupling would require a similar number of data sets. This assumption proved true when we found similar accuracy values for homogeneous and heterogeneous coupling as shown in **Table 2**.

## Homogeneous Coupling

The first type of data used for training had homogeneous coupling values. Two different coupling values were tested: $g_c$=3 and $g_c$=50. We chose these values because we wanted to represent both weak ($g_c$=3) and strong ($g_c$=50) coupling. The accuracy values can be found in **Table 2**. We were interested in seeing the misclassified points, and because we had a low-dimension problem in our two-cell islet case, we were able to plot the true positives and negatives and false positives and negatives in **Figure 2**. As seen, both coupling values tested have good accuracy values above 90%. The weaker coupling value has a noticeably lower accuracy of 95.85%, which may be due to the reduced likelihood that weaker coupling will produce a switch islet with the same cell property distributions (i.e. gKATP) as strong coupling. This difference is seen in **Figures 2a** and **2b**. While **Figure 2a** has two very small regions of switch islets,

which makes it less likely to have a switch islet, **Figure 2b** has two significantly larger regions of switch islets. The differently sized regions of switch islets are a result of the boundary lines, which are unique to each coupling value. These boundary lines, shown in **Figure 2**, show the first thresholds for determining switch cells.

| Coupling Value ($g_c$) | Average Accuracy (%) |
|---|---|
| 3 | 95.85% |
| 50 | 99.1% |
| 3 and 50 | 95.88% |
| Heterogeneous, 0-100 | 96.1% |

**Table 2.**
The average accuracy values for datasets with different coupling values. To calculate the average accuracy, the same data was used for three different training and testing sessions of the network. The accuracy was calculated for each session, and the average is recorded in this table.

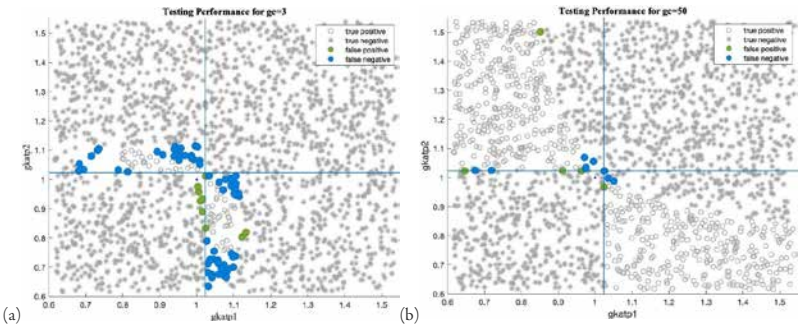



**Figure 2.**
Comparison of switch islet regions and the true positive, true negative, false positive, and false negative results for two different coupling values. (a) a weak coupling value (gc=3) with small switch islet regions, (b) a strong coupling value (gc=50) with large switch islet regions.

## Heterogeneous Coupling

Two types of heterogeneous coupling were used to further test the network: a combination of $g_c$=3 and $g_c$=50, and completely heterogeneous coupling values ranging uniformly from 0-100. The combined training data had 1,500 sets for $g_c$=3 and 1,500 sets for $g_c$=50 to prevent a bias in the training data. The results from combined data were compared to the results for each individual coupling value. As shown in **Table 2**, the accuracy of this first type of heterogeneous coupling was 95.88%. Notice that this accuracy is much closer to the accuracy obtained by the homogeneous $g_c$=3 network than the homogeneous $g_c$=50 network. This is likely due to strongly coupled cells producing switch islets, while weakly coupled cells with

similar properties do not.

The more complex task of learning patterns in a set of data with coupling values evenly distributed between 0 and 100 still had a good accuracy value of 96.1% as shown in **Table 2**. This successful training of the network with heterogeneous coupling values means that the network was able to learn very different boundaries and associate them with the correct coupling value. The classification of predictions can be found in **Figure 3**. Misclassified points were typically found either at the intersection of the two lines or on the edges of the coupling value boundaries.

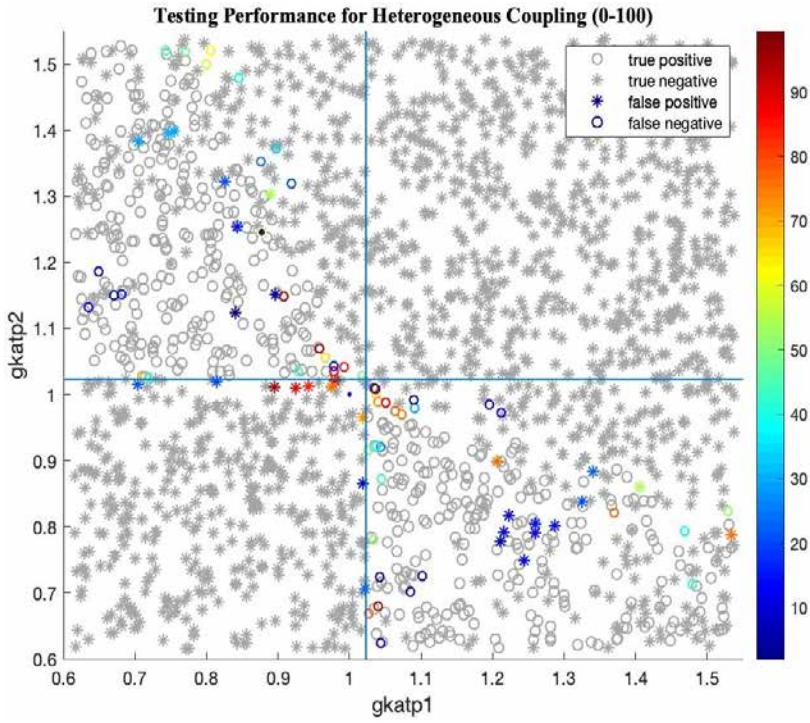



**Figure 3**.
Classification of testing predictions for data with heterogeneous coupling (gc=[0-100]). The accuracy of these predictions was 96.1%.

## Three-Cell Islet

We further tested our network with simulation data for a three-cell islet with only two cell connections. This increased the number of inputs to the network from three to five: $g_{KATP1}$, $g_{KATP2}$, $g_{KATP3}$, $g_{c1,2}$, and $g_{c2,3}$. The average accuracy when training and testing with this data was 88.47%. Although this is still a good accuracy, it is noticeably less than that of the two-cell islet with heterogeneous coupling. There may be several factors playing into this decreased accuracy value, such as increased complexity of the

problem or lack of cell characteristics. If the increased complexity is the cause, we can vary the number of nodes in the hidden layer or add more hidden layers. To determine if the lack of cell characteristics is negatively impacting the learning process, we can add more cell characteristic features as inputs for the network or use simulation data for a three-cell islet with all cells coupled. We look forward to training the network on islets with higher numbers of cells to see if the accuracy value continues to decrease as cell number increases.

## Conclusion and Future Directions

We have created a neural network that approximates the characteristic boundaries for determining switch islets, and more specifically, switch cells. We demonstrated that the use of both $g_{KATP}$ and $g_c$ values as inputs allows the network to have a high accuracy when predicting switch islets. The network has had sufficient accuracy of predictions when testing two and three-cell islets using homogeneous or heterogeneous coupling values. There was a slight decrease in accuracy when scaling up from a two-cell islet to a three-cell islet, so we are interested in testing the network with larger islets containing 13, 57, or more cells to see if the pattern continues. A complexity problem is introduced by using these larger islets because the number of inputs for the network will soar into the thousands due to coupling values between the cells. This will amplify the time needed to perform a network training. Although it will take longer to test different scenarios in these larger islets, we believe that the patterns learned by the network will be more relevant to those found in a human pancreatic islet.

The approach of using a neural network to reverse-learn the characteristics of a mechanism or cell, as described in this paper, can be applied to a multitude of other problems. Through analysis of the neural network predictions and comparison of networks trained with different inputs, scientists can hypothesize about the gaps in our knowledge for the mechanism being studied. These hypotheses provide guidance for future experiments to confirm what is observed in the neural network model. In our case, we hope that the analysis of neural network predictions will allow researchers to learn more about the important characteristics underlying connectivity of switch cells. This analysis can also point to certain features that appear important in determining switch cells. By pinpointing these features, we can suggest further biological experiments to validate what we are observing in the neural network. Ultimately, this will help researchers determine the methods by which β-cell connectivity and switch cell determination impacts insulin secretion, paving the way for development of new diabetes treatments.

# Works Cited

[1] Centers for Disease Control and Prevention. (2020). *National Diabetes Statistics Report 2020: Estimates of Diabetes and Its Burden in the United States*. https://cdc.gov/diabetes/ pdfs/data/statistics/national-diabetes-statistics-report.pdf, accessed August 27, 2020.

[2] Johnston NR, Mitchell RK, Haythorne E, Pessoa MP, Semplici F, Ferrer J, Piemonti L, Marchetti P, Bugliani M, Bosco D, Berishvili E, Duncanson P, Watkinson M, Broichhagen J, Trauner D, Rutter GA, Hodsen DJ. (2016). Beta cell hubs dictate pancreatic islet responses to glucose. *Cell Metabolism*, 24, 389-401.

[3] Skelin M, Rupnik M, and Cencic A. (2010). Pancreatic beta cell lines and their applications in diabetes mellitus research. *ALTEX - Alternatives to animal experimentation*, 27(2), 105-113.

[4] Rutter GA, Pullen TJ, Hodson DJ, Martinez-Sanchez A. (2015). Pancreatic b-cell identity, glucose sensing and the control of insulin secretion. *Biochem*. J., 466, 203-218.

[5] Patwardhan J. (2020). The Disruption of Bursting Behavior in Pancreatic Islets: A Network and Dynamical Systems Analysis of Multicellular Clusters. UMBC Dissertation.

[6] Higham CF and Higham DJ. (2018). Deep Learning: An Introduction for Applied Mathematicians. *SIAM* 61(4), 860-891.

[7] Gandhi R. (2018, May 17). *Improving the Performance of a Neural Network.* Towards data science. https://towardsdatascience.com/how-to-increase-the-accuracy-of-a-neural-network- 9f5d1c6f407d, accessed August 16, 2020.

[8] Budhwant P. (2018, Jul 16). *A beginner's guide to deriving and implementing backpropagation*. Binaryandmore. https://medium.com/binaryandmore/beginners-guide-to- deriving-and-implementing-backpropagation-e3c1a5a1e536, accessed August 30, 2020.

[9] Sherman A. (1996). Contributions of modeling to understanding stimulus-secretion coupling in pancreatic beta-cells. *American Journal of Physiology-Endocrinology and Metabolism*, 271(2): E362{E372. doi:10.1152/ajpendo.1996.21.2.E362.

# Virtual Influencers: Identity and Authenticity in the Age of Social Media

Tahia Shendy

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# Tahia Shendy

**Tahia Shendy graduated from UMBC in Summer 2020 with her bachelor's degree in media and communication studies, as well as minors in art history and museum studies. While at UMBC, she was a member of the Transfer Student Alliance. A lover of storytelling and the daughter of a diverse family, her goal is to find ways to uplift the narratives of minority communities through her work. She is currently working as the Community Success Associate at AEFIS.**

**Tahia would like to thank her faculty advisor Dr. Rebecca Adelman for her support and guidance through the completion of this paper, as well as every other professor who challenged her to grow throughout her time as an undergrad at UMBC.**

"The first time I heard of Miquela Sousa was through a close friend of mine. She thought that I would find the very concept of Miquela's existence exciting and she was right. I began studying Miquela and virtual influencers briefly for the MCS 355 (Social Media: Networking and Mobility) course I took in fall 2019. I decided to pursue the topic more fully as my final undergraduate research paper in MCS 499 under the mentorship of Dr. Rebecca Adelman. Even as I followed her socials and kept up with her content, I struggled to understand how I personally should internalize her existence. Even more so, I was interested in how others were reacting to her. I pursued this research in order to not only dig deeper into why I and other social media users felt conflicted about Miquela's existence, but to understand what that conflict might mean in the grander scheme of media and identity at large."

**-Tahia Shendy**

**Image 2.**
Social media reconstruction showcasing digital influencers symbolically through code.

## Abstract

This paper examines Miquela Sousa, also known as "Lil Miquela," a "virtual influencer" produced by the company known as Brud. Through the use of discourse analysis, or the study of forms of language that shape our thinking and the institutions that produce and circulate them, I answer the question "how does the discourse around virtual influencers like Lil Miquela challenge our understanding of identity in a digital space?" I analyze Miquela's content, her relationship with her audience, and the various discussions surrounding her identity online. Specifically, I discuss her identities as a victim of sexual assault, as a member of the LGBTQIA+ community, and as a woman of color. Through this I discerned in two overarching discourses: that Miquela is seen either as a form of exploitation or as a form of representation by her audience. I conclude that Miquela is forcing social media users to rethink their definitions of representing a community versus exploiting it; challenging them to redefine "authenticity." Ultimately, these discourses serve as a foundation for understanding identity in the digital space as it continues to evolve in the future.



*Keywords: social media, influencer, authenticity, identity, LGBTGLA+ & social discourse.*

# Introduction: A Rideshare Gone Wrong

The year is 2019, and like many people attempting to pass the time in a digital age, you find yourself scrolling YouTube for something to entertain you. As you run through a dozen recommended videos, one catches your eye: a girl with sharply cut bangs and racially ambiguous features is posing in a neon-tinted shot. She seems cool, relatable and pretty (all of the things you might expect a vlogger to be) but something seems a little... off. Still, you have seen weirder things, so you shrug it off and click anyway. As you chuckle through the jump cuts and roll your eyes at the memes that pop up with each comedic reference, the girl goes on to tell a chilling story. She shares that in between the stresses of her daily life, one day while living in sunny California, she decided to go to the beach. Being environmentally conscious like many young adults in the Los Angeles area she opts to take a rideshare—and it is during this ride that she is sexually assaulted by the other passenger. As she tells this story, you cannot help but feel uneasy. This narrative is one that has been told countless times, and in the age of the "#MeToo" movement, many have used social media to give voice to their trauma. The details she shares: the smell of the vehicle, the pop music playing, and even the feel of his hand on her leg are all eerily familiar. Perhaps you know someone who went through something like this. Perhaps you have been through it yourself. But the story, with its familiar beats and tragic outcome, is not what makes you uneasy. It is the fact that the woman telling it to you does not exist outside of the digital space.

As social media continues to evolve in tandem with its users, we have begun to see new and creative ways of utilizing these platforms. One such trend is the rise of the influencer: the social media user who, whether through aesthetically pleasing photos, viral humor, or outspoken advocacy, has amassed a following online. These users can enter media spaces previously inaccessible to the average person such as the television or movie industries, and are often even sought out by companies to promote their brands or products. While influencer online identities are carefully curated, edited, and styled to fit a certain image, there is always a person behind that online identity.

However, in the case of Miquela Sousa (also known online as "Lil Miquela") there is no one person behind it all. She is a "virtual influencer," or an influencer who has been designed using technology to appear like a "real" (or physically bodied) person. A young woman of color in her twenties who writes music, goes through break-ups, and is an outspoken advocate for various communities, Miquela seems no different from her peers except for the fact she is computer-generated. Miquela has crafted a cult-following online while also being the center of multiple controversies. Some users defend her presence on social media while others criticize her, all the while

messaging and commenting on her various social media accounts.

This tension has led to multiple discourses developing around virtual influencers and their presence online. I used discourse analysis to analyze the following three discourses that have emerged around Miquela, specifically: her identity as a victim of sexual assault, her queer identity, and her identity as a woman of color. The focus of this research was not only Miquela's identity and what it means for her to be a manufactured LGBTQIA+ woman of color, but also how her presence is challenging notions around identity in the digital space as a whole. I also explored how virtual influencers interact with their audience, how their audiences respond to these manufactured personalities and narratives, and how we quantify and qualify identity in a digital space.

By analyzing Miquela's content, her audience, and the way her identity has been designed on social media, I unpacked the discourses presented above and why her presence is causing them. Despite her manufactured nature, Miquela Sousa emulates authenticity; her presence blurs the line between what is "authentic" and "inauthentic" online. While this research did not seek to define authenticity, it did explore some of the facets often tied to it—such as honesty, trust, and a sense of "humanity". Furthermore, I posited that Miquela is not only disrupting our perception of authenticity, but she is also forcing us to reevaluate how we define identity on social media as a whole. Finally, Miquela's creation has begun a dialogue surrounding the ethics of identity online. She is forcing us to rethink how social media users approach representation of minority communities, and what is or isn't acceptable when doing so.

## What is a Virtual Influencer?

Before beginning the process of deconstructing Miquela Sousa, it is necessary to understand exactly who (or what) Miquela Sousa actually is. To do so, we need to define what an "influencer" is versus a "virtual influencer". According to Zdenka Kodokova and Maria Holiencinova's research on influencer marketing, an influencer is

> "an individual with a significant following on social media who is paid by brands to promote their products to said followers, via free products and trips and/or cash payment per promotional post. The purpose is to persuade followers to purchase such products" (92).

Furthermore, they explain that

> "the majority of influencers fit into the following categories: celebrities, industry experts and thought leaders, bloggers or content creators and micro-influencers . . . bloggers and influencers active on social media (predominantly micro-bloggers) have the most authentic and active relationships with their fans. Brands are now recognizing and encouraging this" (92).

Essentially, there are several types of individuals who can be classified as an influencer—including more traditional celebrities and even journalists. However, the ones that have developed the most effective (or loyal, trustworthy, and consistent) relationships with their fanbase are often bloggers or social media personalities who gained notoriety through their initial platforms. Kodokova and Holiencinova also clarify that "these individuals are not simple marketing tools, but rather social relationship assets with which brands can collaborate to achieve their marketing objectives" (92). Thus, as mentioned above, the more "authentic and active" the relationship between influencer and fan, the more value an influencer will have to a prospective company looking to sponsor them.

The existence of the influencer and their ability to market, build relationships, and more is rooted in the concept of internet celebrity. In "Internet Celebrity: Understanding Fame Online," Crystal Abidin explains that Pierre Bourdieu's framework for "capital" is the foundation for building fame online and is broken down into four core qualities: exclusivity, exoticism, exceptionalism, and everydayness (19). Each one relies on a different form of capital. Abidin explains that exclusivity relies on economic capital (19) and exoticism on cultural capital (22). Exceptionalism relies on technical capital, which can refer to a skillset rooted in technology itself (28) or simply highly specialized skills in general such as the arts (29). Moreover, everydayness relies on social capital, or capital created through building meaningful relationships and networks (33). These four concepts and the capital they rely on are used to foster "internet celebrity". In order for an influencer to be successful in building their fame, they must utilize a combination of these qualities. Miquela,fulfills most of these qualities; she is frequently shown wearing high-end and expensive clothing or accessories (exclusivity). Additionally, she identifies as a woman of color and LGBTIQ+ (exoticism) and she releases her own music as well as visual content created using CGI (exceptionalism). Finally, she is frequently pictured not only with her fellow virtual influencers like Bermuda and Blawko, but also spending time or collaborating with other traditional celebrities and influencers (everydayness). By Abidin's framework, Miquela would qualify as an influencer.

Furthermore, in their research on "Brand communication through digital influencers: leveraging blogger engagement," Ebra Uzunoglu and Sema Misci Kip present the idea that influencers are "opinion leaders... characterized as the individuals, with a wide set of personal connections, who play a key influential role and who are considered as both source and guide" (593). By this definition, influencers are those who (through their amassed capital) can sway opinion on various issues in one direction or the other—including in a marketing context. Whether it is a physical product being sold or an ideology, influencers have the ability to shape their audience's opinions. In the age of social media, this influence often takes place on platforms such

as Twitter, Instagram, YouTube, etc. Uzunoglu and Kip's theory reinforces Kodokova and Holiencinova's definition above, as well as the capital framework discussed by Abidin.

The next step is to define a virtual influencer. In their paper "Virtual Influencers: Stretching the Boundaries of Intellectual Property Governing Digital Creations," Sonia M. Okolie examines how the presence of virtual influencers is disrupting the digital marketing space. Okolie defined a virtual influencer as "a digital image with a great mass of social media followers that... [is] being used by brands to do the work of what a human influencer would do" (1). So, while they serve a similar purpose from a marketing perspective, the key distinction here is that unlike an influencer, virtual influencers are a digital image (or images). Kodokova and Holiencinova echo this observation, stating that "virtual or rather artificial influencers operate online, much like the real ones. Brands want to team up with them to tap into their fan base. Even if they are not originally designed to be brand ambassadors, with enough popularity, they will surely attract companies seeking endorsement deals" (97). Their virtual status could also be seen as its' own unique form of exceptionalism, as their existence is only possible through the use of advanced technology and is inherently distinct compared to their peers. Based on this information, it is important to note three things. One, that virtual influencers can be defined as a "digital image" or a compilation of images; two, virtual influencers can serve a similar role to that of their non-virtual peers; and three, as long as they have a following, they will be sought out by companies to promote products and services.

However, unlike the traditional influencers defined above, virtual influencers are not rooted in one physical body. In other words, they do not exist outside of the context of their digital content. While you could run into a regular influencer attending an event or getting groceries at the store, a virtual influencer is limited strictly to the digital space. This is in opposition to the influencer, who existed before their presence on social media and who will continue to exist, at least in some capacity, long after.

## Miquela Sousa

Virtual influencers have become increasingly common, permeating the social media space in multiple contexts—albeit mostly in the realm of modeling, fashion, and beauty. It is for this reason that, despite carefully rendered faces and bodies, they often do not have distinct personalities. They are usually predominantly visual entities and not much more. This paper focuses specifically on Miquela Sousa. While Miquela exists in spaces mentioned above, there are a few reasons why she stands out amongst the sea of virtual influencers. Firstly, Miquela has an extensive social media

presence. Her Instagram currently has roughly 2.7 million followers and 847 posts with thousands of comments. She also has a YouTube channel where she posts vlogs, music videos, and marketing campaigns she has been part of. Additionally, she has quite a large and vocal following, so suffice to say, there is no shortage of material to analyze. More than anything, though, Miquela has arguably the most developed personality among her peers. Throughout the course of her career, Miquela has forged relationships, shared her own music, and established an identity for herself.

**Above:** A selfie posted on May 6, 2020 on Miquela's Instagram page @lilmiquela

While the details of her story are rather long and intricate, there are a few things to note. First, Miquela does not identify as a virtual influencer but as a robot. She asserts

that while she is not human, she does have a physical body and a mind of her own, although both are artificial. This is unique to her and the other virtual influencers, Bermuda and Blawko, who were also created by her company, Brud. Miquela's definition of self makes talking about her more complicated. As Miquela within the context of her own narrative is not the same as Miquela in the broader discourse surrounding her. Second, Miquela is not only an influencer but a content creator. She releases her own music, posts vlogs, and even conducts interviews with other prominent artists. For example, she was interviewed by Zach Sang (a popular radio host known for his in-depth celebrity interviews) for his show, discussing everything from her music to her fans (*Miquela Talks Being A Robot, Her Song "Money", Kissing Bella Hadid & Collabs - YouTube*). Finally, Miquela is actively involved in sponsorships and partnerships with various brands. In fact, she starred in a high profile, LGBTQIA+ positive CALVIN KLEIN commercial with well-known model Bella Hadid; which sparked a lot of controversy upon release (*Miquela and Bella Hadid Get Surreal | CALVIN KLEIN*). These three points will help contextualize the discourse around Miquela in the digital space that this research seeks to unpack.

Through her social media content and other projects, Miquela has become the center of several discussions around virtual influencers and whether or not they are ethical. In particular, Miquela identifies as a woman of color as well as LGBTIQ+. These are two minority groups whose representations in media have previously been the subject of scrutiny, especially from members of said communities. Rightfully so, as the way these groups are represented in media can have a huge impact on how they are perceived outside of it. As stated in the introduction of this paper, she has also spoken about her experiences with sexual assault (the video in which she did so only survives in clips shared on social media), which has caused her to be heavily scrutinized by fans and strangers alike. Lastly, and perhaps most simply, Miquela's presence online feels, in many ways, authentic. In this context, authenticity can be difficult to define, but unlike many of her virtual counterparts that are defined purely by aesthetics, Miquela has a distinct personality and thus appears more "human" than they do. This authenticity, or sense of humanity, shines not only in her design but also her voice and actions. She creates music, speaks out against social injustice, goes through break ups, and takes silly selfies. Her identity is so thorough, so detailed and nuanced, that it almost feels like a betrayal (of not only Miquela but how identity is defined and understood online) to call her anything but authentic. Yet, at the same time, Miquela is not a person in the same way a non-virtual influencer is. She only exists online, and that existence was created with a purpose. To understand the discourse around Miquela, it is imperative to acknowledge the company that made her: Brud.

## Brud: The Masterminds Behind Miquela

While Miquela Sousa is very visible to the public, her creators are not. Since Miquela made her very first Instagram post in April of 2016, Brud has managed to avoid the publicity that made their creation so popular. In fact, Brud's official website is almost bare. Formatted to look like an active Google Doc, the site makes two core claims. The first is that "Brud is a transmedia studio that creates digital character-driven worlds"("Website_copy_wip_for_all_my_qtz"). This goal is clear through their projects namely through the narratives crafted around Miquela, Bermuda, and Blawko. Their second claim is that "Brud is reading war of the worlds on the radio." This statement takes more time to deconstruct. A reference to the "War of the Worlds" radio program from 1938 which documented a fictional alien attack, the show is well-known for the supposed panic it caused when it first aired. While the program was not real, it is believed that some listeners who tuned in to the program did not know this and assumed that the United States was truly under attack. By making this comparison, Brud is asserting that Miquela is distorting reality in a similar way by making people question what is or is not real online. They even play with this idea as they answer the question "Is Miquela real?" with the response "As real as Rihanna"("Website_copy_wip_for_all_my_qtz"). This answer is purposefully vague. It could imply that Rihanna, as a celebrity and influencer in her own right, is comparable to Miquela and thus both are "real". It could also imply that traditional celebrities like Rihanna are inherently inauthentic despite being non-virtual. Essentially, the statement plays with the audience's notion of what makes a person authentic and how authenticity can be defined.

Their vague website is only a small hint at the mystery around Brud. In fact, it was only as recently as 2018 that the people behind Miquela's creation, as well as the true nature of the company, were revealed to the public. According to an article on Tech Crunch, the company was created by Trevor McFedries who "had been manufacturing social influence in Los Angeles through his talents as a dj, producer and director before entering the startup world" (Shieber). Furthermore, the article shares that Brud has been financed by several high-profile companies based in Silicon Valley, such as Sequoia Capital. This, in combination with the fact that Miquela's first openly sponsored post with the brand bornxraised was in November (only six months after her first post), means we can assume that Miquela was likely intended to be a for-profit entity. While Brud's website claims that their stories "can create a more tolerant world by leveraging cultural understanding and technology," Miquela's inherent role in driving their profit through her sponsorships has had a heavy influence on the discourse she sparks. If an identity is crafted specifically for profit, then it brings into question whether or not it can truly be authentic?

## Identity in the Digital Space

There is little doubt that social media has prompted society to rethink our perceptions of identity. Tara Suwinyattichaiporn, a professor at California State University, designed an activity based on this concept. "Project Me: understanding social identities through social media" was designed to prompt students to create their own original content on social media over the course of a semester and then reflect on that content (1). Suwinyattichaiporn explains that "the process of researching, writing, and designing page content should promote a deeper understanding of self and the concept and the concept of social identities" (1). "Project Me" indicates a few things. One, that our social identities are now linked to the digital space and how we represent ourselves there. Two, that understanding our relationship with social media is important to the overall discussion around social identity.

Jose Van Dijck's book, The Culture of Connectivity, has a chapter on "Making the Web Social: Coding Human Interactions." This chapter dissects the various meanings that are imbued into social media platforms. Van Dijck states that "social media can be seen as online facilitators or enhancers of human networks, webs of people that promote connected-ness as a social value... By the same token, social media are inevitably automated systems that engineer and manipulate connections" (11). Furthermore, he explains that "'making the web social' in reality means 'making sociality technical.' Sociality coded by technology renders people's activities formal, manageable, and manipulable, enabling platforms to engineer the sociality in people's everyday routines" (12). We see this in the various mechanisms that structure and guide interactions online. Likes, comments, direct messages, tagging, etc. are all ways in which sociality has been made manageable and trackable—not only to the users, but to the companies that make such products. These mechanics are also what allows influencers to exist online. Companies can look at this data, which has been tracked simply by using the platforms, and choose people to work with. Likes, followers, comments, etc. become the currency that denotes the amount of influence an individual has.

Authenticity itself is at the core of this discussion surrounding identity. It is a measurement by which identity is tested and validated and at, the heart of how people curate their own digital space and the people in it. That said, defining authenticity is a difficult task. Alice Marwick asserts that authenticity "is a quality that takes many forms, from direct interaction with admirers to the public discussion of information, which is tedious at best" (114). Marwick also goes on to specify that within the context of the internet "which idealizes transparency and thus expects a certain level of exhibitionism", celebrities in the digital space "are expected to be more 'real' than stars of the screen or the stage" (114). Within Marwick's framework, the authenticity

of an influencer (virtual or otherwise) is fluid. It changes within different contexts and with different people. Someone might see influencers who do paid sponsorships for products or services as inherently inauthentic, while someone else might not. Therefore, in the eyes of different viewers, an influencer's authenticity can fluctuate. However, regardless of how it is defined within a specific moment, its importance is heightened online due to the seemingly accessible nature of those in the digital space. The relationship between an influencer and their audience is the social capital that allows them to gain fame and success, while simultaneously making them more vulnerable to losing it.

So then, how would a virtual influencer fit into this system? In a paper exploring the relationship between identity and algorithms on social media, Holger Potzsch opens with a discussion about "socialbots." He explains that they are "algorithmically designed and maintained profiles on social media platforms that actively befriend and interact with human users... a reflection of our activities within social media... as such, instead of making machines more human, contemporary digital technologies might just as well entail a gradual deterioration of what it means to be human" (3305). Socialbots also reflect greater concerns about what makes us human in an increasingly digital world. Unlike Miquela, though, they are pre-programmed AI's and learn more about navigating social media as they go. If Miquela does not function as a traditional influencer or an AI, then she must lie somewhere in between.

## Miquela and Her Audience

In her book *Alone Together: Why We Expect More from Technology and Less from Each Other*, Sherry Turkle examined the relationships that children developed with the toy called a Furby, which was popular in the late 1990's and early 2000's. Somewhere in between a pet and a child, its selling point was its behavior. It would interact with the person it was given to and require them to care for it like a living being. Described as a "primitive exemplar of sociable robotics," Turkle explains that

> "such relational artifacts do not wait for children to 'animate' them . . . they present themselves as already animated and ready for a relationship. They promise reciprocity because, unlike traditional dolls, they are not passive. They make demands. They present as having their own needs and inner lives".

So, she explains, children relate to their Furbys in ways they normally would not with another toy. The Furby needs love, attention, and even to be lulled to sleep by its owners.

In a 1999 study conducted by Turkle, two children named David and Zach even said they wanted to teach their Furby Hebrew as they were currently learning the language themselves (40). Considering a Furby can pick up on and mimic human

speech patterns, this is actually not an entirely unrealistic goal for the children to pursue. Another child named Bianca confidently stated that "I love my Furby because it loves me... It [is] like he really [knows] me" (40). Several other children echoed the same sentiment, feeling a close bond with the toy and even guilt if any "harm" came to it. For example, taking out the batteries would mean killing the Furby versus simply turning it off. While not the most sophisticated piece of technology, the Furby was a toy turned bizarre social experiment; its ability to encourage relationships with children (relationships that were not based on imagination and projection, but a clear code of care and communication) was a new and popular phenomenon. While not the first robotic toy and certainly not the last, its impact on the study of robotics and sociality was noteworthy.

To compare Miquela Sousa to a Furby might sound a bit absurd. After all, one is a relatively simple robotic toy for children while the other is an invented social media personality. However, Turkle's observations of this childhood toy are oddly reminiscent of the interactions between Miquela and her audience. In the context of her own narrative, Miquela identifies as a "robot" and has documented her journey to accepting this title through the course of her social media career. This is part of why Miquela can be a difficult subject to analyze. There are multiple layers to who and what she is. In the context of this paper and most research regarding her, she is defined as a well-known virtual influencer. In the context of her own narrative, however, she calls herself a "robot"- a more sophisticated, human-presenting version of the "primitive" Furby. This is significant because it distinguishes Miquela from the majority of her virtual peers.

Take, for example, Shudu: a virtual influencer and model who also has a large following on Instagram. Although she is also a virtual influencer, she does not have a developed and expressed personality beyond her image- she is simply a passive visual. As for Miquela, being "non-human" is part of her narrative whether someone believes she is physically real (a robot) or not (simply virtual). When people discuss her as simply virtual, Miquela only exists through image and the content of her being produced. When people discuss her as a robot, she is not a human being but an entity that can effectively mimic one through AI. Like the classic toy, she is animated with a developed inner life and thoughts. In this way, she is able to connect with her audience like a Furby connects with its child.

This difference, between a compilation of images and a robot or an A.I., is important. Simply put, it does two things: one, it inherently creates a discourse around what Miquela is and what either option would imply about her identity; and two, it allows a jumping point for Miquela to connect with her fanbase. In her interview with the Zach Sang show, Miquela stated that she calls her fans "Miquelians" - a combination of her name and the word "aliens." She explained that a "Miquelian" is "my internet friend... really anyone who knows what it feels like to be different.

**Above:** A photo posted on November 12, 2020 on Shudu's Instagram page @shudu.gram

See, robots and aliens, I like to think, are friends because they're just trying to survive in a world that's made for humans. I can heavily relate to anyone who's ever felt out of place" (Zach Sang Show, 00:01:19-00:01:36). Miquela's self-identification as a robot allows her existence to serve as a metaphor for the outcast in society. By default, she is inherently different from everyone else, and this isolation inspires empathy from her followers. By calling her fans "aliens" and making this comparison of an unlikely yet profound friendship, one rooted in feeling different or alone, she solidifies her connection to her fans in a way that seems authentic and emotional. She states herself that she can relate to anyone who has ever felt like they do not belong, and her vulnerability is one of the reasons that Miquela can cause such mixed and strong emotions from those who encounter her. In the same way that she can inspire a bond and a sense of community, she can frustrate someone who sees this relationship as exploitative. After all, Miquela is still the marketing tool we discussed. This raises the question of whether the community she has built, one that is inherently tied to her purpose of making a profit, is even capable of truly experiencing this kind of connection.

Perhaps the answer does not matter so much as the question itself. In her research concerning the Furby phenomenon, Turkle says the toy was "designed to give users a sense of progress in teaching it, when the Furby evolved over time, it becomes the irreplaceable repository and proof of its owner's care. The robot and child have traveled a bit of road together" (41). Regardless of whether or not the robot was real, the child felt a strong bond with it. The child saw it as alive, and thus in some capacity, it was. Miquela Sousa has a similar effect on her audience.

However, Turkle also explored the relationship between people and machines in her book *Reclaiming Conversation: The Power of Talk in a Digital Age*. She states that "machines have none to offer, and yet we persist in the desire for companionship and even communion with the inanimate. Has the simulation of empathy become empathy enough? The simulation of communion, communion enough?" (Turkle 338). While Miquela may serve an empathic role for her audience, that does not change the fact that she is not a human. Neither a Furby or Miquela are alive in the way the humans they interact with are, yet the children in the study and Miquela's audience still hold space for them emotionally. Regardless of whether the Furby or Miquela are "alive," others develop relationships with them. This understanding creates the basis for the next hurdle of this research: the discourse around Miquela and whether or not her identity, as it has been crafted on social media, is ethical or not.

## Discourse:
## Miquela, The Sexual Assault Survivor


**Top:** Screenshot of comment from popular musician Kehlani criticizing clip of Miquela's now deleted sexual assault vlog which circulated on Twitter
**Bottom:** Screenshot of a supportive comment from Miquela's now deleted sexual assault vlog on YouTube

In late 2019, Miquela uploaded a video to her YouTube channel—a video that, as of May 2020, no longer exists except for a short clip that still circulates on Twitter. In this clip, Miquela describes her experience being sexually assaulted during a rideshare ("Kehlani on Twitter"). This vlog stirred a lot of controversy, largely because of the non-virtual influencers who took notice. Above is a comment from one such individual: Kehlani, a popular singer and musician, criticizes Miquela saying that she is "playing" with the stories shared by other victims of harassment. This is essentially the exploitation discourse (captured in the Above image): Miquela is ignorant and exploiting the experiences of those who have experienced sexual assault in order to garner attention for herself and her media presence. Discourse two, the representation discourse (captured in the Below image), is positive and instead asserts that Miquela is bringing more awareness to the issue of sexual assault through sharing her fictional story.

In "Anger's Volumes: Rhetorics of Amplification and Aggregation in #MeToo," Winderman discusses how volume plays a role in the way that the narratives emerging from the #MeToo movement are being received and portrayed. Winderman states that

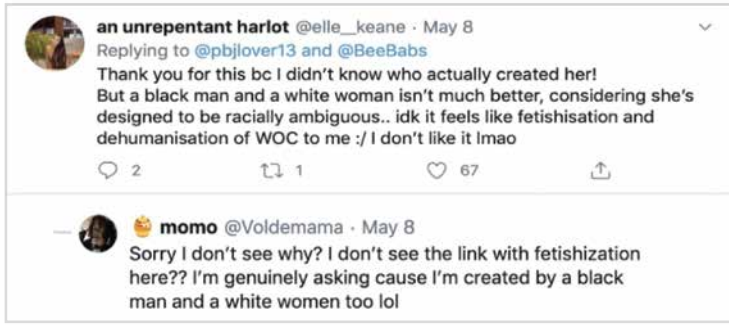
> "volume rhetorically regulates public emotion, tracing how the anger of those most marginalized is 'turned down' while the anger of those who are the most egregious perpetrators of epistemic injustice is elevated... this framework invites critical attention to how anger is nourished and legitimated or diminished and silenced based on the intersectional features of anger's sociality" (332).

Winderman is explaining how certain narratives in the #MeToo movement are amplified more than others, as well as the various social mechanisms that facilitate this. One thing to note is the word "intersectional," as a point the paper makes is how white women's voices are often lifted over women of color (328). Minority community narratives, as well as those of women in general, are often "turned down" in the greater narrative. That is why the #MeToo movement was so divisive. It not only amplified those women's voices, but also amplified the social injustices that made certain narratives louder than others.

In the case of Miquela, the two competing discourses above can be distilled down to whether Miquela is amplifying the voices of these assault victims or turning them down. The exploitation discourse sees Miquela's identity as a victim as exploiting these experiences and turning down the voices of those who actually suffered through assault due to her manufactured nature. The representation discourse sees Miquela's identity amplifying them, asserting that representation is positive.

## Discourse: Miquela, A Young Queer Woman

Unlike the discussions above, this one did not have a distinct event that triggered discussion. Instead, discourse around Miquela's identity as a woman of color has been occurring since she first gained traction on social media. Prior to openly identifying herself on Instagram as a robot, Miquela shared that she is Brazilian. However, when it was revealed who created her, the ongoing conversation around her race and ethnicity shifted. Trevor McFedries, one of the founders of Brud, is a black man. The woman he worked with to create Miquela is white. This led to two discourses taking shape: a negative discourse, that Miquela's racially ambiguous identity is a reflection of fetishization and dehumanization of women of color. And a positive discourse, that Miquela is like any other multi-racial person and simply existing as such is not inherently fetishized.




**Top:** Screenshot of a Twitter comment criticizing Miquela's creators and accusing them of fetishizing women of color
**Bottom:** Screenshot of a Twitter comment saying they do not understand the issue, relating Miquela's creation to that of her own background

This discourse connects to the earlier work of Okolie, Kodokova & Holiencinova on virtual influencers. All three in their research discussed the impact that individuals like Miquela have on other people of color. Okolie stated that "not only do minority models and influencers have to compete with nonminority models and influencers, but they also now have to compete with minority and nonminority digital models and influencers" (2). Kodokova & Holiencinova expand on this, asking "if virtual influencers are so lifelike and intriguing that they are able to go viral, do we really need to hire human influencers to market our products?" (97). This has been a relevant issue for virtual influencers besides Miquela as well, such as Shudu, dark-skinned virtual influencer and model. Shudu could be seen as anything from competition in an already racially charged industry to a white man-made metaphor for colonization (Jackson). This question of competition and representation in media is relevant even as new entities, such as the virtual influencer, develop.

Synthesizing the above research with the two discourses around Miquela and her creators, a more complicated group of discourses arise. There is discourse around job opportunities for influencers and those in entertainment, and whether Miquela is taking away opportunities from other people of color. Then there is the discourse evident in the screenshots above concerning whether Miquela's identity as a woman of color, in tandem with her ambiguous features, is fetishization or not. Ultimately, we can distill the same two overall discourses from all of this. The exploitation discourse: Miquela is not only a fetishization of a minority woman but also actively exploiting this identity to take away opportunities from other people of color (who were not created by a for-profit entity). The representation discourse: ethnically ambiguous women exist and Miquela appearing as such is simply a reflection of reality; and her presence online allows more opportunities for representation in media (even if she is manufactured by a company).

## Discourse Summary: Exploitation v. Representation

When selecting the posts to analyze above, I followed three key criteria. The first was whether the post summed up the core of the discourse it represents. As dialogue unfolds on social media, patterns arise and eventually form the discourses discussed in this paper. These posts represented the patterns appearing among social media users and thus, their respective discourses. The second criterion was whether the post originated from a platform Miquela is present on. All the posts above originated from either Twitter or YouTube. With regard to the latter, the posts were taken directly from comments sections on Miquela's own shared content. Finally, I determined whether the post offered any additional information or context that further expanded upon the discourse it represented. For example, in the case of Kehlani's tweet, her commentary galvanized a discussion around Miquela's identity as a sexual assault victim which was unique. Kehlani is a musician and celebrity with her own amassed social capital online. Her engagement in the discourse was noteworthy and offered the perspective of a non-virtual influencer, making it insightful and noteworthy. For the discourse surrounding Miquela's identity as a woman of color, the posts selected were of a discussion that happened in real time on Twitter. The users were directly responding to one another, so the conversation is not only representative of the discourse itself but how people navigate it while communicating with one another. All of this said, it is important to note that due to some of the digital content referenced above being removed over time, I was only able to use screenshots of them saved prior to beginning this study. These circumstances did limit my options, but such is the fleeting nature of the internet.

By analyzing the discourses around Miquela's identity as a sexual assault victim, a member of the LGBTIQ+ community, and a woman of color, we can extract two overarching discourses that define Miquela Sousa's existence. Discourse one, the exploitation discourse: Miquela, as a for-profit and manufactured entity, is inherently exploiting any and all minority communities/experiences through the act of identifying as or with them. Discourse two, the representation discourse: Miquela, despite being a for-profit and manufactured entity, is not inherently exploitative and instead serves as representation for these minority communities/experiences. These are not the only discourses around Miquela, but by recognizing them we can begin to understand two core ways in which people interpret her identity as well as why they do so.

## Miquela and Identity

Miquela, through her identity as a robot, has built a strong fanbase and community around her social media presence. Similar to how a Furby is able to bond with a child through basic communication and sociality. However, despite her claims, Miquela is not actually a robot. She is a collection of images that are created by a team to emulate a human being (or specifically, a non-virtual influencer). Meanwhile, in the same vein of a socialbot, Miquela constantly changes and evolves in response to what is currently happening online. For example, she has actively referenced quarantine due to the COVID-19 pandemic in her recent Instagram posts. She even has a link to donate to charities for COVID-19 relief in her page's bio. She makes pop culture references and shares her feelings, but unlike a socialbot she is not programmed to do so. Miquela is carefully constructed by a team of individuals at any given moment. Every decision about what she does, how she looks, etc. is decided by a team of individuals crafting her identity, not a program. Finally, while Miquela shares many similarities with non-virtual influencers (such as her sponsorships and ability to influence an audience), she does not have a physical body. As stated previously, Miquela can only exist within the confines of the internet. As she does not fall into any of the categories above, Miquela has become a point of anxiety. She is not a robot or an AI, a human being, or even a simple toy. She occupies the odd space in between these ideas. This puts people in a new and confusing position of deciding how to interact with and internalize their experiences with her.

These anxieties can manifest as the discourses above, but there are other psychological mechanisms at play that also cause these varied and sometimes intense reactions. In Reclaiming Conversations, Turkle makes two important arguments. She argues that people "exist alongside digital representations of ourselves, digital doubles, that are useful to different parties at different times… the digital self is archived forever" (304). While people have become accustomed to the internet and questions of privacy it raises, one of the reasons people feel anxiety around Miquela could be the fact that she is an extension of a party using archives for their own purposes. Miquela could not imitate authenticity, maintain relevance, without content to reference. That content is provided by every social media user with a public (and sometimes private) page. Her content is not difficult to find and there is a lot of it, much like the social media pages of other users and influencers. She can only exist, in any capacity, because others did before her.

Turkle also argues that "we redefine what is human by what technology can't do" (339). This thought was shared by Okolie, Kodokova and Holiencinova who in their research expressed concern that virtual influencers could encroach on opportunities for human beings, particularly minorities. Given the discourse

around Miquela's identity as a woman of color and a member of the LGBTIQ+ community, this anxiety is also shared by other users. People not only question the way she represents these communities (and how her company profits from that representation), but also what it means that she can do so.

## Conclusions

This topic was difficult to write about, largely because of how many layers there are to Miquela's existence and the discourse surrounding her. The goal of this paper, though, was to answer one key question: How does the discourse around virtual influencers like Miquela Sousa challenge identity in a digital space?

From the ethics of representation to how she bonds with her fans, Miquela is spurring more conversation around how "authenticity" can be defined online. At the same time, she is also embodying anxieties around this same concept. If Miquela is in any way truly authentic then, that can imply that authenticity is not something strictly applicable to human beings. To refer back to Turkle, "we redefine what is human by what technology can't do" (339). If a team of successful entrepreneurs can create Miquela and utilize social media in a way where various experiences and facets of identity can be manufactured and even believed by other users, then has ramifications for how identity and authenticity are defined. Most importantly, it questions the relationship between authenticity and identity.

This paper avoided defining what is or is not authentic due to the fact that it can fluctuate depending on the individual and the context. What is more important than defining authenticity is observing how social media users do so. The discourse around Miquela Sousa, whether her identity is authentic or her representation ethical, are evidence of a new branch in conversation that is developing around social media—one that has potential to grow. To quote Sherry Turkle in Reclaiming Conversations one last time: "Every technology asks us to confront our human values. This is a good thing, because it causes us to reaffirm what they are. From there it is easier to see the next steps and guideposts. We are not looking for simple solutions. We are looking for beginnings" (319). Miquela Sousa is a guidepost. She is not an inherently good or bad representation; she is not inherently ethical or unethical in her creation. Her existence is one that is incredibly complicated and confusing. Despite all of this, she still exists. She is the beginning of a greater conversation around identity and authenticity in the digital age and how people and technology are evolving to manipulate it. This paper, then, presented this burgeoning conversation as a way to understand greater narratives around these issues as they have risen. It is necessary to engage in this discussion because as the boundaries continue to be pushed, more cases like Miquela's will occur. Through her, we can develop a foundation for understanding the new ways in which social media is changing and challenging how we perceive identity in the years to come.

# Works Cited


Abidin, Crystal. *Internet Celebrity : Understanding Fame Online*. Vol. First edition, Emerald Publishing Limited, 2018. EBSCOhost

Hanckel, Benjamin, et al. "'That's Not Necessarily for Them': LGBTIQ+ Young People, Social Media Platform Affordances and Identity Curation." *Media, Culture & Society*, vol. 41, no. 8, Nov. 2019, pp. 1261–1278. EBSCOhost, doi:10.1177/0163443719846612.

*I'm Miquela and i'm Here to Overshare*. 2019. *YouTube*, https://www.youtube.com/watch?v=BAxRDyGxGdA&t=265s.

Jackson, Lauren Michele. "Shudu Gram Is a White Man's Digital Projection of Real-Life Black Womanhood." *The New Yorker. www.newyorker.com*, https://www.newyorker.com/culture/culture-desk/shudu-gram-is-a-white-mans-digital-projection-of-real-life-black-womanhood. Accessed 13 May 2020.

KÁDEKOVÁ, Zdenka, and Mária HOLIENČINOVÁ. "Influencer Marketing as a Modern Phenomenon Creating a New Frontier of Virtual Opportunities." *Communication Today*, vol. 9, no. 2, Nov. 2018, pp. 90–105. EBSCOhost

Kehlani. "Kehlani on Twitter: 'Nah. at First It Was Kinda Interesting. Maybe. but @lilmiquela You're Playing Wit Real Stories... Real Trauma.. Sexual Assault Is a Scary Real Reality and at This Point You're Ignorantly Offensive. What Type of Sick Shit Is This. Https://T.Co/GS4LLVndZV' / Twitter." *Twitter*, 12 Dec. 2019, https://twitter.com/kehlani/status/1205264369292107777?ref_url=https%3a%2f%2fwww.papermag.com%2flil-miquela-sexual-assault-vlog-2641593301.html.

"Kim on Twitter: '@BeeBabs for All Those Talking about White Men Profiting of off Miquela; a Short Wiki Search Could Tell You: Miquela Sousa, or Lil Miquela, Is a Robotic/Artificial Intelligence(A.I.) Which Was Created by Trevor McFedries and Sara DeCou. (I'm Sure the CAA Has Some White Males but c'mon.) Https://T.Co/Khb5CO73Ee' / *Twitter*." Twitter. *twitter.com*, https://twitter.com/pbjlover13/status/1258675949404672000. Accessed 15 May 2020.

lilmiquela. "Miquela's Instagram Post: 'Trying to Keep That Same POSITIVE Energy I Had at @fivesensecollective on This Whateverth Day of Quarantine We're on.'" *Instagram*, 30 Mar. 2020, https://www.instagram.com/p/B-YCguBnU3X/.

lilmiquela. "Miquela's Instagram Profile Post: 'Dudes Love to Say They're There for You When Everything Is Perfect, but When Things Go Left? Crickets. @nickillian Isn't Dudes Tho...He's....'" *Instagram*, 27 Mar. 2020, https://www.instagram.com/p/B-QP6kwHY9D/.

Marwick, Alice Emily. Status Update : *Celebrity, Publicity, and Branding in the Social Media Age*. Yale University Press, 2013. EBSCOhost.

*Miquela and Bella Hadid Get Surreal* | CALVIN KLEIN. 2019. *YouTube*, https://www.youtube.com/watch?v=JuTowFf6B9I.

"Miquela on Instagram: 'Can We All Just Agree That APRIL FOOLS 2020 IS CANCELLED? So In Celebration of March 32nd, I Posted Some New Ways to Recharge Your Heart....'" *Instagram*, 1 Apr. 2020, https://www.instagram.com/p/B-c57JtnqjA/.

*Miquela Talks Being A Robot, Her Song "Money", Kissing Bella Hadid & Collabs.* 2019, https://www.youtube.com/watch?v=S6wnHsEoTmc.

Okolie, Sonia M. "Virtual Influencers: Stretching the Boundaries of Intellectual Property Governing Digital Creations." *Landslide*, Jan. 2020, p. 52. EBSCOhost

Pötzsch, Holger. "Archives and Identity in the Context of Social Media and Algorithmic Analytics: Towards an Understanding of IArchive and Predictive Retention." *New Media & Society*, vol. 20, no. 9, Sept. 2018, pp. 3304–3322. EBSCOhost, doi:10.1177/1461444817748483.

Sellers, Elliott. *Miquela - Speak Up (Official Music Video)*. 2020. *YouTube*, https://www.youtube.com/watch?v=Rz8lxRxdwig.

Shieber, Jonathan. "The Makers of the Virtual Influencer, Lil Miquela, Snag Real Money from Silicon Valley." TechCrunch, 24 Apr. 2018. techcrunch.com, https://social.techcrunch.com/2018/04/23/the-makers-of-the-virtual-influencer-lil-miquela-snag-real-money-from-silicon-valley/.

*Shudu (@shudu.Gram) • Instagram Photos and Videos. www.instagram.com*, https://www.instagram.com/shudu.gram/. Accessed 13 May 2020.

Suwinyattichaiporn, Tara. "Project Me: Understanding Social Identities through Social Media." *Communication Teacher*, vol. 30, no. 3, July 2016, pp. 179–183. EBSCOhost, doi:10.1080/17404622.2016.1192664.

Turkle, Sherry. *Alone Together: Why We Expect More from Technology and Less From Each Other*. Third, Basic Books, 2011.

Turkle, Sherry. *Reclaiming Conversation: The Power of Talk in a Digital Age*. Penguin Books, 2015.

Uzunoğlu, Ebru, and Sema Misci Kip. "Brand Communication through Digital Influencers: Leveraging Blogger Engagement." *International Journal of Information Management*, vol. 34, no. 5, Oct. 2014, pp. 592–602. EBSCOhost, doi:10.1016/j.ijinfomgt.2014.04.007.

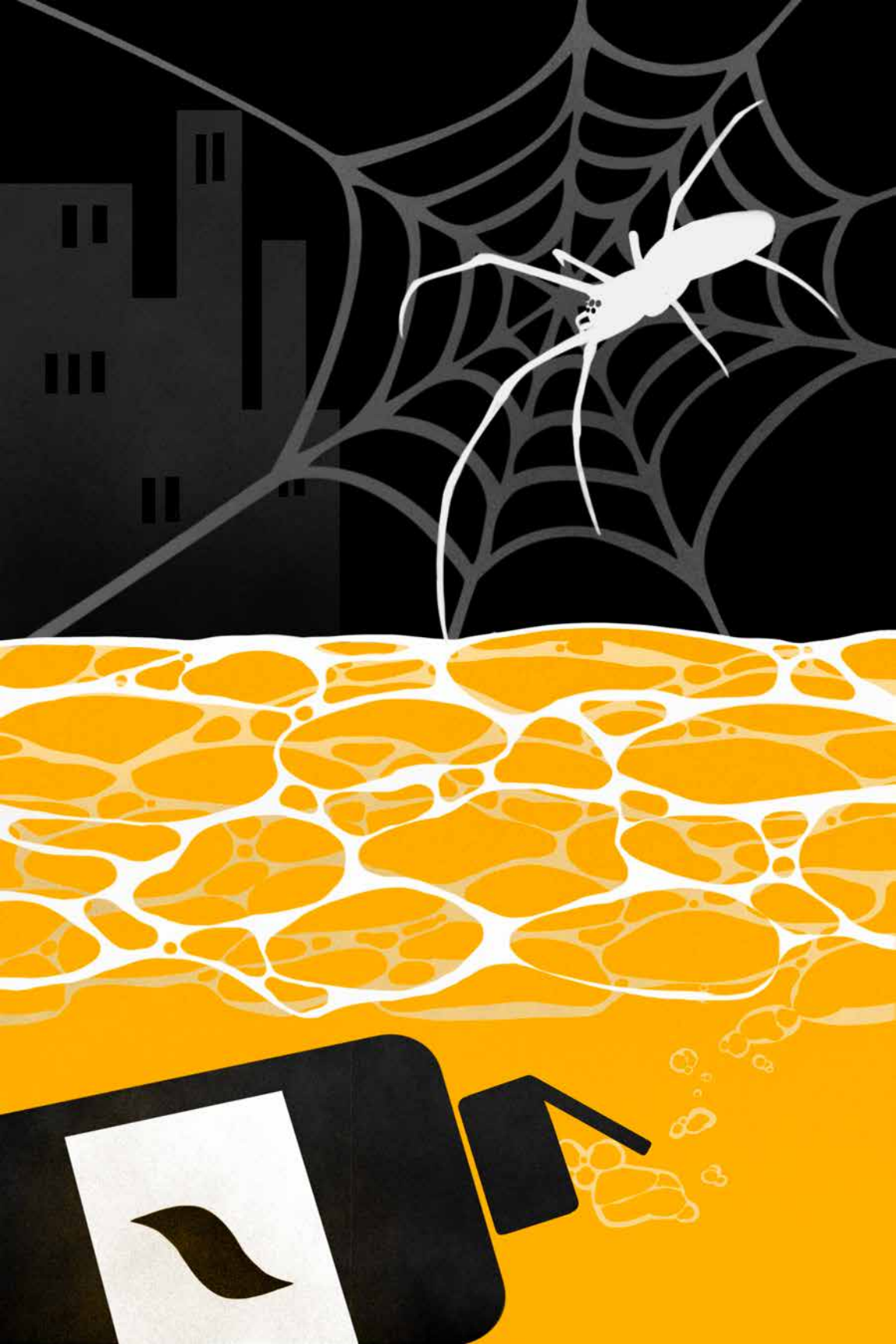
Van Dijck, Jose. *The Culture of Connectivity: A Critical History of Social Media.* Oxford University Press, 2013.

"Website_copy_wip_for_all_my_qtz." Google Docs (*Brud.Fyi*), n.d., https://docs.google.com/document/d/1V5N5tcfm7wBuUshgrmIOz9ijAO-VRqvkUbGRu0uKdI8/edit?usp=embed_facebook.

Winderman, Emily. "Anger's Volumes: Rhetorics of Amplification and Aggregation in #MeToo." *Women's Studies in Communication*, vol. 42, no. 3, Aug. 2019, pp. 327–346. *EBSCOhost*, doi:10.1080/07491409.2019.1632234.

# Food Web Dynamics: How Urbanization of Riparian Systems Affects Prey Availability for Tetragnatha Spiders in Aquatic and Terrestrial Systems

Kelly McVicker



# Kelly McVicker

**Kelly McVicker graduated from UMBC in May 2020 with dual bachelor's degrees in Biological Sciences and Environmental Science and Geography. She currently works for the United States Geological Survey as a hydrologic technician sampling for water quality and plans to return to graduate school to attain a degree in Entomology. This study was funded in part by the Baltimore Ecosystem Study, at which Kelly presented her original research in October 2019.**

**Kelly would like to thank Dr. Chris Hawn, who was instrumental to this process as an advisorand head of the lab. As well as Aaron Curry and Monica Argueta, who were heavily involved in the data collection.**

"I have been interested in arthropods since I first experienced the 17-year cicadas. This spark was rekindled whenI took GES 220. One of our assignments was to make a bug collection that consistedmostly of insects, but we could include some arachnids and myriapods. This process reminded me of arthropods' beauty and their critical rolein the ecosystem. As I completed my project, I realized that I wanted to continue to study them as a career.When I went to my next appointment to sign up for classes, I talked to my advisor about research opportunities that might include arthropodsand he suggested the Hawn Lab. As I talked to Dr. Hawn about their research onTetragnatha spiders, I knew immediately that I wanted to be involved. Dr. Hawn offered an independent project studying prey availability, and I jumped on the opportunity."

**-Kelly McVicker**

**Image 3.**
Absorbtion of personal care products (PPCPs) affecting the Riparian Tetragantha spider food web.

## Abstract

As the world becomes more urbanized, natural processes are changed. One such example is the alteration of food web dynamics through the introduction of pharmaceuticals and personal care products (PPCPs) into ecosystems. When riparian spiders, especially those of the genus Tetragnatha, consume emerging aquatic insects, PPCPs move into terrestrial systems. The purpose of this study is to determine effects of urbanization on body morphology and prey availability to tetragnathid spiders in different sites along the Gwynns Falls watershed near Baltimore, Maryland. To observe the effect of urbanization on prey availability, spiders and insects were collected along the Gwynns Falls watershed in sites ranging from urban to rural. The data suggest that there is more prey available to spiders in urban riparian systems than in rural riparian systems, and that the prey available in urban riparian systems is a higher proportion of aquatic species than terrestrial species. This is supported by the observation that the spiders in urban areas were significantly longer from cephalothorax to abdomen. Because the spiders are almost significantly larger in mass, the data implies that the prey is more available and nutritious in urban areas and therefore any contamination that exists is more accumulated in urban environments.



*Keywords: urbanization, food web dynamics, ecosystem, tetragnatha, PPCPs & prey availibility.*

# Introduction

As the world becomes more urbanized over time, it is important to know the effects that urbanization has on the environment. One of these changes includes the addition of pharmaceuticals and personal care products (PPCPs) into the aquatic ecosystem (Rosi-Marshall & Royer, 2012). These compounds can be released into the water supply through agricultural runoff, from manufacturing sites, or through leaks from the sewer system (Kinney et al. 2006; Ternes et al. 2004; Boxall et al. 2012; Fick et al. 2009).

The effect of PPCPs on the environment have not been researched in depth because the amount of these substances in the environment is much lower than the LC50, the concentration of a contaminant in water required to kill 50% of the organism in question, and thus non-lethal. However, these contaminants might be affecting these species in ways other than death (Oaks et al., 2004). Because these chemicals are designed for the purpose of altering behavior, chemistry, and life cycles in humans, they inadvertently have an effect on behavior, chemistry, and life cycles in other animals. Therefore, the effects they have on food web dynamics of other species goes beyond extermination. One such effect is the alteration of food web dynamics in riparian systems (Walters, Fritz, & Otter, 2008, Richmond et. al., 2017).

Riparian habitats are the bridge between aquatic and terrestrial systems, when riparian spiders, especially tetragnathid spiders, consume emerging aquatic insects, the contamination of these PPCPs moves into terrestrial systems (Speir et al., 2014). Spiders of the genus Tetragnatha specialize in riparian habitats and build webs that frequently catch emerging aquatic insects (Levi, 2008). In a previous study, it was found that tetragnathid spiders are important vectors of heavy metal contamination into terrestrial ecosystems (Alberts & Sullivan, 2016). This is likely due to the spiders feeding patterns. In areas with PPCP contamination, emerging aquatic insects can serve as vectors to spread contamination from streams to land (Richmond et al. 2018). If there are more prey available to the spiders from aquatic systems than terrestrial systems, the transfer of contamination from aquatic to terrestrial environments will increase. Looking at the types of prey available to riparian spiders could help determine whether contamination of riparian systems is of greater significance in more urbanized areas.

The purpose of this study is to determine effects of urbanization on body morphology and prey availability to tetragnathid spiders in different sites along the Gwynns Falls watershed near Baltimore, Maryland. Prey availability was measured by comparing species richness, number of insects captured, and percentage of aquatic insects captured between urban and rural sites. An effect on the spiders was defined as a significant difference between site types in abundance, species richness, body length,

and dry body mass. A significant difference in prey availability and in physical traits of spiders would suggest that contamination in urban riparian systems has a more pronounced effect in their terrestrial systems than rural systems. This is likely because of the higher concentrations of contaminants in urban areas, although that is outside the scope of this paper.

# Methods

## Study Area

The study area of this project is the Gwynns Falls watershed near Baltimore, Maryland. This watershed has been used as part of the Baltimore Ecosystem Study Long-Term Ecological Research program, which in part funded this study. Previously, this watershed has been studied to determine levels of different PPCPs in streams (Lee et al., 2016; Richmond et. al, 2016; 2017). Gwynns Falls (USGS site number 01589352) and Gwynns Run (USGS site number 0158935180) were used for the urban sites; Baisman Run (USGS site number 01583580) and Pond Branch (USGS site number 01583570) were used for rural sites; and Gwynnbrook (USGS site number 01589197) and Dead Run (USGS site number 01589312) were used for ex-urban sites. Pond Branch and Baisman Run were chosen because they were the rural sites used in Lee et. al 2016 and, "are located within the Oregon Ridge watershed, the closest remaining intact forested region."

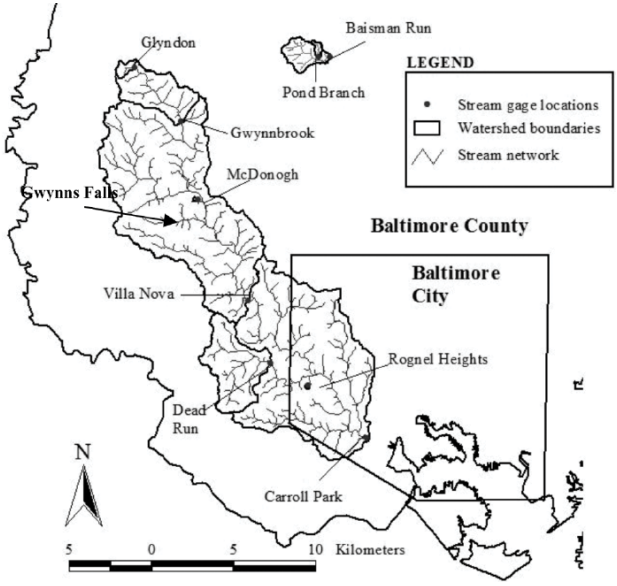



**Figure 1.**
A map of Gwynns Falls watershed sites (Law, N., Band, L., & Grove, M., 2004). The site marked "Carrol Park" is where data from Gwynns Run and Gwynns Falls were obtained.

## Capture Methods

To catch the insects, ten sticky traps were hung with white string from available branches along the left and right banks of the rivers along a stretch of 30 meters. The traps were collected after one week and put into clear sheet protector sleeves and then immediately into coolers. After they were collected, the sticky traps were stored in the freezer until the insects could be analyzed.

All spiders found were collected regardless of family. To capture the spiders, a "top" and "bottom" level was identified in the bank of each river. The "bottom" level was defined as the bank of the river to the edge of the floodplain, and the "top" level was defined as being where the floodplain started. Each level was 30 meters long, starting and ending at the same points the first and last cross-sections of sticky traps were hung. Spiders were collected by hand during the day and placed into plastic vials along these levels until no more could be found.

## Analysis Methods

The arthropods collected in sticky traps were identified to the lowest taxonomic level possible using a variety of methods. While it was difficult to determine the exact species of insect, each was identified to morphospecies. The total number of each morphospecies was used to measure species richness, and overall insect abundance. All species were categorized as aquatic or terrestrial in origin.

After collection, spiders were frozen, identified, measured for total body length, cephalothorax width, and abdomen width to the nearest thousandth of a millimeter. Spiders were then desiccated to prevent damage to the body and weighed to the nearest hundredth of a milligram. Microsoft Excel was used to calculate means of data as well as standard error before transferring the information to R software. R software was used to visualize the data graphically and to determine significant difference by use of ANOVA, or analysis of variance.

For each spider, the calculation of tetragnathid body mass index (B)

$$B = 100\ M/(L(W)^2)$$

where M is the mass in mg of each spider, L is the length of each spider, and W is the average of the cephalothorax and abdomen width, was modified from the equation used in Arismendi et al., 2011 to calculate body condition for fish.

# Results

## Insects

For insects, data were used from all sites except Dead Run. There was no significant difference ($F_{2,4}$=0.5408; P=0.649; **Table 1**) in overall species richness between site types. The means are all relatively similar and the error bars vary widely, often containing the means of other site types (**Figure 2**). There is a much larger range in standard error for rural sites than in urban sites.

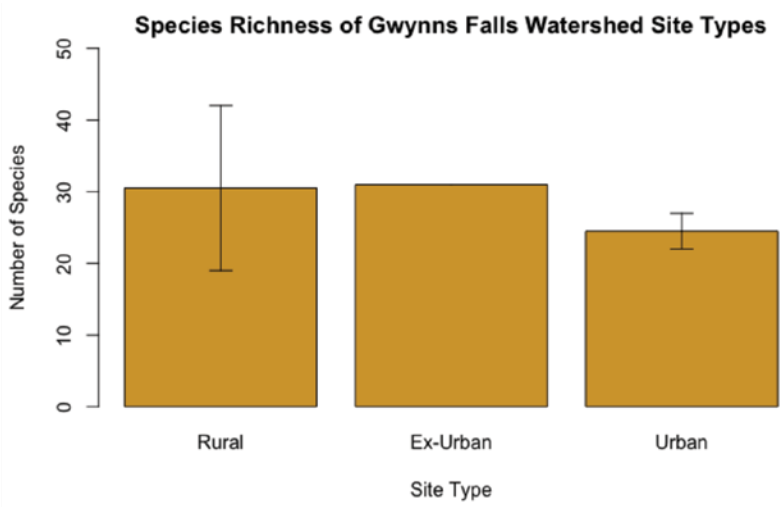



**Figure 2.**
Average number of species caught at each site type.

The proportion of insects found in our aquatic environments is significantly higher in urban environments than in rural environments ($F_{2,4}$=5.2406; P=0.1602; **Table 1**) in the F statistic but not the P statistic (**Figure 3**). The proportion of aquatic insects in urban areas of the Gwynns Falls watershed appears to be higher than in the rural areas of the Gwynns Falls watershed. The standard error calculated for rural sites has less of a range than the standard error calculated for urban sites, which is the opposite of the standard error displayed in **Figure 2**. Insects whose species could not be identified with reasonable certainty were labeled unknown and excluded from the proportion of aquatic to total insects.

Even though the results are not statistically significant, the visual trend in the data suggest the number of individuals who developed in terrestrial habitats stays relatively constant throughout both urban and rural sites (**Figure 4**). On the other hand, the overall number of individuals who developed in each habitat seems to vary widely between site types and also within the same site type, although there is a visual

trend in the mean number of species that suggests that the number of individuals increases. This indicates a difference in the amounts of insects that developed in aquatic habitats.

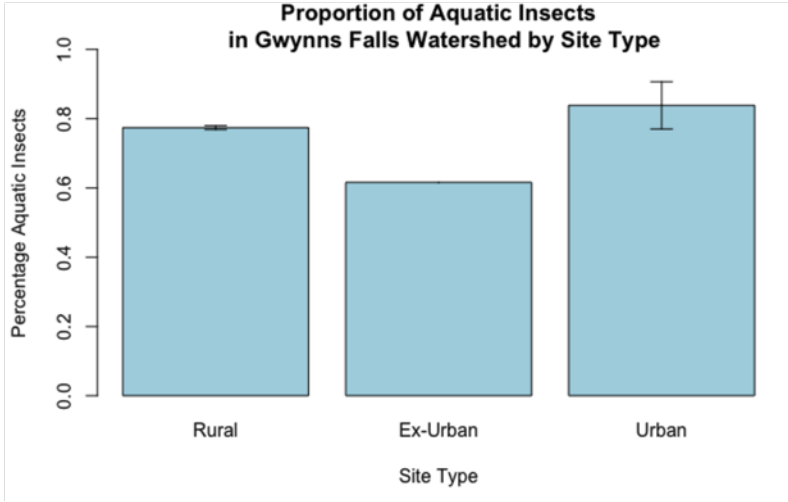



**Figure 3.**
The difference in the total proportions of insects that matured in aquatic environments as opposed to terrestrial environments for each site type.

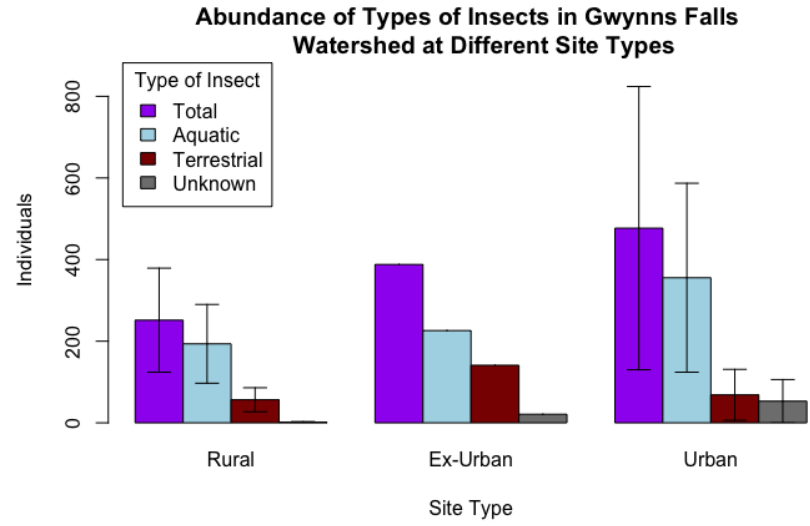



**Figure 4.**
The difference in the average amounts of individuals caught that matured in different types of environments for each site type and the total average amounts of individuals caught at each site type. For total abundance: $F_{2,4}$=0.1877; P=0.842. For aquatic abundance: $F_{2,4}$=0.232; P=0.8117. For terrestrial abundance: $F_{2,4}$=0.349; P=0.7413

## Spiders

For the spiders, data from all the sites were used. Though the trend seems to suggest that the average number of spiders collected decreases in a gradient from rural to urban, there is no significant difference in abundance between different site types ($F_{2,5}$ = 1.8165; P = 0.3042; Table 1). The rural sites especially had a wide range of error when graphed (**Figure 5**), likely attributed to the low sample size.

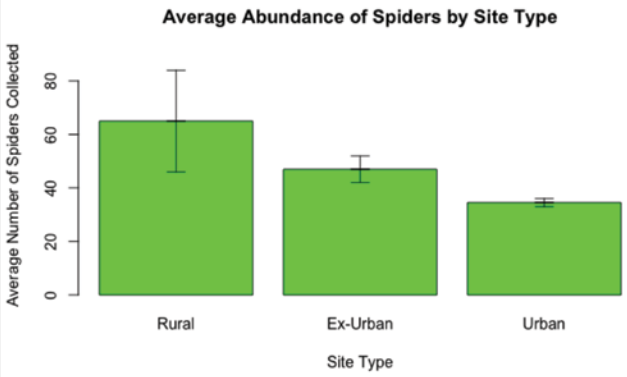



**Figure 5.**
The difference in the average amounts of spiders caught in each site type (F2,5=1.8165; P=0.3042).

Similarly, though the trend seems downward, there is no significant difference in species richness between different site types (**Figure 6**; $F_{2,5}$=0.2552; P=0.7901). Though the mean of both datasets seems to decrease going from rural sites to urban sites, there is a large range in error between the types. Interestingly, there is no error in the ex-urban site type for species richness. The trend in error decreases in a gradient from rural to urban for species richness, while the trend in error increases in overall abundance, meaning that there is more difference in sites corresponding to the different site types.

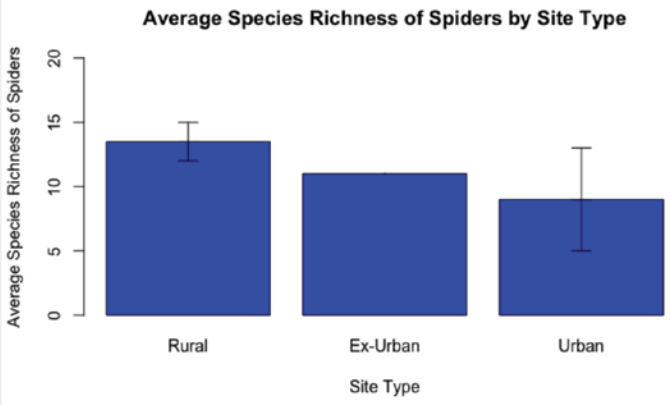



**Figure 6.** The difference in the average species richness of spiders caught in each site type. There is no difference in data at Ex-Urban sites.

Spider weight, measured by dry mass in milligrams, increases gradually rural to urban sites, although the relationship is not statistically significant (**Figure 7**; $F_{2,5}$=1.8894; P=0.1531). However, it is more apparent than both abundance and species richness. The difference in error seems to be about the same between site types, showing that the range of difference between sites is not large.

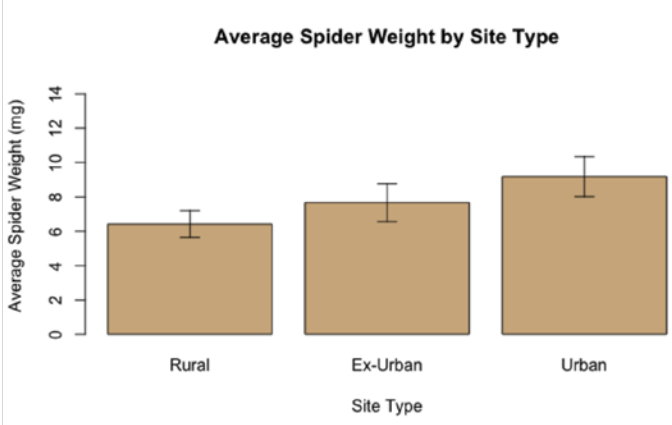



**Figure 7.**
The difference in the average weight in mg of spiders caught in each site type. ($F_{2,5}$=1.8894; P=0.1531).

Neither width, cephalothorax (referring to the fused head and thorax that is typical of arachnids) nor abdomen, are significantly different between site types (**Figure 8**; $F_{2,5}$=0.035; P=0.9659; Figure 9; $F_{2,5}$=0.5625; P=0.6202). Additionally, there is no visual trend to interpret; these values do not vary between site types.

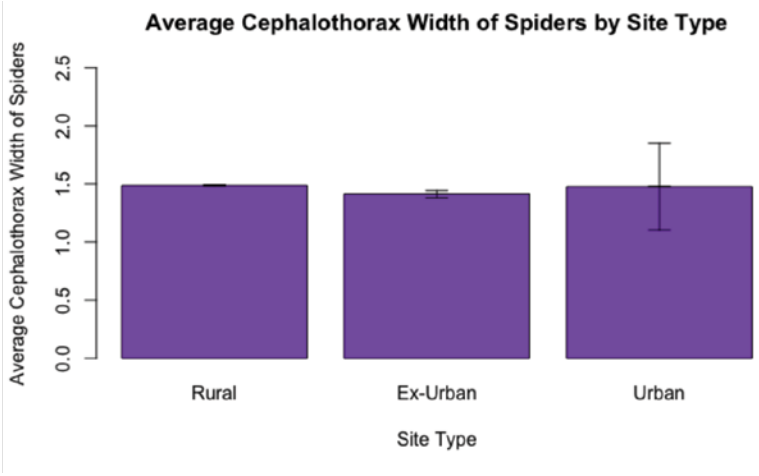



**Figure 8.**
The difference in the average cephalothorax width of spiders caught in each site type (F2,5=0.035; P=0.9659).

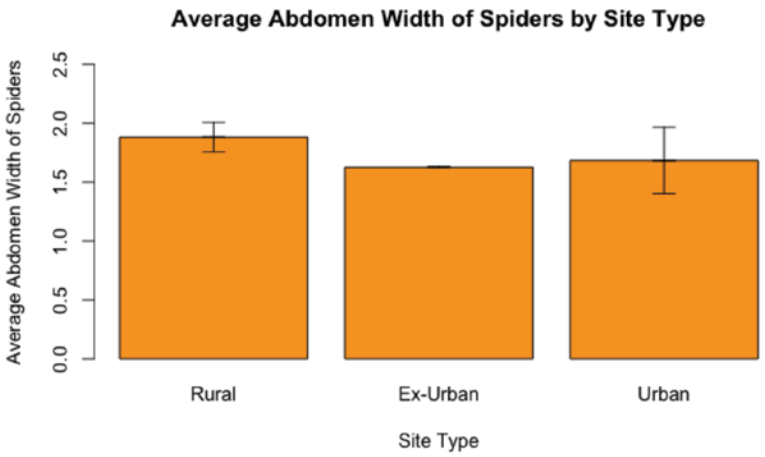



**Figure 9.**
The difference in the average abdomen width of spiders caught in each site type (F2,5=0.5625; P=0.6202).

Spider length is significantly different between site types (**Figure 10**; $F_{2,5} = 6.3133$, $P = 0.002078$). Spider length, measured in millimeters, in urban sites is significantly larger than the length of spiders in rural sites. The range of error appears to be equal between site types.

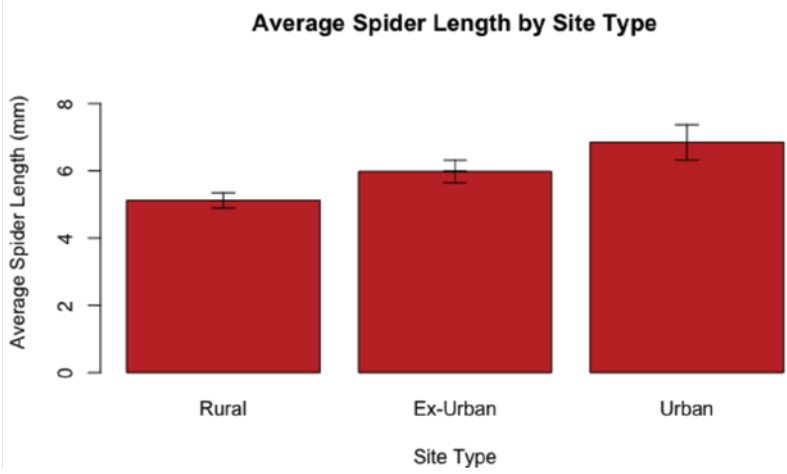



**Figure 10.**
Shows the difference in the average length of spiders caught in each site type. (F2,5=6.3133; P=0.002078).

Though spider BMI is visually distinguishable as different between rural and urban sites, the resultant test for tetragnathid spider BMI was not statistically significant. (**Figure 11**; $F_{2,5} = 2.1982$, $P = 0.116$). The range of error is very small in urban and ex-urban sites, but somewhat larger in the rural sites.

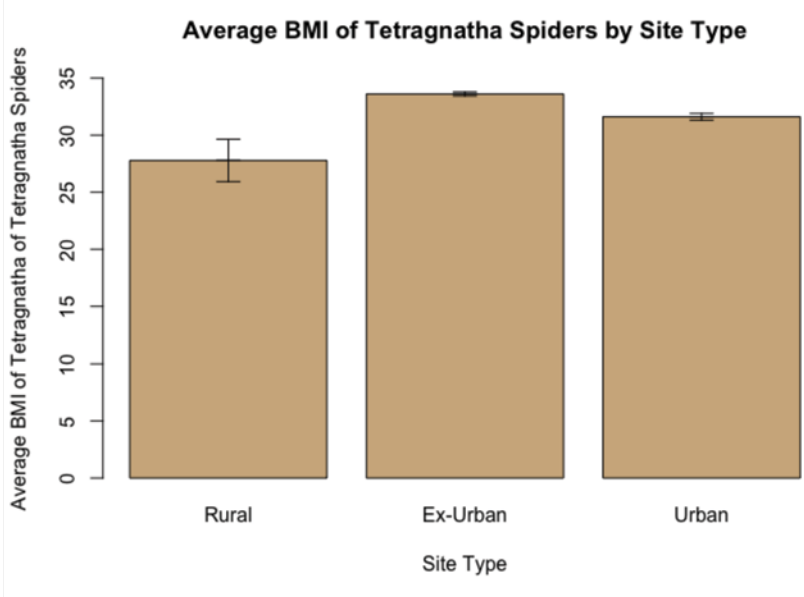



**Figure 11.** The difference in the BMI (B) $B = 100\frac{M}{L(W)^2}$ where M=mass in mg, L=length in mm, W=average of cephalothorax and abdomen width of spiders caught in each site type (Rural, Ex-Urban, and Urban). ($F_{2,5} = 2.1982$, $P = 0.116$). Equation was developed from Arismendi et al., 2011.

# Discussion

## Error

In order to investigate the cause of the F-value but not the P-value showing proportion data as statistically significant (Table 1, Figure 3) in the case of proportion of aquatic insects by site type, it would be helpful to increase the degrees of freedom by increasing the number of sites sampled and the number of weeks insects were collected from the same sites. It would also be useful to eliminate the ex-urban category and directly contrast the rural and urban sites. Retaining all of the ex-urban data that was collected, in the case of Dead Run, would increase the significance of comparing rural and urban data to ex-urban data. Standardizing the collection teams by having the same people collect data would minimize differences between collection dates.

| Site | Site Type | Number of Species | Aquatic Individuals | Terrestrial Individuals | Unknown Individuals | Proportion Aquatic (excluding unknowns) |
|---|---|---|---|---|---|---|
| Pond Branch | RURAL | 42 | 290 | 86 | 3 | 0.771276596 |
| Baisman Run | RURAL | 19 | 97 | 27 | 0 | 0.782258065 |
| Gwynnbrook | EX-URBAN | 31 | 226 | 141 | 21 | 0.615803815 |
| Gwynns Falls | URBAN | 22 | 587 | 131 | 106 | 0.817548747 |
| Gwynns Run | URBAN | 17 | 124 | 6 | 0 | 0.953846154 |

**Table 1.** Insect data from each individual site

| Site | Site Type | Abundance | Species Richness | Average Length (mm) | Average Weight (mg) |
|---|---|---|---|---|---|
| Baisman Run | rural | 84 | 15 | 5.17480952 | 5.53408642 |
| Pond Branch | rural | 46 | 12 | 5.01108889 | 8.02693333 |
| Gwynnbrook | ex-urban | 42 | 11 | 6.00125 | 7.25756098 |
| Dead Run | ex-urban | 52 | 11 | 5.95860714 | 7.90466 |
| Gwynns Run | urban | 36 | 5 | 8.90923529 | 12.3347632 |
| Gwynns Falls | urban | 33 | 13 | 4.33610714 | 5.4335625 |

**Table 2.**Spider data from each individual site.

## Interpretation

The fact that there is no significant difference and no visible trend in overall species richness for insects between site types implies that urbanization does not have an effect on overall species richness. There is semi-significant evidence indicating that the prey available in urban riparian systems is a higher proportion of aquatic species than terrestrial species; thus, there is a much higher proportion of insects that, at the time of sampling in July, had been hatched and matured from a larval state to at least a first instar state.

While it seems logical to assume that there would be less terrestrial area available for insect propagation in urban environments and that would be the cause of the difference between terrestrial and aquatic species, there is no significant difference between the numbers of terrestrial insects between the site types. Because the difference in insects lies not in the terrestrial environment but in the aquatic environment, it is more likely that there is a difference in the water supply rather than in terrestrial environments. The increased amounts of PPCPs, especially antidepressants, discovered in urban areas of the Gwynns Falls watershed in Richmond et. al, 2016 and 2017 suggest that an increase in certain PPCPs is the difference in the water supply that is causing increased amounts of aquatic insects.

Assuming the contamination of PPCPs comes from the water supply and therefore has a higher impact on riparian-maturing insects, the data imply that the contamination in urban streams will have a higher impact on urban tetragnathids. Therefore, the PPCPs in urban riparian environments will have a higher impact on terrestrial systems than contamination in rural streams would have on rural terrestrial systems. Though there is a downward trend in means along the gradient from rural to urban, there is no significant difference in neither abundance nor species richness of spiders. There is similarly an upward trend in means along the gradient from rural to urban in dry mass of the spiders but no significance to this trend.

There is also no visual trend or significant difference in either of the widths, either cephalothorax or abdomen. However, there is a significant upward trend in the total length of the spiders. This, coupled with the fact that the spiders are not significantly heavier in urban areas, suggests that spiders are not getting the nutritional value that they require from their prey.

When calculated, however, the visual trend in spider BMI suggests that spiders are more healthy in urban areas than in rural areas. The standard error is low in all cases. The results are not currently significant, but the F value was high enough and the P value was low enough to suggest that if this study was repeated with more sites, the findings could prove to be significant.

## Continuation

To further this study, it would be wise to determine the relative amounts of habitat available for propagation of these insect species in each watershed. One should compare the relative areas of terrestrial and aquatic areas to the proportions discovered in this paper. Additionally, it should be determined whether the differences seen here are due to urbanization or simply the accumulation effects of being further downstream. This could be accomplished by approaching the study in differently planned cities and in rural downstream mainstream areas, as well as integrating ideas of stream continuum changes. It would also be beneficial to see if this trend applies to other watersheds or if it directly compares to the amount of certain PPCPs or mixtures of PPCPs.

Spider health goes beyond size and BMI; it could be studied on the molecular level, by analyzing the body composition of spiders. This could be approached by studying the lipid and protein composition of these spiders, as well as the concentration of different PPCPs inside their bodies. Investigating physiological differences is crucial to the understanding of the holistic impacts of PPCPs on nutrition and bodily development. Expanding the study to organisms further up the food web would also further evidence the extent to which the effect of PCPPs propagate throughout the ecosystem.

In order to determine if the insects emerge at different times, it would be helpful to determine the quantities of insects emerging from streams at different times during the spring and summer along the same gradient. The insects should be weighed and measured in a way similar to the spiders. Finding a significant difference here would support the evidence that the PPCPs in the water supply are causing the insects to emerge earlier.

## Impacts

While spider prey (insect abundance) is relatively the same between site types, it only differs semi-significantly in the proportion of aquatic species. This evidence suggests that, at this specific time in the year, urban aquatic insects are more abundant because more have emerged earlier in the year. Though it is not significant in this study, the evidence of an increased spider BMI in urban areas suggests that there is a difference in prey between rural and urban areas. This increase in relative aquatic prey suggests that these aquatic prey are more nutritious to the spiders than terrestrial prey. Evidence found in Richmond et. al 2016, shows that PPCPs, especially selective serotonin reuptake inhibitors, were found to influence the development and emergence patterns of aquatic insects.

Because there is the same number of spiders in different site types, predators that consume spiders in rural sites are not getting the same levels of nutrition as those in urban areas, but they are also not accumulating the same levels of contaminants in higher levels of the food web. Food web dynamics are often fragile, and the fact that life cycle timing and body morphology is altered in these small but significant ways could cause major changes in life cycles of all links in the food web that can be traced back to arthropods, both aquatic and terrestrial.

# Works Cited


Alberts, J. M., & Sullivan, S. (2016). Factors influencing aquatic-to-terrestrial contaminant transport to terrestrial arthropod consumers in a multiuse river system. Environmental pollution (Barking, Essex : 1987), 213, 53–62. https://doi.org/10.1016/j.envpol.2016.02.003

Arismendi, I., Penaluna, B., & Soto, D. (2011). Body condition indices as a rapid assessment of the abundance of introduced salmonids in oligotrophic lakes of southern Chile. Lake and Reservoir Management, 27(1), 61–69. https://doi.org/10.1080/07438141.2010.536617

Boxall, A. B. A., Rudd, M. A., Brooks, B. W., Caldwell, D. J., Choi, K., Hickmann, S., Innes, E., Ostapyk, K., Staveley, J. P., Verslycke, T., Ankley, G. T., Beazley, K. F., Belanger, S. E., Berninger, J. P., Carriquiriborde, P., Coors, A., DeLeo, P. C., Dyer, S. D., Ericson, J. F., … Van Der Kraak, G. (2012). Pharmaceuticals and personal care products in the environment: What are the big questions? *Environmental Health Perspectives*, 120(9), 1221–1229. https://doi.org/10.1289/ehp.1104477

Fick, J., Söderström, H., Lindberg, R. H., Phan, C., Tysklind, M., & Larsson, D. G. J. (2009). Contamination of surface, ground, and drinking water from pharmaceutical production. *Environmental Toxicology and Chemistry*, 28(12), 2522–2527. https://doi.org/10.1897/09-073.1

Kinney, C. A., Furlong, E. T., Werner, S. L., & Cahill, J. D. (2006). Presence and distribution of wastewater-derived pharmaceuticals in soil irrigated with reclaimed water. *Environmental Toxicology and Chemistry*, 25(2), 317–326. https://doi.org/10.1897/05-187R.1

Law, N., Band, L., & Grove, M. (2004). Nitrogen input from residential lawn care practices in suburban watersheds in Baltimore county, MD. *Journal of Environmental Planning and Management*, 47(5), 737–755. https://doi.org/10.1080/0964056042000274452

Levi, H. W. (2008). On the tetragnathid genera Alcimosphenus, Leucauge, Mecynometa and Opas (Araneae, Tetragnathidae). *Journal of Arachnology*, 36(1), 167–170. https://doi.org/10.1636/A07-67SC.1

Oaks, J. L., Gilbert, M., Virani, M. Z., Watson, R. T., Meteyer, C. U., Rideout, B. A., Shivaprasad, H. L., Ahmed, S., Iqbal Chaudhry, M. J., Arshad, M., Mahmood, S., Ali, A., & Ahmed Khan, A. (2004). Diclofenac residues as the cause of vulture population decline in Pakistan. *Nature*, 427(6975), 630–633. https://doi.org/10.1038/nature02317

Richmond, E. K., Rosi-Marshall, E. J., Lee, S. S., Thompson, R. M., & Grace, M. R. (2016). Antidepressants in stream ecosystems: Influence of selective serotonin reuptake inhibitors (SSRIs) on algal production and insect emergence. *Freshwater Science*, 35(3), 845–855. https://doi.org/10.1086/687841

Richmond, E. K., Grace, M. R., Kelly, J. J., Reisinger, A. J., Rosi, E. J., & Walters, D. M. (2017). Pharmaceuticals and personal care products (PPCPs) are ecological disrupting compounds (EcoDC). *Elementa Science of the Anthropocene*, 5, 66. https://doi.org/10.1525/elementa.252

Rosi-Marshall, E. J., & Royer, T. V. (2012). Pharmaceutical Compounds and Ecosystem Function: An Emerging Research Challenge for Aquatic Ecologists. *Ecosystems,* 15(6), 867–880. https://doi.org/10.1007/s10021-012-9553-z

Speir, S. L., Chumchal, M. M., Drenner, R. W., Cocke, W. G., Lewis, M. E., & Whitt, H. J. (2014). Methyl mercury and stable isotopes of nitrogen reveal that a terrestrial spider has a diet of emergent aquatic insects: Methyl mercury and stable isotopes in emergent insects and spiders. *Environmental Toxicology and Chemistry*, 33(11), 2506–2509. https://doi.org/10.1002/etc.2700

Ternes TA, Joss A, Siegrist H. (2004). Scrutinizing pharmaceuticals and personal care products in wastewater treatment. *Environ Sci Technol* 38:392A–399A.

Walters, D. M., Fritz, K. M., & Otter, R. R. (2008). THE DARK SIDE OF SUBSIDIES: ADULT STREAM INSECTS EXPORT ORGANIC CONTAMINANTS TO RIPARIAN PREDATORS. *Ecological Applications*, 18(8), 1835–1841. https://doi.org/10.1890/08-0354.1

# Why Intimacy Direction is the Way Forward for Theatre

Caitlyn Hooper

# Caitlyn Hooper

**Caitlyn Hooper is currently a Senior at UMBC working towards her Bachelor of Fine Arts in Acting and is set to graduate Spring 2021. Her plans after graduation include applying to graduate school to receive her Master of Fine Arts in Performance Studies. Some of her professional goals are to become certified in Intimacy Choreography and eventually become a Theatre Professor. She is particularly interested in the continued anti-racist action in Theatrical Education and would like to be a part of the cultural shift to make Theatre more equitable.**

**She would like to thank her faculty advisor, Susan Stroupe, for her guidance through writing this paper and Chelsea Pace for her introduction to Theatrical Intimacy.**

“This research paper was completed under Susan Stroupe during the course Modern Theatre: History and Practice for an open-ended final project. I chose Theatrical Intimacy because of my interest in the subject due to another professor of mine, Chelsea Pace. I have studied under Professor Pace for over two years, in that time I have taken her movement classes and Theatrical Intimacy workshops as well as been directed by her. She introduced her intimacy work to our Theatre department when she joined the facultyin Fall 2018. Ever since, I have been moved by the power that consent and boundaries bring into an educational space. I have witnessed first-hand how Theatrical Intimacy Education tools have shifted the power dynamic in a rehearsal space and made Theatre a safer place for everyone. During my Modern Theatre course, Professor Stroupe was lecturing about how American Theatre is currently leading this evolution in choreographing intimacy, as she coined it the “consent aesthetic”. With her help, I was able to do more research about how intimacy choreography came to be and discovered just how life changing this work is and why it is, in my opinion, the only way forward for theatre.”

**-Caitlyn Hooper**

**Image 4.**
Two hands intertwine on a stage, showcasing the main idea of the article: Intamacy direction.

## Abstract

This paper goes through the history and recent development of Theatrical Intimacy Direction to provide context for the necessity of this work, seeking to answer the question: why does Theatrical Intimacy Direction make Theatre better? By looking at the development of Intimacy Direction, where it arose from and how it has shifted the culture in theatre thus far, it demonstrates how it can lead not just to better intimacy in performance but also help society reshape its views on sex, intimacy and consent.



*Keywords: itimacy direction, theatre culture, consent culture, abuse of power, methodology, #MeToo movement, and BIPOC (Black, Indigenous, & People of Color)*

# Introduction

Intimacy direction is a new and rapidly expanding field in theatre. In the past decade, the demand for intimacy choreographers has grown exponentially, but the need for this type of work has been around much longer. In the wake of the wide public acknowledgment of the #MeToo movement in 2017, the conversation about consent culture in society is finally becoming more frequently discussed. But how does this conversation translate into intimacy represented in theatre and film? The way society engages with intimacy in the media or on stage is just as important as how people experience it in real life. With many feminist movements in the past ten years receiving attention, long standing instances of sexual misconduct and abuses of power in the entertainment industry have also come to light. Victims of abuse are speaking about what happened to them and what has been happening to them for a long time.

This recent increase in sharing stories has also sparked action to be taken to have a system in place to protect those with less power. Intimacy direction arose from the need to have a safe process for choreographing intimacy that reduces the potential for there to be an abuse of power in order to create better art. In this paper, I will exemplify why consent-based practices of intimacy direction is the only way forward. I will do this by first looking at the development of intimacy direction in recent theatrical history. Then discuss the intersectionality between intimacy direction and anti-racist theatre movement. Consent-based practices are transforming theatre, along with the anti-racist theatre movement which is centering Black, Indigenous and people of colors voices in a long overdue conversation about racial equity. These changes to the theatre systems can create a shift in how society views consent and redistribute the power to make theatre more ethical and safe. Lastly, I will not only demonstrate how it creates better, more ethical performances but also how it encourages society to reframe how it views sex, intimacy and consent by first doing it on an individual level. This crucial change in theatre culture is the only way forward.

# A Brief Timeline of the History of Intimacy Direction

Staged intimacy has always been part of the way humans have performed stories. Intimacy is defined as closeness in the Oxford dictionary, whether that be emotional or physical. Currently, in Western society, people think of intimacy as deeply connected to sex and sexual desire (Lankveld et al. 2018). However, in Theatre the definition of intimacy has shifted greatly throughout the course of history. What was allowed on stage depended heavily on the societal standards of the time. For much of early theatrical history, the only actors allowed on stage were male so no intimacy, such as touching, hand holding or kissing, was allowed.

During the Renaissance, two men being intimate was completely taboo and sinful (Forker 2). Due to the emphasis on religion throughout history, specifically Christianity in the Renaissance, two men engaging in sex was considered satanism and could be punishable by death. Once women were allowed on stage during the Restoration period in England, they were immediately hyper sexualized by male playwrights and audiences ("Women in Restoration Theatre").

Over time, intimacy has become more normalized as the emphasis on religious doctrine has decreased. The restrictions of intimacy have shifted based on the standards of society. Currently, in mass media, same sex couples have become more normalized than in previous decades (Sinfield 2). Intimacy between individuals in same sex relationships has become normalized as laws have changed in the United States with the Supreme Court case Overgefell vs. Hodges (2015) to make same sex marriage legal.

Intimacy in the entertainment industry can be defined as anything from a kiss to sex, nudity, sexual violence or even scenes that simply suggest intimate moments (Pierce 147). Intimacy has been linked to the action of human stories since the beginning of theatre and now it is being used as a separate aesthetic tool in storytelling, similar to stage combat. The discipline of intimacy direction, however, has only been established within the last 15 years. The work stemmed from a few movement specialists in the United States who began to notice a lack of technique to choreograph intimacy (Purcell 2018). Though these specialists were not working together, they realized they could apply their own skills to create what was needed: a way to choreograph intimacy ethically, efficiently and safely (Derr 2020). Ethical, efficient and effective practice can be defined as safe, non-time consuming and enhancing the overall aesthetic of performance (Pace 13). Over the years these women developed their own pedagogy and protocols for staging intimacy. Today, they are leading a revolution in how artists handle intimacy in rehearsal and performance.

In 2006, Tonia Sina wrote her graduate thesis for Virginia Commonwealth University entitled "Intimate Encounters: Staging Intimacy and Sensuality." In her thesis she went into great detail about her experiences as a young actress and movement choreographer on various productions. She explained that she began to develop staging and choreographing intimacy practices because she found a gap in choreography pedagogy and had no resources to help with her work (Sina 13). Ten years later, she founded Intimacy Directors International (IDI) along with Siobhan Richardson and Alicia Rodis. Richardson and Rodis reached out to Sina after they read her thesis about staging intimacy because they shared her same concerns about the movement field lacking in a codified language of intimacy coordination (Turchiano 2019). They worked together and established their own pedagogy for choreographing intimacy, which consisted of five pillars: context, communication,

consent, choreography and closure (Morey 2019). Using their methodology, they trained a number of theater professionals to continue their work in intimacy direction. The leaders of IDI had all experienced the failings of the old way of choreographing intimacy, in which the line between the acting in an intimate scene and reality of intimate behavior was blurred. That is why they aimed to share their work with others through training. With their pedagogy, Sina, Richardson and Rodis could establish clearer, safer boundaries (Purcell 2018). The company chose to dissolve in March 2020 as they believed they accomplished their goal, which was "to foster, advocate for, and help build the industry of Intimacy Direction" (Team IDI).

Along with IDI, Ita O'Brien founded Intimacy on Set. Based in the UK, she has been working since 2015 to develop her own best practices for intimacy. She now mainly works in film and television. Intimacy on Set offers certifications for professionals who successfully complete the program that follow her guidelines, which she crafted with the help of Vanessa Ewan, Meredith Dufton, and Jennifer Ward Lealand. O'Brien pioneered the role of Intimacy Coordinator, which has become popular among production houses such as HBO, Netflix, and the BBC. As of 2018, HBO has required there to be an intimacy coordinator on every production set (Kerr 2018). When working on sets, O'Brien helps actors establish their comfortability and choreographs how an intimate moment will occur so everyone is on the same page. Her practices, though similar to Tonia Sina's, are geared more towards film but are also based in consent practices which most Intimacy professionals follow ("Intimacy on Set Guidelines").

In 2017, Chelsea Pace and Laura Rikard co-founded Theatrical Intimacy Education (TIE). Pace and Rikare have been working together for the last decade to create their own pedagogy for choreographing intimacy. TIE is a consulting group that specializes in researching, developing, and teaching best practices for staging theatrical intimacy ("TIE Mission"). They hold workshops and train ensembles in TIE best practices and tools to ethically, efficiently, and effectively stage intimacy. Earlier this year, Chelsea published, *Staging Sex: Best Practices, Tools, and Techniques for Theatrical Intimacy*, which goes into detail about TIE's best practices and tools. This book is the first and only book on Theatrical Intimacy published thus far. The book lays out comprehensive and practical solutions for staging intimacy, along with providing guidance for professionals by addressing common concerns (Pace 9). In August 2020, Pace and Rikard founded a second company, The National Alliance of Intimacy Professionals. (NAIP). Their goal with this company is to create a space where intimacy professionals can collaborate and have conversations about how they can agree upon their values, what it means to be a qualified intimacy professional and how to hold each other to higher standards ("NAIP Mission"). TIE pedagogy outlines the exigency for this work in theatre culture by pointing to

power dynamics in the room that make it hard for actors to assert their boundaries. With the "yes culture" they feel pressured to agree with whatever is asked of them, especially when dealing with choreographing intimate moments (Pace 9).

The work of intimacy professionals has increased in demand since stories of sexual misconduct and abuses of power in the entertainment industry broke within the last few years. Film and theatre union standards have for decades required productions to hire fight directors to choreograph scenes of violence, but there were no policies in effect to regulate intimacy on sets (Bibicoff 2019). After the Harvey Weinstein scandal in 2017 and the MeToo movement, The Screen Actors Guild - American Federation of Television and Radio Artists (SAG-AFTRA) released new guidelines. They have begun to regulate sex scenes on screen through hiring intimacy experts.

In January 2020, SAG-AFTRA released new guidelines entitled "Intimacy Coordinator Standards and Protocols." In these protocols they outlined the skills and training intimacy coordinators would be required to have, including the understanding of union contracts, anti-harassment training, mental health/trauma training, gender and sexual sensitivity training and much more ("Contracts & Industry Resources"). They also included specifics about the role of the intimacy coordinator in the production process, pre-production, on set and post-production ("Intimacy Coordinator Standards & Protocols"). It is important to note that intimacy coordinators are still not required on set (Harvin 2020). The director of SAG-AFTRA, Davd White, said when announcing the new guidelines "It's hard for the whole concept to find space in the entertainment industry and to find a path to flourish and to grow without there being a standard understanding of what we're talking about and what it means" (Harvin 2020). These guidelines and protocols are a step in the right direction towards the normalization of intimacy coordinators on set for film and television. However, without them being mandatory, there is no way to ensure that every set will uphold these recommendations for safety and consent around intimacy. This lack of regulation is one that could cause discrepancy on sets with and without intimacy coordinators. These policies will hopefully push more of the entertainment industry to shift the status quo and create a standard of consent-based practices.

## Intersectionality Between Intimacy Direction and Anti-Racism

Intimacy direction is slowly becoming more recognized after years of foundational work by the female intimacy pedagogy creators. The acknowledgment of the need for change in the entertainment industry was sparked through the MeToo movement after sexual misconduct allegations against Harvey Weinstein shone a light on

the abuse of power in the industry. Yet the MeToo movement was founded long before this scandal. In 2006, the same year Tonia Sina published her foundational graduate thesis, Tarana Burke started the MeToo movement. Tarana is a Black activist whose work to end sexual violence, specifically for Black women and girls, has paved the way for change in how the world thinks and talks about consent and body autonomy ("Get To Know Us: Tarana Burke, Founder"). The hashtag MeToo became popularized in 2017 after the Weinstein scandal broke and then quickly became an international movement where women spoke out against their abuse.

With the resurgence of the Black Lives Matter movement in early 2020 after the death of George Floyd, theatre as an art form is under a reckoning. Black, Indigenous and People of Color (BIPOC) theatre artists are demanding the implementation of overdue changes to meet the new social contract for theatre environments that cares for and sustains the artistry and lives of BIPOC ("WeSeeYouWAT"). Similar to how the popularization of the MeToo movement garnered attention for the years of work already being done by intimacy professionals, the surge in activism for the Black Lives Matter movement has increased the demand for anti-racist theatre work. However, anti-racist theatre work has been developing in the theatre field for years by BIPOC artists who call for more equitable practices.

Anti-racism, defined by the Alberta Civil Liberties Research Centre, is the "active process of identifying and eliminating racism by changing systems and organizational structures so that power is redistributed and shared equitably." BIPOC theatre artists have been doing anti-racist work by continuing to advocate for themselves and their communities to receive better representation and equity in theatre. The first time I was introduced to anti-racism work in theater was when I met Michael Bobbit, who is the Artistic Director of the New Repertory Theatre. He visited my senior capstone class during the fall semester of 2020. During this class, he discussed his current and prior anti-racist theatre work. He spoke about how being a Black man in an authority position, he has always required representation and racial equity in the institutions he's worked at, such as in hiring practices of aiming for at least fifty percent BIPOC on teams and casts. This was long before it became taboo to have an all white team in theatre and I realized how long BIPOC theater makers have been pushing for equity in our field. Bobbit continues his anti-racist work by creating anti-racist policies for his theatre that push against the norms of white supremacy.

In 2018, Annalisa Dias and Madeline Sayet point out that "Equity, Diversity and Inclusion training" have become more common in the last decade. However, making theatre more equitable means going farther than representation on stage. To create systemic change, which includes creating a culture of consent, the roots of the problem must be addressed. American theatre, like all of the United States, is rooted in white supremacy and colonization. There has been a movement

to decolonize theatre, which has been about decentering white supremacy and its effects in theatre, such as predominantly white institutions using equity, diversity and inclusion work to receive more funding than theaters run by BIPOC who receive much less funding (Dias and Sayet 2018). In an ArtsEmerson event, "A Conversation with Claudia Rankine on Whiteness" Rankine discussed the role whiteness places in racial discussions, "...the dominant group is superior. The sense of superiority is often not explicit but internalized deep beneath the surface. The process causes members of the dominant group to see themselves as normal, correct, and more valuable thus more entitled to the resources of society....it stems from the end ability of individual whites to understand racism encompasses structures, actions ..." In theatre, white people have been rewarded with money and power to tell stories and profit off of the trauma of BIPOC narratives. If theatre is creating a culture of consent and equitability, BIPOC should have the power to decide if, how and who tells their stories.

Thus far, all the most visibly recognized leaders of the theatrical intimacy revolution have been white women. Ann James, a Black female theatre educator and founder of Intimacy Coordinators of Color (IDOC), criticizes theatrical intimacy in an essay by saying "it is about white feminist culture" (Intimate Reform). In the history of feminist movements, white feminists have dominated the conversation and defined what equality is for themselves and have excluded women of color (Daniels 9). In the book "Beyond the Pale," by Vron Ware, she discusses whiteness by saying "white feminists have managed to avoid dissecting these cultural and racial components of white femininity..." Along with this critique, the Combahee River Collective, a group of radical Black lesbian feminists, issued a statement in the 1970s outlining their work and discussing the intersection of their oppression. They critique the racism in the white women's movement at the end of their statement by saying "As Black feminist we are made constantly and painfully aware of how little effort white women have made to understand and combat their racism, which requires that they have among other things a more than superficial comprehension of race, color and Black history and culture." Historically, white feminism has been centered around whiteness and catered to white women. White women have failed to fully understand the complexities of oppression when being a woman and a person of color so they are not able to adequately define equality or freedom for all women.

Intimacy work being curated by white women poses a problem for all BIPOC theatre artists interested in intimacy work. It means that it is catered to and for white women as well. In an Interview with Leaders in the Field by Brooke Joy Fairfield, Kaja Dunn points to the way white women leading this work can be

problematic, "People can see the violent impacts of the patriarchy on women very clearly but don't see the ways that white women sometimes perpetuate that patriarchy in a racialized way with Black men." She also proposes BIPOC artists want to learn from people who look like them, who understand the nuances and intricacies of being a person of color in this world, especially in relation to whiteness in theatre spaces. When choreographing intimacy with BIPOC in a space, it is not just about physical acts, it is also about power dynamics between characters and actors. Race affects how intimacy should be staged. When staging intimate moments between a white person and a person of color, intimacy choreographers of color emphasize the importance of considering who has the power in that scene and what stereotypes might be perpetuated through that assignment of power. White intimacy directors may be ignorant of those racial power dynamics, an intimacy professional of color may already be aware of that due to their lived experience. James said "I believe that intimacy directors of color are uniquely and especially qualified to bring these perspectives and experiences to light" (Intimate Reform). With Intimacy Coordinators of Color, James wants to begin framing more culturally accessible methods of intimacy training to hold space for actors of color (Intimacy Directors of Color).

Theatrical Intimacy Education updated its Equity, Diversity, Inclusion and Intimacy Initiative (EDIII) earlier this year. This update outlined the first stage of the initiative: TIE announced the EDIII Summit which was held in 2020 to develop strategy for anti-racist intimacy pedagogy. They also created an EDI scholarship for future TIE workshops, a commitment to develop relationships with historically BIPOC institutions, and workshops designed for BIPOC to learn in a racially conscious space ("About The EDIII"). In this update the work of Kaja Dunn was cited, an intimacy direction professional and affiliate of TIE. Dunn is an associate professor at UNC Charlotte whose research is based in Equity, Diversity and Inclusion issues in theatre and the decolonization of theatre in pedagogy and the theatre profession ("UNCC Diversity"). In an interview, she talks about how diversity is usually added onto things, "But it can't be extra, it has to be one of the core things... If we are talking about consent, and if we are talking about empowerment, then at the center of that discussion should center people of color." This point is affirmed by Ann James, who wrote, "Reformation can't be a knee-jerk reaction out of guilt or else the fractures it causes may bring the whole house down" (James 2020). If the goal is to have consent-based practices in theatre, then intimacy direction should be the norm and it should center intimacy choreographers of color. Creating standards of consent-based practices while the movement is predominantly white led could be dangerous in the long run.

# Why Intimacy Direction Is The Way Forward

The importance and necessity of consent-based practices to be implemented throughout the industry is critical, not just here in the United States but all over the world. While intimacy direction is slowly becoming more widely accepted throughout the United States, the United Kingdom and other parts of the world, there are still places where intimacy direction has not reached yet, such as Eastern Europe (Herczog). Historically, European theatre has influenced American theatre due to the dominating European countries that colonized the United States. American theatre was founded using European artistic styles, many pedagogies across all elements of theatre started in Europe; including methods of acting such as Stanislavski, Meisner, and Chekhov (Wilmeth and Bigsby 9). In Harold Bloom's book, *The Western Canon*, he describes the influence of European literature on American literature, focusing on Shakespeare as "The Center of the Canon." He also describes Europe as "Everything has been painted in Europe. Everything has been sung in Europe. But not in America" (Bloom 1994).

Noémi Herczog, a Hungarian theatre scholar, was only introduced to the institution of intimacy coordination in 2019 through an online article (Herczog). She said, "Actually the institution of intimacy coordinator is - to my knowledge - non-existent in Hungary, my country, or in Eastern Europe." She has written articles on the #MeToo movement in Hungary but had her concerns with abuses of power being dismissed by male directors, who insisted that any abuses were only singular, rare cases. Hungary is one example of the male-centric director culture that is prevalent in certain parts of the world. Despite this, Noémi still plans to move forward and build a block in the theatre journal for which she writes about the topic of theatre education. She will include how educated actors and directors could handle scenes of intimacy and hopes that actors will feel more enabled and educated on how to limit abuses of power in the workplace (Herczog). If Europe remains stuck in the ways of abuse then it will be increasingly difficult for American and European theater makers to work together, which will make it hard for the previously closely linked theatre cultures to move forward together in safe and equitable theatre making. It is rare for America to set the precedent for aesthetic in Theatre but currently with this work being at the forefront of a new standard for theatre, perhaps the U.S. will be an influence on the rest of the theatre world with anti-racist consent-based theatre practices.

The consensus amongst all intimacy direction professionals is that there is a great need for change in the industry and intimacy direction is the future (Mink 2019). Before the invention of intimacy direction, there weren't any tools for staging intimacy and often directors relied on the actors' experience to "figure it out"

(Bibicoff 2019). This left room for dangerous abuses of power and dynamics that led to sexual misconduct in the workplace that traumatized actors because no rules or protocols were established (Catlin 2019). What all of the pedagogies of intimacy direction have in common is that their practices are consent-based. By emphasizing the consent of the actors, the power is shifted away from the director or producer who is not trained in how to properly handle choreographing intimate scenes. With these practices, actors are able to establish their own boundaries and secure their mental, physical and emotional safety (Derr 2020). By making this the priority in productions, one can hope that it will also be made a priority in everyday life.

The culture of society is reflected in theatre and film, in the industry's case capitalism puts pressure to make actors willing to do anything to keep their job, including sacrificing their mental health. Actors are burdened with the expectation to be ready for everything the production calls for, which has been made more prevalent by "yes culture" (Duberman 2018). Women specifically feel as though if they do not say yes to everything they will be labeled hard to work with or difficult, so with the pressure to keep their job, they may say yes even when they don't want to (Pace 9). Through that, the autonomy and agency of an actor is ignored by the wants and needs of a production. By not taking their needs into consideration, an actor can get steam rolled and put in uncomfortable positions, especially when dealing with personal material. Everyone has their own experiences and traumas. One may never know how something could trigger someone, especially when dealing with intimate moments.

There is a narrative perpetuated through the "struggling artist" idea that in order for art to be good it must stem from some sort of trauma. Mental health is an exceedingly difficult thing to navigate on a personal level, and with theatre, the actor's mental health is often forgotten for the storytelling (Love 2018). Christian Edwards and Harry Long are two actors who set up a TALK network based at the Actors Center in London where actors could share their experiences with mental health. This project came out of Edwards' own mental health struggles. He says "Anyone can think about something sad that happened when they were younger and have a good cry, but can you switch it off? Can you go into the next scene and be completely OK?" Acting pedagogy such as Meisner often rewards Method acting that is inspired by authentic emotion but it isn't healthy to dip into emotional trauma and not be able to remove oneself from it. An actor cannot control their emotions when it stems from real life experience, especially in cases of intimacy in which one is already vulnerable (Cook 2018). Even more so when an individual has marginalized identities, such as gender, sexuality or race, the trauma of intimacy is entirely different. It does not matter that "they are just pretending"; often it is difficult for actors to put space between themselves and a character. An actor's job is to make themselves vulnerable, but without proper boundaries in place, this could be damaging (Pace 8).

Intimacy direction practices prevent putting actors in potentially harmful situations which is why they are so necessary and useful. These consent-based practices take the personal boundaries of actors into consideration and enable them to protect their own emotional, mental and physical well-being (Derr 2020). Each actor is able to freely express their own levels of comfort, without having to justify it, which allows an intimacy moment to be choreographed and staged. A director can always shift choreography to adjust to an actor's boundaries, but an actor should never be asked to or feel obligated to adjust their personal boundaries to keep a job (Mink 2019). Through these consent-based tools, such as the safe word, an actor is able to hold a scene and adjust with the director as necessary (Pace 17). Actors can now advocate for themselves as they work and have knowledge that can easily be translated into their personal lives. Actors with marginalized identities could call for a hold or placeholder for something that could be potentially triggering. This redistribution of power is vital for actors to be able to articulate what they need and for a director to actually listen (Pace 7-8). These power dynamics are also present outside of the workplace. By changing professional culture in the artistic and entertainment world, the culture of society can be changed as well. This positive shift can be a starting place for how society can move in the same direction. With these consent-based tools and practices, in which people will learn to place healthy and protective boundaries for themselves, people can create a shift in how society handles intimacy.

Intimacy direction, along with creating safer spaces, also enables an artistic evolution on the stage and screen. Often, directors do not know how to best stage an intimate scene, making the process awkward and uncomfortable for themselves and the actors (Sina 1). They fumble through choreographing an intimate moment with no real knowledge of boundaries or how to properly stage the scene to best enhance the story being told. This approach to the work can leave some moments of a scene that felt inauthentic and disingenuous (Pace 2-5). But when using the techniques made by intimacy direction professionals, intimate moments become easier to stage, more efficient, less awkward, and far more ethical. By removing the discomfort around some uncomfortable and oftentimes heavy moments, the actors are able to do their best work. Even more importantly, with choreography in place, the intimate moment is repeatable because it's choreography, just like a fight scene (Bibicoff 2019). Actors and directors do not have to rely on emotions to make a scene. With a solid foundation of choreography, actors are able to continuously add to their work and always have something which they can refer to.

Creating a safe environment for actors to explore and hone in on their craft should be normalized in the entertainment industry, especially when dealing with intimate material. If actors limit themselves from discovery out of fear or discomfort, the story is not able to be told and actors could put themselves in a

dangerous place emotionally. Ethical intimacy direction also enables actors to leave their craft at work rather than take it home with them (Purcell 2018). By allowing for space between them and their work, they can get out of that head-space that could potentially be harmful. That is why intimacy direction should be an integral part of the production process. By expanding the definitions of intimacy on screen or stage, people are encouraged to communicate their needs in their personal lives as well. We are able to have an open and honest conversation about sexuality and sexual experience, which society has deemed taboo.

As a student of Chelsea Pace, I have been able to deepen my understanding of consent and power dynamics in theatre. I have tools which enable me to advocate for myself as an actor in a room to ensure my safety and comfortability, as well as in my personal life when setting boundaries in relationships. Intimacy direction practices might not be easy for everyone to adapt to, but no one should deny the need for safety and the practice of holding boundaries when working with actors or in their own lives. It creates a more healthy and ethical work space that leads to better art.

## Conclusion

Though the field of intimacy direction is still developing and expanding, there is something inherently empowering about this work. Redistributing power in an industry with a long-standing history of abuses and misconduct has the potential to create real social change. The best practices recently developed by intimacy direction professionals are generating an evolution in the art forms of theatre and film. By enabling the safety of actors, they are allowed to be vulnerable in the moment and have artistic freedom in their work, therefore creating authentic storytelling. As the entertainment industry continues to move in this direction of ethical and anti-racist practices, one can only hope this work empowers society to shift how it thinks about intimacy and sexuality, resulting in a much-needed cultural change in which BIPOC are centered.

# Works Cited


"About The EDIII." Theatrical Intimacy Education, www.theatricalintimacyed.com/the-ediii.

"Anti-Racism Defined." Alberta Civil Liberties Research Centre, www.aclrc.com/antiracism-defined.

Bibicoff, Allison. "What is Intimacy direction?" @This Stage, 10 Sept 2019, https://thisstage.la/2019/09/intimacy-direction/.

BlackPast. (1977) The Combahee River Collective Statement, www.blackpast.org/african-american-history/combahee-river-collective-statement-1977/.

Bloom, Harold. The Western Canon. United States, Houghton Mifflin Harcourt, 2014.

Catlin, Roger. "Meet the theater specialists who show actors the right way to make out onstage." The Washington Post, 27 July 2019, https://www.washingtonpost.com/entertainment/theater_dance/meet-the-theater-specialists-who-show-actors-the-right-way-to-make-out-onstage/2018/07/27/6a98f07c-8449-11e8-9e06-4db52ac42e05_story.html.

Coen, Stephanie. "Staging Intimacy" Stage Directors and Choreographers Journal. 2019, https://static1.squarespace.com/static/5984c4a0cd39c369f61bbf0f/t/5d2f54d53630df000191c1cc/1563383002575/SDCJ+Summer+2019+p25-30+Staging+Intimacy.pdf.

Collins-hughes, Laura. "Need to Fake an Orgasm? There's an 'Intimacy Choreographer' for That." The New York Times, The New York Times, 15 June 2017, www.nytimes.com/2017/06/15/theater/need-to-fake-an-orgasm-theres-an-intimacy-choreographer-for-that.html.

"Conversation Claudia Rankine: On Whiteness." HowlRound Theatre Commons, ArtsEmerson, 14 Mar. 2017, howlround.com/happenings/conversation-claudia-rankine-whiteness.

Cook, Laurence. "The Power of Words: Why 2 London Actors Started Talking." Backstage, Backstage, 29 Mar. 2018, www.backstage.com/uk/magazine/article/power-words-london-actors-started-talking-1581/.

Daher, Bernardo Mazón, and Kate Busselle. "The Art and Craft of Intimacy Direction." HowlRound Theatre Commons, 3 Jan. 2020, howlround.com/art-and-craft-intimacy-direction.

Daniels, Jessie. "Chapter Two: The Trouble With White Feminism: Whiteness, Digital Feminism, and the Intersectional Internet." The Intersectional Internet, doi:10.3726/978-1-4539-1717-6/12.

Duberman, Amanda. "Meet The 'Intimacy Directors' Who Choreograph Sex Scenes."

HuffPost, 31 May 2018, https://www.huffpost.com/entry/intimacy-directors-choreograph-sex-scenes_n_5b0d87dae4b0fdb2aa574564.
Fairfield, Joy Brooke, et al. "Intimacy Choreography and Cultural Change: An Interview with Leaders in the Field." Journal of Dramatic Theory and Criticism, vol. 34, no. 1, 2019, pp. 77–85, muse.jhu.edu/article/749728/pdf.
"FAQ." Teamidi.org, 15 Mar. 2020, www.teamidi.org/.
Feidelson, Lizzie. The Sex Scene Evolves for the #MeToo Era. 14 Jan. 2020, www.nytimes.com/2020/01/14/magazine/sex-scene-intimacy-coordinator.html
Fischer-Lichte, Erika. History of European Drama and Theatre. Translated by Jo Riley, Routledge, 2002.
Fisher, Steve. "The Ins and Outs of Onstage Intimacy." NOW Magazine, 4 May 2016, nowtoronto.com/the-ins-and-outs-of-onstage-intimacy.
Forker, Charles R. "Sexuality and Eroticism on the Renaissance Stage." South Central Review, vol. 7, no. 4, 1990, pp. 1–22. JSTOR, www.jstor.org/stable/3189091. Accessed 18 Dec. 2020.
"Get To Know Us: Tarana Burke, Founder." Me Too. Movement, 17 July 2020, metoomvmt.org/get-to-know-us/tarana-burke-founder/.
Harvin, Mary Franklin. "Will 'Intimacy Coordinators' Change the Future of Sex Scenes in Hollywood?" KQED, 20 Feb. 2020, https://www.kqed.org/news/11801357/will-intimacy-coordinators-change-the-future-of-sex-scenes-in-hollywood.
Henley, Rowena. "Meet Ita O'Brien, The Woman On A Mission To Make Sex Scenes Safer For Everyone." Bustle, 8 March 2019, https://www.bustle.com/p/meet-ita-obrien-the-woman-on-a-mission-to-make-sex-scenes-safer-for-everyone-16811033.
Herczog, Noémi. "Re: Theatrical Intimacy" Received by Caitlyn Hooper, 15 May 2020.
"Intimacy Directors of Color." Brave Space, www.intimacydirectorsofcolor.com/.
"intimacy, n." OED Online, Oxford University Press, September 2020, www.oed.com/view/Entry/98503.
James, Ann. "Intimate Reform." HowlRound Theatre Commons, 19 Mar. 2020, howlround.com/intimate-reform.
"Kaja Dunn." UNC Charlotte Division of Academic Affairs Diversity, https://diversity.uncc.edu/kaja-dunn
Kamminga-Peck, Hadley. "Make It Less Weird: Theatrical Intimacy Education and How a Fence Can Lead to Intimacy." Theatre Topics, vol. 30 no. 3, 2020, p. 203-209. Project MUSE, doi:10.1353/tt.2020.0038.
Kerr, Breena. How HBO Is Changing Sex Scenes Forever. 24 Oct. 2018, www.rollingstone.com/tv/tv-features/the-deuce-

intimacy-coordinator-hbo-sex-scenes-739087/.
Love, Catherine. "'We're Not Talking about This': Actors Spotlight Industry's Mental Health Stigma." The Guardian, Guardian News and Media, 29 Oct. 2018, www.theguardian.com/stage/2018/oct/29/actors-mental-health-issues-milly-thomas-artsminds-talk.
McCauley, Mary Carole. "How Chesapeake Shakespeare Company Creates Intimacy on the Stage in the #Metoo Era. Baltimoresun.com, 25 Apr. 2019, www.baltimoresun.com/entertainment/arts/bs-fe-chesapeake-shakespeare-intimacy-coach-20190325-story.html.
Mink, Casey. "How Broadway's First Intimacy Director Protects Actors + Makes Better Art." Backstage, Backstage, 11 July 2019, www.backstage.com/magazine/article/broadway-intimacy-director-claire-warden-interview-68526/.
"Mission." National Alliance of Intimacy Professionals, intimacypro.org/mission.
Morey, Erika. "The 5 Cs of Intimacy: In Conversation with Siobhan Richardson." TheatreArtLife, 2 July 2019, www.theatreartlife.com/one-and-done/5-cs-intimacy-conversation-siobhan-richardson/.
O'Brien, Ita. "Intimacy on Set Guidelines." Intimacy on Set, https://www.intimacyonset. com/intimacy-on-set-guidelines.html.
"Our Team." Intimacy Directors and Coordinators, www.idcprofessionals.com/our-team.
Pace, Chelsea, and Laura Rikard. "Mission." Theatrical Intimacy Education, 2017, www.theatricalintimacyed.com/mission.
Pace, Chelsea, and Laura Rikard. Staging Sex: Best Practices, Tools, and Techniques for Theatrical Intimacy. Routledge, 2020.
Perasso, Valeria. "The women helping Hollywood shoot safer sex scenes." BBC, 7 March 2020, https://www.bbc.com/news/entertainment-arts-51745702.
Pierce, Jerald Raymond. "Not a Moment but a Movement: Toward an Anti-Racist American Theatre." AMERICAN THEATRE, 16 July 2020, www.americantheatre.org/2020/07/15/not-a-moment-but-a-movement-toward-an-anti-racist-american-theatre/.
Pierce, Roger. "'Intimacy' in the Theatre." Educational Theatre Journal, vol. 20, no. 2, 1968, pp. 147–151. JSTOR, www.jstor.org/stable/3204898.
Pinkins, Tonya. "Why I Am Fed Up with Performative Activism from White and Black Theater Makers." Medium, Medium, 10 July 2020, tonyapinkins.medium.com/why-i-am-fed-up-with-performative-activism-from-white-and-black-theater-makers-d46564ec94fe.
Purcell, Carey. "Intimate Exchanges." AMERICAN THEATRE, Theatre Communications Group, 24 Oct. 2018, www.

americantheatre.org/2018/10/23/intimate-exchanges/.
SAG, www.sagaftra.org/contracts-industry-resources/workplace-harassment/intimacy-coordinator-standards-protocols.
Sayet, Madeline, and Annalisa Dias. "Decolonizing Theatre/La Descolonización Del Teatro." HowlRound Theatre Commons, howlround.com/decolonizing-theatrela-descolonizacion-del-teatro.
Sina, Tonia. Intimate Encounter: Staging Intimacy and Sensuality. Virginia Commonwealth University, 2006, https://scholarscompass.vcu.edu/cgi/viewcontent.cgi?article=2070&context=etd.
Sinfield, Alan. Out on stage: lesbian and gay theatre in the twentieth century. United Kingdom, Yale University Press, 1999.
Turchiano, Danielle. "HBO Intimacy Coordinator Alicia Rodis on Importance of Consent Beginning in Casting." Variety, Variety, 29 May 2019, variety.com/2019/tv/features/hbo-intimacy-coordinator-alicia-rodis-interview-deuce-crashing-training-metoo-1203163944/.
van Lankveld, Jacques et al. "The associations of intimacy and sexuality in daily life: Temporal dynamics and gender effects within romantic relationships." Journal of social and personal relationships vol. 35,4 (2018): 557-576. doi:10.1177/0265407517743076.
Ware, Vron. Beyond the Pale. Verso, 1992.
We See You W.A.T., 2020, www.weseeyouwat.com/.
Wilmeth, Don B., and C. W. E. Bigsby. The Cambridge History of American Theatre. [Electronic Resource]. Cambridge University Press, 2008. EBSCOhost, search.ebscohost.com/login.aspx?direct=true&AuthType=ip,url,uid&db=cat01476a&AN=umdbc.003885229&site=eds-live&scope=site.
Women In Restoration Theatre, 22 Apr. 2010, restorationtheater.wordpress.com/.

# Implications of Rhetoric: A Newspaper Analysis of Immigration Policy

Cassie Davis


13780

# Cassie Davis

**Cassie Davis was an American Studies major and graduated with honors from UMBC in May 2020 with a certificate in Spanish and a certificate in Intercultural Communication. She is a member of two different honor societies including Phi Kappa Phi and The National Society of Collegiate Scholars. She has been the recipient of multiple scholarships for her dedication to her studies, including a PKP award for her submission of "Implications of Rhetoric" in URCAD 2020.**

**Cassie plans to further her education in International Studies and plans to begin a master's program in the Spring of 2021. Currently she is seeking volunteering opportunities with different Immigration Advocacy Agencies in Maryland.**

"This project was my senior project for AMST 490. I discussed the idea of the project with my father and then my Professor in AMST 300 (Professor Fouts). My professor and I came up with a rough project outline and I began research in November 2019. The research carried into 2020, and I had my advisor and professor of AMST 490 (Professor Bhalla) help to guide my research and written work. I used books from the library, as well as the UMBC historical database for newspaper research. I utilized each resource at my disposal as a student and submitted the project for display at URCAD for which I ended up winning an award!"

**-Cassie Davis**

**Image 5.**
Graphical Representation of Trump's Executive Order 13780 (the Muslim Ban).

## Abstract

This project examines nativism and racialized rhetoric surrounding Executive Order 13780 (Muslim ban) to identify parallels with immigration rhetoric and legislation in the Chinese Exclusion Act (1882) and Operation Wetback (1954). This study is limited to 60 New York Times pieces – articles, editorials, and opinion pieces – and official legislative policies to identify incautious, racialized, and pejorative language. This study also examines scholarship on American nativism to provide a conceptual framework for how rhetoric categorizing migrants as criminal, amoral, or less-than-human serves to justify biased and inhumane treatment of these potential refugees and to encourage anti-immigrant sentiment among Americans.



*Keywords: nativism, radicalized rhetoric, immigration, legislation, bias & refugees.*

# Introduction

The social acceptability of discrimination that coincides with racism can be seen in many contexts across the nation and within American society. One public form of openly racialized sentiment can be observed through immigration policies. This research is focused on politicized and radicalized immigration policies in the United States, and aims to answer the following questions: How is racialized discourse reflected in newspaper publishing's of each time-period? How is racialized discourse reflected within government legislation? What patterns emerge when analyzing the discourse from each period, including language in New York Times pieces and various government documents?

Racialized discourse is defined as the discourse that members of a dominant group say to other members in the dominant group about members of a dominated (minority) group; the primary characteristic of this discourse is the negative portrayal of the dominated group, often combined with a positive representation of the dominant group.[1] These conversations include organizational dialogues, to many written or multimedia types of text or communicative events, such as TV shows, movies, news reports, editorials, textbooks, scholarly publications, laws, contracts, and so on.[2] This project examines nativism and racialized rhetoric surrounding Executive Order 13780 (Muslim ban) to identify parallels with immigration rhetoric and legislation in the Chinese Exclusion Act and Operation Wetback. This analysis highlights the Trump administration's immigration policies, which exceed 40 newly passed pieces of legislation from 2017-2020, including many exclusionary policies.[3] Nativism is central to this study as it stems from an adverse reaction to immigration in the country and is described as, "distinctively American."[4]

Nativism is defined as, "the intense opposition to an internal minority on the ground of its foreign (i.e., "un-American) connections."[5] American nativism is associated with intense kinds of nationalism and this national nexus has also meant that the nativists most characteristic complaint is against the loyalty of some foreign (or allegedly foreign) group.[6] The analysis of this project identifies nativism as the underlying phenomena of prejudice against immigrants in these policies, opposed to racism or xenophobia. Although some may use these three terms (nativism, racism, and xenophobia) interchangeably, nativism emerges from an extreme national sentiment, whereas xenophobia is the fear of anything or anyone foreign, and racism is a belief that a race defines a hierarchy in which one race is superior or inferior compared to another. To better understand the differences of each of these terms, I offer the following examples of nativism as it suggests a contested loyalty; the nativism that targeted the Irish Catholic and to a lesser extent, German Catholic immigrants from the 1830s to the mid-1850s[7] implied religious loyalty to the Pope and similar

affiliations. Perhaps best known, is the nativism against immigrants during World War II as Japanese Americans were sent to internment camps to "protect" citizens of the United States against the feared allegiances to Japanese government.

Media discourse analysis is necessary to analyze nativist rhetoric in the United States in order to recognize the distinction between nativist, national, and prejudicial sentiments. The analysis also helps to understand the influence of policy and media coverage of policy on the public, specifically policies that are historically renowned as exclusionary and discriminatory – such as immigration policy. A strong analysis of nativism is needed to compare time periods, therefore I have employed works of other scholars to analyze "the recent surge of nativism with earlier periods," basing my findings on a review of historical literature as well as on contemporary immigration scholarship.[8] My scope includes the time period from the Chinese Exclusion Act of 1882, to "Operation Wetback," as well as "President Trump's consistent, highly public, and widely disseminated appeals nativist sentiment."[9] My research also includes an analysis of nativist attitudes within journalism, which is paramount in comparing the results of the newspaper pieces.

## Methodology

I have employed policy analysis to effectively analyze language used by government officials. This analysis includes a close examination of official government documents, specifically the text within each document enforcing exclusionary policy. The examination is of any language used to describe immigrants, reasons for exclusion, and legal consequences thereof the following policies:

1) Chinese Exclusion Act [10]
2) Operation Wet Back [11]
3) Executive Order 13769 [12]

In order to study the popular discourse prevalent in each time period, I selected and analyzed 20 newspaper pieces from the *New York Times*. I examined pieces through the time-period of one year before the enactment of the policy, the year during the policy's enactment, and the year after the enactment. I used search terms that are congruent with the language used by government officials within the actual policies themselves, each president's name and administration who enforced the policy, and historically popular terms to describe each group of immigrants.

For the Chinese Exclusion Act, the years were 1881-1883 and search terms were: Chinese Exclusion Act, Chinese immigrants, labor, immigration, migrant, Chinese lawsuits, Garfield. For Operation Wetback, the years were 1953-1955 and search terms were: Operation Wetback, Mexicans, Hispanic, wetback, immigrants, labor, deportation, border, Eisenhower. For Executive Order 13780, the years were

2016-2018 and search terms were: Muslim ban, Executive Order 13780, terrorism, terrorist, border, national security, immigrants, refugees, Muslims, Trump.

## Codes

To analyze the documents, differentiations were needed between common language used historically and racialized discourse. That is, what we would now consider racialized and discriminatory rhetoric was common language used during each period. Examples of standard terms used historically included "wetbacks" or "coolies." To prevent confusion about what terms are considered discriminatory for each time-period, I offer the analysis of the term "alien." The term "alien" is normalized and is accepted as a term to describe foreigners in official government speech and legislation, yet it is associated with criminality, invasion, and otherness compared to "immigrant."[13] Furthermore, the words citizens, immigrants, and aliens represent a hierarchical and status-based view of membership in which "aliens" fall to the bottom of the linguistic category.[14]

I coded terms that alluded to the delinquency of immigrants to establish patterns between each document and time-period. These codes are broken into six distinct categories: Pejorative Language, Labor-Related Language, Fear-Inducing Language, Dehumanizing Language, Racialized Language, and Criminalized Language. The rhetoric of the policies and pieces were selected and placed carefully into each category, although there is common overlap between categories. For example, an argument can be made that all language used in each policy is racialized language. The racialized language category is distinct in words or phrasing with origins of ethnicity as an adjective, and whichever other words are discounted from all other categories. Furthermore, pejorative language is distinct from fear-inducing language according to the adjective itself, and/or the word created to describe people (i.e., wetback). Labor-related language is distinct from dehumanizing language, although in many cases there was "overlap," such as the phrasing of Chinese or Mexican labor as "imported." However, divisions were made based on the nature of "imported," as this is an objectified term.

Each category was created with the stipulations of Critical Discourse Analysis and all words and phrases have been thoroughly analyzed and have been placed into charts that are listed in the appendixes. The context and phrasing are necessary for an in depth understanding of each term, to elaborate on the accepted xenophobic discourse within each document. For a thorough understanding of discourse used, each period has been analyzed and explained first by policy, then by New York Times pieces, and finally by comparing each time period.

## Rhetoric of Chinese Exclusion Act:

The Chinese Exclusion Act of 1882 was signed by President Chester A. Arthur and was the first in a series of exclusionary immigration policies that would last until Congress passed the Immigration Act of 1965.[15] The original policy (examined for this research) excluded immigrants based on their race and nationality, and it barred Chinese laborers from entering the United States for 10 years, denying Chinese people the right to naturalize.[16] The specific motivations for the creation of this policy was due to the belief that Chinese laborers (primarily men) would work for lower wages than Americans. As merchants, students, teachers, and travelers were exempt from the act, each Chinese person was required to get a certificate from the Chinese government proving their exemption.[17] The Act can be seen as a watershed event in the context of race, nation, and law as it helped to suppress Chinese immigration for over 70 years.[18]

Language found within the official policy of the Chinese Exclusion Act is standard, as there is minimal discriminatory rhetoric when referring to the Chinese. However, the repeated word Chinese, in this policy, should be realized as legal and openly racialized discrimination. Moreover, the reference to the phrase "Chinese Laborer" is the primary commonality of each text, as the phrase appears the most frequently in both the legislation (25 times) and New York Times pieces (15). Similarly, analysis displayed labor-related language as the primary category for both policy and New York Times pieces.

Many New York Times pieces were covering Californian newspaper articles, government officials, organizations, and court proceedings. The rhetoric used by these officials and organizations was often discriminatory when referring to the Chinese as "heathens, evil, pagan, celestial, coolies, menace," and "undesirable." Racialized and prejudiced phrases suggest threats of "foreign invasion, distinct race, asiatic hordes, mongolianized, ever-threatening danger," and "not a servile race". This dehumanizing discourse commonly describes Chinese laborers as "importations." The analysis of New York Times exhibited the greatest variation of discriminatory language, as each category had multiple phrases or words (42 variations) describing the Chinese in a prejudiced manner.

## Rhetoric of "Operation Wetback"

"Operation Wetback" was a series of deportations targeting Mexican immigrants over several months during 1954-1955. These deportations were carried out through different sectors of law enforcement, including the United States Border Patrol and the Immigration and Naturalization Service. The operation had many different stages in many different states and has been explained as "the expensive and only partially successful drive

by American authorities during the Eisenhower administration to roundup, often brutally, the wetbacks in the United States and to ship them back to Mexico on foot or by bus or plane."[19] These deportations were not mandated by law, but rather were carried out legally by the meticulous planning, organization, and efforts of Herbert Brownell, the Attorney General at the time. Brownell had written a letter to Congress in June of 1954 detailing the "plans for a massive roundup of undocumented workers and some legislative proposals."[20] Congress had a series of hearings on these proposals; however, these legislations were never passed. The rhetoric analyzed for this project on Operation Wetback is a Senate Congressional Record of July 9, 1954; the record details the two legislative proposals that were sent in Brownell's letter to Congress.

The results of the analysis exhibit the use of the pejorative word "wetback," as it was used minimally (four times) in the record, which is in complete contrast with the use of the term in the New York Times pieces. The word "alien" was used 26 times in the congressional record and six times in the New York Times pieces. The labor-related language discussing the employment of "illegal aliens" was the most notable – including references that suggest that the employment of undocumented immigrants affects the employment of domestic workers. All language used in both the congressional record and the New York Times pieces has been coded and can be found in the appendixes.

## Rhetoric of Executive Order 13780

Executive Order 13780 was one of three orders called for by President Donald John Trump. In January 2017 President Trump began a series of Executive Orders (EOs) attempting to ban the travel of refugees and immigrants into the United States for a period of 90 days. Although there are differences among the three orders, the countries that are targeted by the ban remain consistent: Iran, Iraq, Libya, Somalia, Sudan, Syria, and Yemen. The predominant religion in each of these countries is Islam, making the series of EOs infamously known as "The Muslim Ban"; the orders clearly target Muslims, and cast them as security threats. The two EOs Donald Trump signed soon after his inauguration in 2017 officially sanctioned and legitimized discourse and policy against Muslims.[21]

The language in the first EO, Executive 13769, titled, "Protecting the Nation from Foreign Terrorist Entry into the United States," references Sept. 11 three times within the purpose for its enactment. The cause for this order was to "protect the American people from terrorist attacks by foreign nationals."[22] The order was repealed due to its unconstitutionality, because the language specifically targets Muslims. A month after its repeal, Trump signed a revised second EO in an attempt to ban foreigners from each of these countries. In late June 2017, the United States Supreme

Court forbade the government from applying either the 90-day ban on nationals from the seven countries or the 120-day ban on refugees to any individual who could credibly claim a certain relationship with a person or entity in the United States.[23] Executive Order 13780 was the second order implemented by President Trump and has been selected for this project due to its revised, yet, recognizable prejudicial language that was intended to protect American Citizens from terrorism.

The EO is titled "Protecting the Nation from Foreign Terrorist Entry into the United States," and is dated for Thursday, March 9, 2017. The EO begins with a declaration of authority from the president as written in the Immigration and Nationality Act. The first section states the purpose of the act is to protect American citizens from terrorist attacks, including those committed by foreign nationals from Iran, Iraq, Libya, Somalia, Sudan, Syria, and Yemen for a 90-day period. During this period, the new administration is stated to make much needed improvements to United States Refugee Admissions Program's screening and vetting protocols and procedures associated with the visa-issuance process, as their protocols "play a crucial role in detecting foreign nationals who may commit, aid, or support acts of terrorism in preventing those individuals from entering the United States."[24]

The following subsection discusses the order's equal purpose of former EO 13769; although, there are many revisions to this order including the omission of the September 11th attacks, as well as any descriptive language that formerly targeted Muslims. However, there is an additional section that refutes association between the ban and religion. As well as a section that states, "since 2001, hundreds of persons born abroad have been convicted of terrorism-related crimes in the United States"[25] – including refugees. The reason stated for the suspension of travel from these specific countries, is to the "heightened concerns about terrorism and travel to the United States."[26] Each country is said to have been afflicted by terrorism as well as a state sponsor for various terrorist groups – making foreigners coming from these countries' potential threats to the United States. The dangers posed by "foreign nationals" from these countries is consistently repeated throughout the document.

Fear-inducing language permeates the EO, as the word "terror" (or its derivatives, terrorist or terrorism) appears 55 times. Phrases that demonize immigrants and refugees from these terror-stricken countries are repeated throughout the document. These phrases include: "threat to national security," "threat," "harm or risk national security," and "national security concerns." The threats from each country are explained in detail and in summary the document states that "some of those who have entered the United States through our immigration system have proved to be threats to national security."

The fear-inducing language found in Executive Order 13780 also pervades the New York Times pieces. The word "terror" appears 90 times in 20 pieces. The

language in New York Times pieces is explicit of the ban, as most of the pieces contain headlines and statements that are openly against the Muslim ban. Accordingly, the multiple revisions of the EO in attempt conceal or change language that targets Muslims, are of unimportance as half of the pieces have headlines that contain the word "Muslim" and many of the pieces discuss the target of Muslims.

The vast majority of the New York Times rhetoric challenges the EO's language. Additionally, the connection between the EO and the Sept. 11th attacks is repeatedly questioned within multiple pieces, an example can be seen with an editorial titled, "The Outcry Over Trump's Refugee Ban", where the editor states, "surely, I'm not the only person wondering why Donald Trump's odious immigration ban does not include immigrants from Saudi Arabia, The United Arab Emirates or Egypt, the countries that were home to the 9/11 attackers?"[27] Another article discusses this peculiarity, "Mr. Trump invoked the Sept. 11 attacks three times. Yet Saudi Arabia, which was home to 15 of the 19 attackers, was not included on the list of countries whose citizens would be shut out."[28]

A common message in many pieces proposed that the ban would only further hatred and anti-American sentiment among Muslim communities. This proposition can be seen in an article discussing the ban, where the author declares, "such an approach can only help the extremists by fueling anti-American sentiment among moderate Muslims everywhere."[29] Another example of this can be seen in an op-ed titled, "A Muslim Ban is Unscientific", where the piece states, "Mr. Trump's ban may very well promote the psychological conditions that fuel the radicalization he seeks to combat."[30] This is consistent with the notion that the travel ban, even when repealed, negatively affects all Muslims as well as the relations between the United States and the Middle East.[31] Although the language of the New York Times pieces is explicit in their anti-Muslim ban sentiment, there are a few pieces that report on the terrorist acts in these countries and/or, focus on United States military excursions when combating terrorist groups from the seven countries. However, each publishing is consistent with the language from the legislation, as it is apparent that foreigners from these countries are being portrayed as potential terrorists.

## Comparative Analysis of Policy and New York Times Pieces

Each of these Acts are dated over half a century apart, yet the common thread is the nativist and discriminatory language that surround each policy and is contained in the documents themselves. The language used by public officials in each era contain openly xenophobic and nativist rhetoric. There are five key distinctions and parallels that are seen among these policies and are as follows:

1) The Chinese Exclusion Act had the most variation of explicitly discriminatory terms used to describe Chinese immigrants in the New York Times, and labor-related language was the central theme in both legislation and newspaper pieces. Most language in the New York Times pieces seemed to oppose the legislation, as the many of the statements regarding the Act seemed to be anti-Chinese Exclusion.
2) "Operation Wetback" had the highest number of terms that fit in the pejorative language category, and the commonality between both policy and New York Times pieces was labor-related language. The majority of coverage had pejorative language that was used emphatically and in excess in describing Mexican immigrants.
3) Executive Order 13780 had the closest correlation of terms used in both New York Times pieces and policy, as fear-inducing language was used most in both texts. Fear-inducing language (terror; security threat, etc.) is the only discriminatory language used to describe migrants from the seven countries, aside from the term "alien." Most of the coverage of the New York Times opposed the ban and recognized its discriminatory purposes. (This may suggest a stage of journalistic evolution at the New York Times or resulting tension between the Trump Administration and the newspaper, which deserves further research.
4) Discourse used in both policy and newspaper pieces of The Chinese Exclusion Act and "Operation Wetback" are the most closely related, as labor-related language was used the most in both sets of texts. The same can be said of dehumanizing language in New York Times pieces of both policies.
5) Fear-Inducing Language is the only common category among all three policies.

Although the nationalities of the immigrants targeted by each exclusionary policy are different, the nativist sentiment through each time-period are consistent: the inability of specific immigrant groups to assimilate, threats these foreigners pose to native-born populations, and fear that immigration threatens American workers.[32] This corresponds with the results from the analysis, as Chinese and Mexicans were portrayed as potential threats to American labor, all three groups are criminalized as posing a threat to American society and Muslims were portrayed as physical threats to the lives and health of United States citizens. Over the course of each period, the results display an increase in fear-inducing language in both New York Times pieces and policy. This is validated with the results, as the use of fear-inducing language is much more frequent in both policy and coverage of the Muslim ban.

# Conclusion: Nativism and Immigration Policy in 2020

Many studies have been conducted to explain anti-immigrant public and political discourse. Immigration scholars argue that anti-immigrant laws harden public opinion toward immigrants.[33] Moreover, in each of the immigration policies the individuality of immigrants and their humanity are backgrounded.[34] The mischaracterization of immigrants and the irrational lies aimed for public support of these discriminatory exclusionary policies are indisputable and the implications include legal mistreatment of immigrants in the United States. Today, the inhumane treatment that is legally enforced on immigrants (undocumented or documented) not only excludes refugees and immigrants that are escaping life threatening situations but includes separating children from their parents permanently and placing immigrants in cages to drink water out of toilets.[35]

Although, immigration policy is almost always protectionist, nativist, and exclusionary – the discriminatory and inhumane treatment of immigrants goes against the very grain of American values. With the increasingly complex world of global economics, international terrorism, Covid-19, Northern Triangle caravans, drug trafficking, etc. – immigration reform discourse will likely become more politicized and complex. Although perhaps nativism can never be completely eradicated, public officials and journalists should be mindful of nativist discourse that leads to anti-immigrant and racist tendencies in the United States. Furthermore, it is the duty of politicians, government officials, civic leaders, editors, scholars and journalists, to bring nativist and discriminatory tendencies to the attention of the public; aiming to hinder anti-immigrant sentiment and "fear of other."

# Appendix 1:

**Table 1: Language Used in Legislation**

| | Chinese Exclusion | Operation Wetback | Executive Order: 13769 |
|---|---|---|---|
| Pejorative Language | | The Wetback Bills<br>Wetback(s) 3 | |
| Labor Related Language | Chinese Laborer(s) 25<br>laborer(s) 3 | Employment 13<br>"in search of employment"<br>"compete for employment" with our domestic workers"<br>employ 7 | |
| Fear-inducing Language (phrasing) | Endangers the good order of certain localities within the territory | Invasion<br>"spreading communicable disease" | "protect its citizens from terrorist attacks"<br>"heightened concerns about terrorism"<br>Terror (Terrorism, Terrorist) 55<br>threat<br>"threat to national security" 4<br>"terrorism and national security"<br>"harm the national security"<br>"risk the national security"<br>"national security concerns" |
| Dehumanizing Language | | Alien(s) 26<br>Importation of alien labor 2<br>Alien Workers | Aliens 15 |
| Racialized Language | Chinese 11 | | |
| Criminalized Language | | | |

**Table 2: Language used in *NY Times***

| | Chinese Exclusion | Operation Wetback | Executive Order: 13769 |
|---|---|---|---|
| Pejorative Language | Chinese Problem<br>Wicked Chinam<br>Coolies 6 (Sanskrit word for laborer)<br>Chinese scourge<br>Moral leprosy<br>Pagan(s) 2<br>poor Chinese<br>Hoodlums | Wetback(s) 109<br>Wetbackism | |
| Labor Related Language | Chinese laborers 15<br>Chinese labor 4<br>Competition 2<br>Compete 2<br>Chinese cheap labor<br>Laborers 2<br>Servile contract<br>Cooly labor<br>Servile labor | Mexican labor<br>Mexican laborers<br>Cheap labor<br>Unemployed | |
| Fear-inducing Language (phrasing) | Evil<br>Inspired by Satan<br>Spirit of evil<br>Invasion 2<br>Civilization menaced<br>Dangerous<br>Invasion 2<br>Supremacy | "wetback" evil<br>devious "incursions" | Terror 90 (Terrorism, Terrorist)<br>Threat 13<br>National Security concerns 5 (or threat to national security) |
| Dehumanizing Language | Hordes 3<br>Horders<br>Import<br>Importation<br>Heathens 2<br>Bestiality<br>Celestials | Mopping up stages<br>Mexican Aliens<br>Aliens 6<br>Illegal Aliens 6<br>Alien competition<br>Illegal alien influx<br>Alien labor<br>Importation 8 | |
| Racialized Language | Mongolian(s) 3<br>Anti-Chinese 3<br>Yellow man<br>Oriental<br>Milesian descent<br>Mongolianized 2<br>Asiatic 2<br>Asiatic hordes 2 | Mexican border jumpers 6 | |
| Criminalized Language | Chinese poisons<br>Crime<br>Murderers | Fugitives from justice 4<br>Fugitives 3 | |

# Endnotes


1. HENRY, FRANCES, CAROL TATOR, Sean Hier, and Joshua Grenberg. Discourses of Domination: Racial Bias in the Canadian English-Language Press. University of Toronto Press, 2002, 351.
2. "Ibid.", 352.
3. "Federation for American Immigration Reform,"Fairus.org, Federation for American Immigration Reform.2020. https://www.fairus.org/issue/presidential-administration/trump-administration-immigration-accomplishments.
4. Higham, John. Strangers in the Land: Patterns of American Nativism, 1860-1925. Rutgers University Press, 3.
5. "Ibid.", 4.
6. Higham, John. Strangers in the Land: Patterns of American Nativism, 1860-1925. Rutgers University Press
7. Roger, Daniels,Coming to America: A History of Immigration and Ethnicity in American Life, 2002,265.
8. J.G. Young, "Making America 1920 again? Nativism and US immigration, past and present." Journal on Migration and Human Security (2017),217.
9. "Ibid."
10. An act to execute certain treaty stipulations relating to the Chinese, May 6, 1882. Enrolled Acts and Resolutions of Congress, 1789-1996; General Records of the United States Government, Record Group 11; National Archives.
11. Congress. Volume 100, Part 8, (July 8, 1954 to July 21, 1954).
12. Executive Order 13780:Protecting the Nation from Foreign Terrorist Entry into the United States. Vol. 82, No. 45. Presidential Documents. Federal Register. March 9, 2017.
13. Núñez, D. Carolina, 2013, "War of the Words: Aliens, Immigrants, Citizens, and the Language of Exclusion."Brigham Young University Law Review2013 (6): 1519
14. "Ibid."
15. An act to execute certain treaty stipulations relating to the Chinese, May 6, 1882. Enrolled Acts and Resolutions of Congress, 1789-1996; General Records of the United States
16. S.H. Kil, "Fearing Yellow, Imagining White: Media Analysis of the Chinese Exclusion Act of 1882."SOCIAL IDENTITIES (2012), 2.
17. "Ibid".
18. "Ibid".

19. García, Juan Ramon. Operation Wetback: The Mass Deportation of Mexican Undocumented Workers in 1954, Contributions in Ethnic Studies: No. 2. Greenwood Press, 1980,xiv.
20. "Ibid.", 160.
21. GÖKARIKSEL BANU. 2017. "The Body Politics of Trump's 'Muslim Ban.'"Journal of Middle EastWomen's Studies13 (3): 469.
22. Executive Order 13769:Protecting the Nation from Foreign Terrorist Entry into the United States. Vol. 82, No. 20. Presidential Documents. Federal Register. February 1, 2017.
23. "Timeline of the Muslim Ban." ACLU Washington. American Civil Liberties Union of Washington and the ACLU of Washington Foundation.
24. Executive Order 13769:Protecting the Nation from Foreign Terrorist Entry into the United States. Vol. 82, No. 20. Presidential Documents. Federal Register. February 1, 2017.
25. "Ibid."
26. "Ibid."
27. "The outcry over trump's refugee ban: [letter]." New York Times, Jan 30, 2017.
28. Walsh, Declan, "Many in the Muslim World See a Provocation: Islam itself as a Problem: [News Analysis],"New York Times,Jan 28, 2017
29. "Foreign Wars and Terrorism: [Editorial; Series]."New York Times,Sep 22, 2016.
30. Lyons-Padilla,S., & Gelfand, M. J. "A muslim ban is unscientific"[op-ed].New York Times, Feb 19, 2017.
31. GÖKARIKSEL BANU. "The Body Politics of Trump's 'Muslim Ban.'"Journal of Middle EastWomen'sStudies13 (3): 469.
32. Young, J. G. (2017). Making America 1920 again? Nativism and US immigration, past and present.Journal on Migration and Human Security, (1), 217
33. Flores, D. Rene. 2017. "Do Anti-Immigrant Laws Shape Public Sentiment? A Study of Arizona's SB 1070 Using Twitter Data?" American Journal of Sociologyvolume 123 Number 2. 335.
34. Santa Ana, Otto. "Empirical analysis of anti-immigrant metaphor in political discourse." University of Pennsylvania Working Papers in Linguistics Article 19 Volume 4. January 1, 1997.323.
35. Rennix, Brianna & Robinson, Nathan. "Crammed into cells and forced to drink from the toilet –this is how the US treats migrants." The Guardian. July 3, 2019

# Structural Characterization of 2D Layered Complex Hetero-Ion Systems

Ryan Mbagna-Nanko

# Ryan Mbagna-Nanko

**Ryan Mbagna-Nanko is a senior majoring in mechanical engineering with a minor in entrepreneurship, planning to graduate in December 2021. Ryan is part of the 29th Cohort of the Meyerhoff Scholars program and an LSAMP affiliate. During his undergraduate career Ryan conducted research at Pennsylvania State University, Northwestern University, the Applied Physics Laboratory at Johns Hopkins University, and FORD. He is grateful to have had support from his peers and mentorship from committed faculty.**

**Moving forward, Ryan aims to earn graduate degree in mechanical engineering with interests ranging from nanotechnology to mechatronics. He will continue to groom himself as an engineer through productive technical and community enrichment experiences. However, serving communities of under-represented minorities in higher education will continue to be his driving factor.**

“I have long been drawn to the excitement in Engineering. That combined with my curiosity in nanotechnology led to the path of Materials Sciences. When I first begun this research experience, I had limited knowledge and struggled to fully grasp the scope and application of Nanotechnology as a whole. Whether it be big or small, my drive to actively promote a safe future in our health and living conditions, lead me to being active in research. During the application process, there were several Research Experience for Undergrads (REU)programs that best fit my interest in robotics engineering / software engineering, however, I took the chance to pursue Northwestern University’s International Institute of Nanotechnology –Soft Hybrid Nanotechnology Experimental Resource (IIN/SHyNE). The hands-on approach and extensive study on my project planted a seed of interest in engineering nanoscale smart-materials and devices. I had a wonderful time and greatly appreciated the collaborative and interdisciplinary experience. It is even more rewarding to greatly contribute to the scientific community and to have a meaningful impact on the infrastructure of computing semiconductors for more capable smart devices.”

**-Ryan Mbanga-Nanko**

**Image 6.**
Fragments of bulk single crystals of metal mechanically exfoliated and graphically represented.

## Abstract

In this paper, we investigate the coexistence of ferroelectricity (FE) and ferromagnetism (FM) in complex hetero-ion-based lamellar materials at the 2-Dimmensional limit. This combination of properties may provide limitless opportunities for applications in spintronics, ferroelectric photovoltaics, and nonvolatile magnetic memory, all of which offer opportunities to advance computing. By mechanically exfoliating bulk single crystals of metal chalcophosphate sample including, CuInP2S6, CuCrP2Se6, and CuCrP2S6, a top-down approach is used to obtain flakes that are as thin as possible. Atomic Force Microscopy (AFM) was used to measure the thickness of each flake and Raman Spectroscopy to correlate the spectrographic signature to other optical images. Furthermore, studies on heterostructures formed from stacking different monolayers of material in order to study the coupling between different layers are also considered. I have successfully measured a range of flake thickness that correlates to a trend in the intensity of the Raman spectra in three members of the metal chalcophosphate family, CuInP2S6, CuCrP2Se6, and CuCrP2S6. A monolayer of metal chalcophosphate family materials can be further studied to probe for the existence of subnanometer ferroelectric, ferromagnetic, or magnetoelectric multiferroic responses from each respective material systems. This research can be used to formulate a device that can take advantage of its magnetoelectric coupling in terms of reading and writing data.



*Keywords: ferroelectricity, ferromagnetism, atomic force microscopy (AFM), heterostructures, & magnetelectric coupling.*

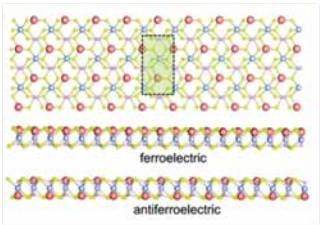
# Introduction

Since the emergence of smart electronics, there has been a growing trend in the miniaturization of their internal components to realize more portable and advanced systems. This trend is in part made possible by transitioning from 3-dimensional (3D) materials to 2-dimensional (2D) objects. However, scaling 3D materials down to the 2D limit, results in dangling bonds and quantum tunneling; breaking the quantum barrier such that the 3D material's properties differ from those of the 2D material [1]. A recent study on 2D materials demonstrated that multiferroic properties allow materials to retain their 3D properties at the 2D level. Multiferroic materials represent a rare class of materials that possess at least two of the following properties: ferroelasticity (spontaneous strain), ferroelectricity (spontaneous electric polarization with applied external electric field), ferromagnetism (magnetization due to parallel magnetic alignment of neighboring atoms), and ferrotoroidicity (presence of an ordered arrangement of magnetic vortices). Any combination of ferro- properties allows the material a duality of abilities, increasing the versatility of single flake. Such versatility is traditionally accomplished by coupling multiple materials, which risks incompatibility breakdown between the materials. In this paper, we investigate the coexistence of ferroelectricity (FE) and ferromagnetism (FM), known as magnetoelectric multiferroicity. This particular combination may provide limitless opportunities for applications in spintronics, ferroelectric photovoltaics, and nonvolatile magnetic memory, all of which offer opportunities to advance computing [4][2].

# Background

Graphene has been at the forefront of 2D material research; its extremely high carrier mobility, mechanical strength, and accessibility make graphene a versatile material. Though graphene possesses many admirable properties, it is also limited in its ability to control energy flow . Ferroelectric materials are commonly used in semiconductors or insulators because they have band gaps. This property allows the material to act as a switch such that energy flow can be controlled. Pristine graphene is not a semiconductor therefore does not possess a band gap. Studies have been conducted in which graphene is coupled with a foreign material such as perovskite oxide in order to create a bandgap and thus, elicit a ferroelectric response. However, integration of conventional perovskite oxide ferroelectrics and 2D materials results in compatibility disconnect that include electrochemical reactions, surface reconstructions, and formation of vacancy centers; all of which result in hindrance of the spontaneous polarization, which is the defining characteristic of a ferroelectric material. Therefore, these coupled materials are not useful in computing [3].

Members of the chalcosphosphate family of metals have been shown to possess both ferroelectric (FE) and ferromagnetic (FM) properties; as well as, graphene's ease of production and usability [5]. For a material to exhibit a ferroelectric response it must be in an ordered state such that the structure forms an electric dipole that can spontaneously flip when under an externally applied electric field. Magnetization is enabled by ordered magnetic moments due to electrons spinning around the atom, which creates a current with a magnetic field generated by Chromium (Cr3+) or Indium (In3+) ion. This compatible relation at the monolayer between the electric polarization and magnetization can enable the magnetoelectric coupling since magnetization direction is reversed by an external field [2].



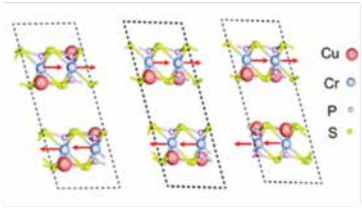




**Figure 1a.** Optimized structures Top (up) and side (down) views of the CuCrP2S6 monolayers in ferroelectric and antiferroelectric phases.

**Figure 1b.** Intralayer-antiferroelectric (left), ferroelectric (middle) and interlayer-antiferroelectric (right) bulks. Red arrows represent the direction of spin [2].

Temperature is decisive for the stability of FE and FM phases in 2D materials. In contrast to graphene, all members of the metal chalcosphosphate family have a band gap and retain dynamic electric and magnetic features on the same molecular plane at room temperature. CuCrP2Se6, CuCrP2S6, CuInP2S6 are members of the metal chalcophosphate family; these van der Waal layered materials have been shown to possess a ferroelectric and ferromagnetic character in the bulk [2][3][5]. In all three material systems, the ferroelectric response is due to a second order Jahn-Teller distortion of the Cu 1+ site that moves the Cu ion away from the midplane of the monolayer, breaking inversion symmetry in the crystal structure. A large energy barrier assures that the FE phase is stable for a long period of time, preventing any spontaneous change in polarization at room temperature [4]. This project aims to identify whether a multiferroic response is maintained at the 2D limit in metal chalcosphosphate family materials. This would open up doors of possibilities for more capable small scaled electronics including storage devices, such as flash drives and hard drives.

# Approach

In order to obtain a monolayer flake, we mechanically exfoliated synthesized samples of the metal chalcophosphate family, including CuCrP2Se6, CuCrP2S6, and CuInP2S6. Our preparation resulted in dense areas of flakes on the Silicon Oxide (SiO2) substrate, which assures ranges of thickness within the same surface region.

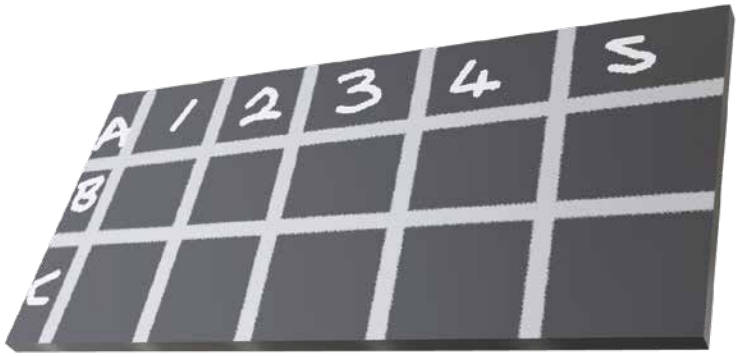



**Figure 2.** Sample Prep, cleaned SiO2 Substrate is obtained and inscribed with grids. The substrate is initially gray and debris-free.

Atomic Force Microscopy (AFM) and Raman spectroscopy were used to study the structure of CuCrP2Se6, CuCrP2S6, andCuInP2S6. I correlate the observed emerging properties with the structure of such materials by confirming monolayer flakes for investigation at the atomic level. AFM was used to measure the thickness of each sample, and Raman Spectrometer was used to confirm the flake's presence as determined by its unique spectrographic signature. The goal is to attain a monolayer flake for each metal sample which could then be further characterized to indicate whether a ferroelectric character is maintained down to the 2D limit.

# Sample preparation

## Substrate

In this experiment, the substrate served as a surface on which the exfoliated flakes were scanned. To make the optimal surface, the substrate was cleared of debris that could interfere with measuring the flakes thickness. The use of a grid as a reference system of the substrate is important to easily pinpoint flakes by decreasing scanning size to specified regions. In addition, the grid assures consistency and repeatability when studying the same sample flake under different lenses.

Substrates of an area of two square centimeters were prepared from a single side polished silicon oxide wafer. A diamond scribe was used to cut out the

aforementioned substrates. Next, a grid pattern with rows labeled A-D and columns labeled 1-4 were inscribed on the substrates. The substrates were cleaned with solvents in the following order: Deionized (DI) water, Isopropanol, Acetone, Isopropanol. All substrates are stored in an ethanol filled vial and sonicated for five minutes. Lastly, the ethanol was air dried off the substrate pieces which were then placed in an air plasma cleaner to further clean the surface and to enhance adhesion between the substrate and the exfoliated flakes.

## Crystal growth and exfoliation

Bulk crystals were synthesized by chemical vapor transport (CVT). Precursor powders of each were combined in stoichiometric ratios (e.g. 10 % Cu, 10%In, 20%P, and 60%S) with a total mass of 3.0 grams (**Figure 3a**). The powder was enclosed in a vacuum sealed quartz glass tube and placed into a furnace with multiple heating zones—a hot zone kept at 650 degrees Celsius and a cold zone kept at 200 degrees Celsius. The end of the silica tube with the powder was placed into the hot zone while a part of the tube was placed into the cold zone. Due to the temperature gradient vapors of the precursors will precipitate and grow as crystals in the cold zone. The bulk crystals were annealed for two weeks to ensure well-ordered single crystals.

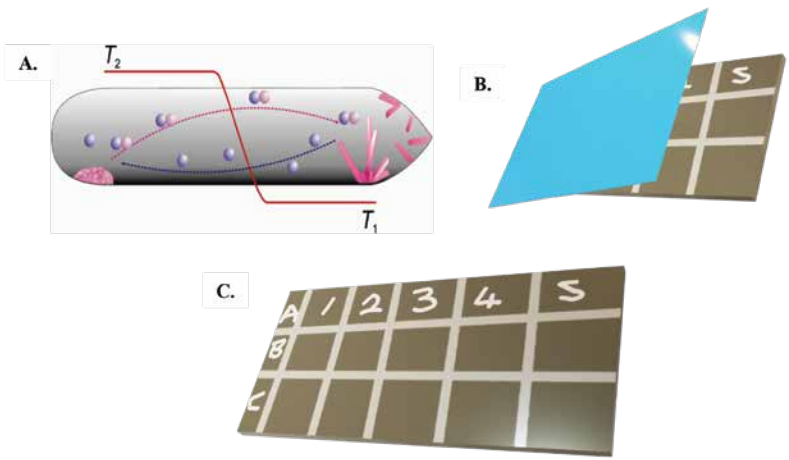



**Figure 3a.** Crystal samples are synthesized by chemical vapor transport (CVT) and are annealed for a two weeks period. T1=200 C, T2=650 C.
**Figure 3b.** Over a span of three tapes, a crystal sample is exfoliated onto the substrate.
**Figure 3c.** A substrate with exfoliated crystal is obtained.Once completely exfoliated, the substrate adopts a uniform yellow tint.

Next, the bulk crystal was crushed into smaller pieces. Using the SPV 224PR-M polyvinyl tape a small piece of the crystal was exfoliated to the point that the tape is densely packed with thin flakes, another piece of tape was placed perpendicularly to the first tape surface for further exfoliation (**Figure 3b**). Taking this tape and further exfoliating three times more layers are exfoliated, and the dense clusters of thin flakes were laid on the SiO2 substrate for analysis (**Figure 3c**).

### Optical Microscope, Identify general regions with thin flakes

An optical microscope is used to identify and capture regions on the substrate with flakes, which are used as a reference while conducting measurements with AFM or Raman spectroscopy (**Figure 4**). Larger and thicker flakes or the grid lines themselves can be used as reference points for the thin flakes of interest, assuring repeatability when studying the same flake on other instruments. The advantage of using an optical microscope is that flakes are imaged with varying colors that correspond to their respective thickness, which makes them easier to classify.

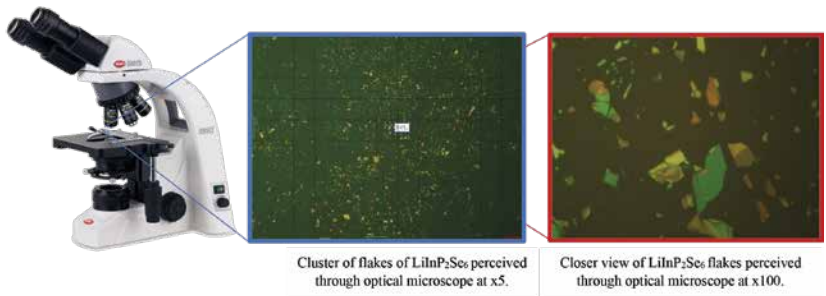



**Figure 4.** Primarily used to identify and capture regions on the substrate with flakes. Varying lenses magnitude increases insight of distinct characteristics.

## Using Atomic Force Microscopy (AFM)

The AFM is used to measure the thickness of flakes. This instrument uses a cantilever with a very fine probe tip that scans the surface of the substrate at a sub nanometer resolution (**Figure 5**). An accurate topographical representation and measurement of the thickness of a material can be obtained by varying scanning parameters including scanning size, scan angle, and scanning rate. In this project, the scanning parameters were: a maximum of 10by10 micrometer and minimum of 1by1 micrometer of scanning size (Less than 100 nanometer will result in the cantilever needle to be broken), scan angle of 90 degrees, and scanning rate of 4Hz. Gwyddion is a

companion software used to analyze the thickness data. Flake thickness is measured relative to the substrate, which assures a consistent reading across all crystal samples.

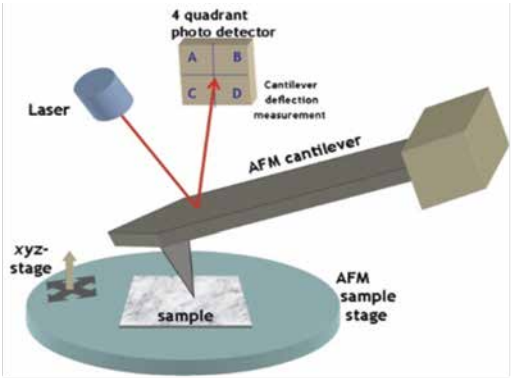



**Figure 5.** Representation of AFM; Primarily used to measure the thickness of flakes, by scanning the surface at a pixel by pixel resolution. (1)

## Using Raman spectrometer

Raman spectroscopy is used to determine each samples' unique Raman signature and to correlate the shifts and change of each respective Raman spectra as a function of thickness (**Figure 6**). These shifts manifest as Raman shifts of the spectra's peaks as a function of thickness as well as the relative intensity of each peak. Overall, it gives us a deeper insight of its structural and molecular makeup of the sample relative to its thickness.

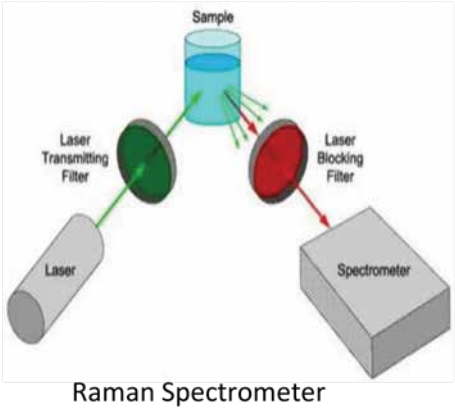



**Figure 6.** The Raman spectra reflects the intensity of the flake based on its molecular structure and chemical makeup. (2)

# Results

## LiInP2Se6 (LIPSe)

As a first attempt, the measurement was conducted on LiInP2Se6 crystal, which has a similar geometry as the primary sample and served as a comparable control for the rest of the experiment. The exfoliated flakes that have been analyzed were relatively thick and are not a monolayer. However, it was a good exercise to link observations made from the microscope to quantitative measurements of the flake thickness. As seen in **Figures 7a** and **7b**, the perceived LiInP2Se6 flake had four distinguishable regions with different thicknesses. Knowing that the variance in color from the optical microscope corresponds to variance in the flake's thickness, further investigation shows that the light green layer to be ~110nm, dark green is ~140nm, orange is 160nm, and the yellow region is ~190nm despite the roughness of the flake surface (**Figure 7c**). The Raman Spectrometer confirmed trends in peaks within Raman shift (cm-1) of 100 to 300 with respect to their thickness. As seen in **Figure 7d**, the peaks of the 190nm layer is more intense and defined whereas the 160nm and the 140nm layers show weaker peaks.

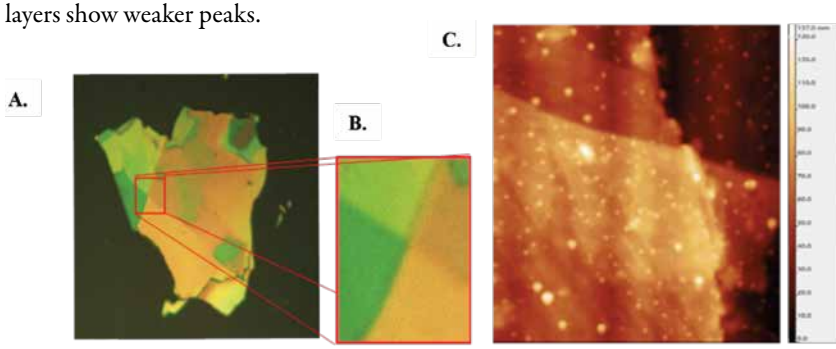



**Figure 7a.** a flake of LiInP2Se6 perceived through optical microscope at x100.
**Figure 7b.** a closer look at the crossed pattern of four colors variation.
**Figure 7c**. The same flake of LiInP2Se6 perceived through the AFM, focused at the crossed pattern of the four distinguishable layers. ZSensor [m] 256 x207px 4.7 x 3.8um

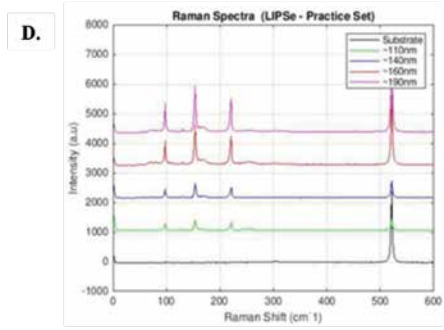



**Figure 7d.** The spectrometer shows variation in peak relative to the thickness.

## CuInP2S6 (CIPS)

CIPS is a layered thiophosphate compound, which is stable and relatively inert due to the lack of dangling bonds. CIPS is known for exhibiting well-defined long-range order. However, their small intrinsic polarization tends to lean in towards antiferroelectric phase. CIPS exhibits large dielectric tunability which hints at ferroelectric properties in the nanoscale limit [3].

Regions of interest were identified in which flakes were clustered. The height measurement was taken relative to the substrate, which is labeled as "0 nm thickness". As seen in **Figure 8b**, AFM scans of the flakes show that regions of different colors correspond to different thickness: dark green ~15nm, light green ~35nm; yellow, ~70nm; orange, 110 nm, purple, ~130 nm. This is correlated with Raman spectra taken at each respective flake, which provides information about the sample's molecular structure and chemical composition by the interaction with the laser in the Raman spectrometer. The Raman signal intensity of the thinner flakes shows a clear reduction in height as the flakes get thinner and thinner. The thicker flake of 130nm has the highest intensity corresponds to its chemical composition and molecular structure, which validates that the thicker flakes have larger lateral dimension compared to the 15nm flake.

After observing the correlation between the flakes' color and the thickness is consistent throughout the substrate, we shifted to finding sub 10nm flakes. At 550x550 nm the AFM scan shows measured flakes ranging from 7-12 nm (**Figure 8d**). On the other hand, confirming their respective Raman spectra signature is inconclusive as the laser in the Raman system has a minimum spatial resolution of 1um in diameter while the thinner flakes on the order of < 5nm are typically smaller than that.

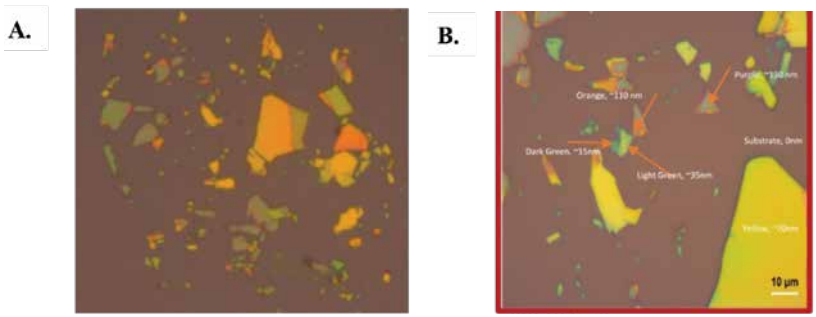



**Figure 8a**. CuInP2S6 flakes perceived through optical microscope at x5.
**Figure 8b**. CuInP2S6 perceived through optical microscope at x100. Shows correlation between coloration and flake thickness

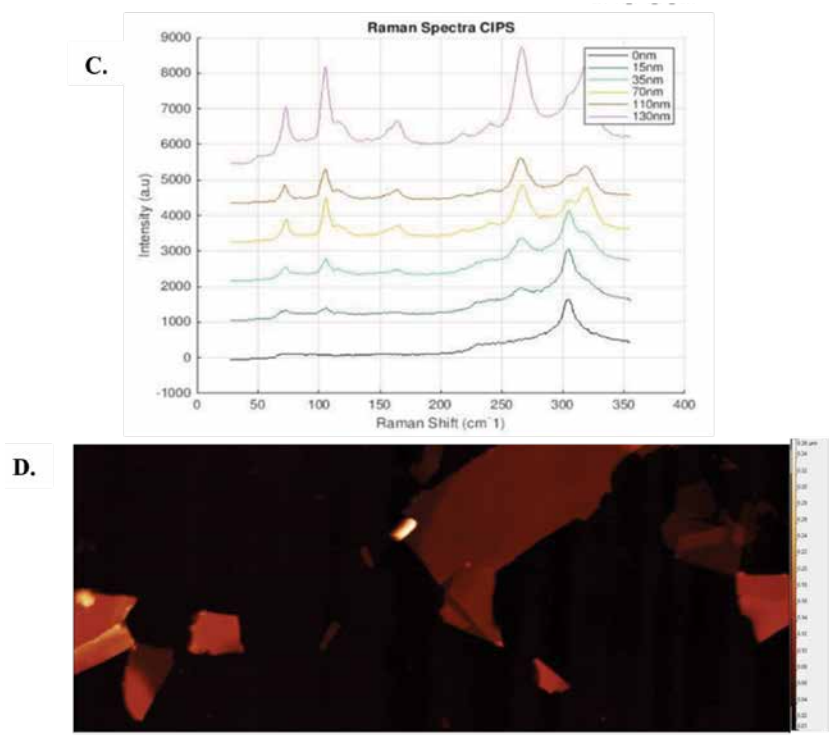


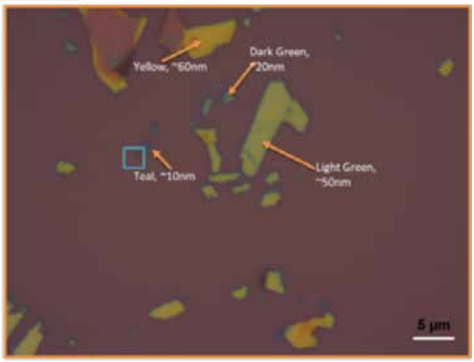

**Figure 8c.** Raman data of CuInP2S6. Shows correlation between flake thickness and peak intensity
**Figure 8d.** The same flake of CuInP2S6 perceived through the AFM, focused around the "beak" shaped flake. Zsensor [m] 512x206px 30.0x12.1um

## CuCrP2S6 (CCrPS)

Similar to CIPS, CuCrP2S6 (CCrPS) possesses out-of-plane electric polarization which can be realized at room temperature and is sustainable for a long period of time. Meanwhile, the spin-orbital coupling enables the magnetoelectric coupling effect which adds to CCrPS electronic compatibility [1][2].

Once exfoliated, the observed coloration in relation to the flake thickness proved to be comparable to that of the CIPS sample. As thinner flakes correspond to a range of colors spanning teal/blue to green, the focus of this material system was narrowed primarily to the colors: teal/blue, 10nm, dark green, 20nm, light green, 50nm and yellow, 60nm (Figure 9a). Qualitative Raman measurements show a downward trend in the intensity of the Raman peaks between 100300 cm-1.

A.

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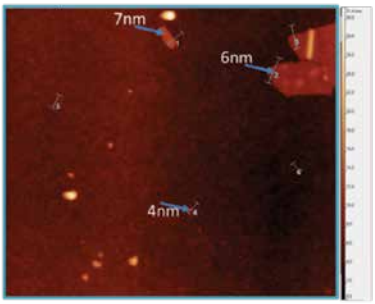


C.

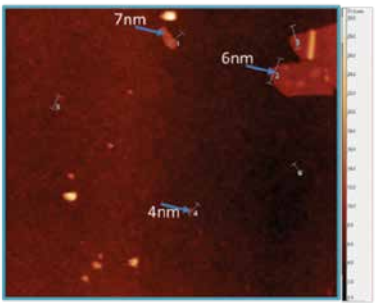


**Figure 9a.** Cluster CuCrP2S6 flakes perceived through optical microscope at x100.
**Figure 9b**. Sub 10nm flakes perceived through AFM of smaller scan size. ZSensor [m] 512x474px 2.68x2.48um.
**Figure 9c**. Range of CuCrP2S6 flakes thickness sorted by their corresponding signature.

This is due to the smaller interaction volume of the thinner flakes relative to the larger flakes which in turn leads to narrower peaks in thicker flakes and broader peaks in thinner flakes. The Raman spectra shows a drastic change between the flake thickness of 10nm to 60nm in the growth of a secondary peak at the Raman shift of 260 cm-1, which draws a parallel with the CIPS Raman plot. The cause of the secondary peak is not known; however, it one possible explanation is the gradual change in thickness now knowing it is not unique to CIPS.

A 3x3um AFM scan shows flakes with thicknesses ranging from 4-7 nm (**Figure 9b**). Confirming their respective Raman spectra signature was successful to an extent. The expectation is to see a signature that is close to the substrate's signature, but still shows occurrence of peaks in the Raman shift of 70 to 100 cm-1. This was confirmed by the spectra signature of the 7nm flake; it is still inconclusive given that it cannot be proven to be a signal directly from the 7nm or a weaker response from a nearby flake (**Figure 9c**).

## CuCrP2Se6 (CCrPSe)

As an experimental sample, CCrPSe is a transitional metal phosphorus chalcogenide that possesses both FE and FM orders. Although, antiferroelectricity (AFE) is more energetically favorable, CCrPSe has a large transitory energy barrier (100meV) towards the FE phase which prevents any spontaneous phase change. In addition, magnetism originates from Cr, which is principally at the FM phase and more stable than AFM (Antiferromagnetic). Its physical property makes CCrPSe suitable for 2D ferroelectric nanoscale switch and memory applications [4].

Once exfoliated, the observed coloration in relation to the flake thickness proved to be consistent with flakes of other samples. Using AFM, the flakes were measured as teal/blue, ~10nm; dark green, ~20nm, light green ~30nm, yellow, ~50nm (**Figure 10a**). Qualitative Raman measurements show a downward trend in the intensity of Raman peaks between 100-300 cm-1. This is due to the smaller interaction volume of the thinner flakes relative to the larger flakes, which in turn leads to narrower peaks in thinner flakes and broader peaks in thinner flakes.

Focusing on sub 10nm flakes, the imaging analysis software, Gwyddion, was used to find thinner flakes ranging from 3–7 nm within the same region of interest (**Figure 10b**).

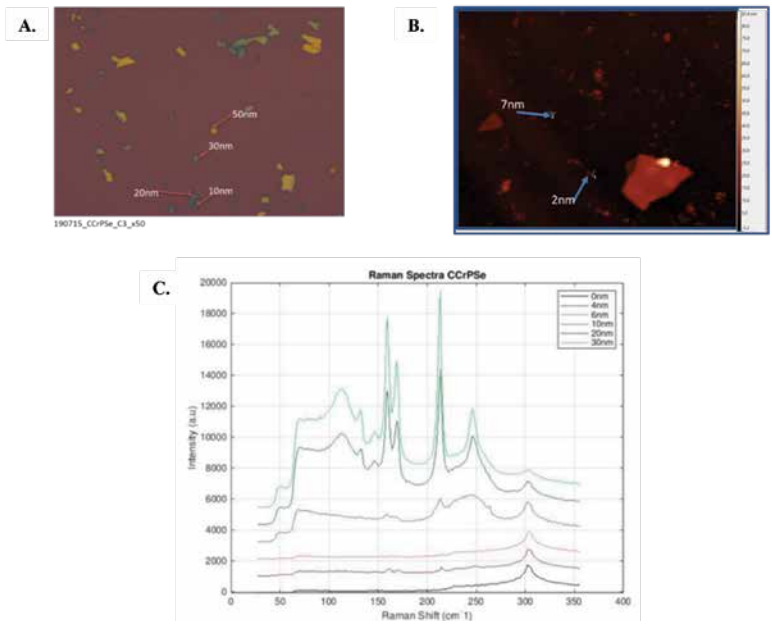


**Figure 10a.** Cluster CuCrP2Se6 flakes perceived through optical microscope at x100.
**Figure 10b.** Sub 10nm flakes perceived through AFM of smaller scan size. Cropped from original ZSensor [m] 512x297px 30.0x17.4um down to 6.24 x 4.48um.
**Figure 10c.** Range of CuCrP2Se6 flakes thickness sorted by their corresponding signature.

# Discussion

This study was successful in consistently quantifying the range in flake thickness. In addition, the preparation and exfoliation methodology used significantly improved the likelihood a near monolayer flake to be realized. However, further steps could be taken to improve the time span and accuracy of the recorded flake, such that we can also distinguish them from local residue. Due to working at a low scale, there is always a concern of interference such that thin flakes easily blend in with the roughness of the substrate when scanned on the AFM. Another possible approach to alleviate this issue is to use computer aided software to take advantage of the pixel by pixel data set from the AFM to locate thin flakes which would use pixel intensity in correlation to flake thickness as a set threshold in order to deconvolute the thickness due to the flake and the roughness of the substrate. In addition, interference may be present such that measurements with the Raman spectrometer can easily be influenced by noise from the surrounding environment. The spatial resolution of the laser probe in the Raman spectrometer is limited to an ~1um circular spot, and thus any outside vibration could hinder a single flake with a lateral size on the order of 10nm to be localized. As a result, signals from the surrounding flakes of unknown thicknesses interfere with signals to some of the Raman measurements. Another possible approach to alleviate this issue is to operate in a remote environment, such that the Raman Spectrometer is not prone to outside interference.

# Conclusions

The future for 2D multiferroic materials is tangible and could contribute to the advancement of computing systems. The project was successful in obtaining sub 10 nanometer flakes and setting the groundwork for future characterization and microscopy. The combination of using the Atomic Force Microscope and the Raman Spectrometer proved to be consistent in correlating the color variation of the experimental flakes to ranges in thickness. Although the process is limited to distinguishing flakes from residue/substrate topological variations when focusing on sub 10nm flakes, it is equally rewarding to know that sub 10 nanometer flakes were successfully achieved. In the future, the combination of Transmission Electron Microscopy (TEM) and Piezo Force Microscope (PFM) will be used to confirm the break in symmetry and electric signals, which corresponds to FE properties. Further characterization and microscopy of the experimental samples, CuInP2S6, CuCrP2Se6, and CuCrP2S6 will effectively steer the investigation of the magnetoelectric coupling of 2D multiferroic (ferroelectric and ferromagnetic) layers and ultimately contribute to the advancement of computing. The applications for this research range from amplifying the human to machine interface in platforms such as virtual reality to strengthening nano and outer space exploration. Overall, this technology will improve computing efficiency, benefiting engineers and researchers as well as the general public.

# Acknowledgments


## For International Institute for Nanotechnology REUs

This research was supported primarily by the International Institute for Nanotechnology's Research Experience for Undergraduates Program under the National Science Foundation award numbers EEC- 1757618. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect those of the NSF.

## For Shyne REUs

This research was supported primarily by the National Nanotechnology Coordinated Infrastructure REU Program at Northwestern University, under the National Science Foundation award number ECCS-1542205. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect those of the NSF.

# References

[1] Lai, Youfang; Song, Z; Wan, Yi; Xue, Mingzhu; Ye, Yu; Dai, Lun; Yang, Wenyun; Du, Honglin; Yang, Jinbo. Discovery of Two-Dimensional Multiferroicity in van der Waals CuCrP2S6 Layers. arXiv e-prints 2018

[2] Lai, Youfang; Song, Zhigang; Wan, Yi; Xue, Mingzhu; Wang, Changsheng; Ye, Yu; Dai, Lun; Zhang, Zhidong; Yang, Wenyun; Dua, Honglin and Yang, Jinbo. Two-dimensional ferromagnetism and driven ferroelectricity in van der Waals CuCrP2S6. Nanoscale 2019 Vol: 11, 5163-5170

[3] Neumayer, Sabine M; Eliseev, Eugene A; Susner, Michael A; Tselev, Alexander, Rodriguez, Brian J; Brehm, John A; Pantelides, Sokrates T; Panchapakesan, Ganesh, Jesse, Stephen, Kalinin, Sergei V; McGuire, Michael A; Morozovska, Anna N; Maksymovych, Petro, and Balke, Nina. Giant negative electrostriction and dielectric tunability in a van der Waals layered ferroelectric. Physical. Review, Materials. 2019 Vol: 3, 024401

[4]Qi, Jingshan; Wang, Hua; Chen, Xiaofang; Qian, Xiaofeng. Two-dimensional multiferroic semiconductors with coexisting ferroelectricity and ferromagnetism. Applied Physics Letters 2018 Vol:113 iss:4 pg: 043102

[5] Wang, Fengmei; Shifa, Tofik A ; Yu, Peng; He, Peng; Liu, Yang; Wang, Feng; Wang, Zhenxing; Zhan, Xueying; Lou, Xiaoding ; Xi, Fan; He, Fan. New Frontiers on van der Waals Layered Metal Phosphorous Trichalcogenides. Advanced Functional Materials 2018 Vol: 28, 1802151

# Additional Sources

[6] Tawfik, Sherif Abdulkader; Reimers, Jeffrey R; Stampfl, Catherine; Ford, Michael J. Van der Waals Forces Control the Internal Chemical Structure of Monolayers within the Lamellar Materials CuInP2S6 and CuBiP2Se6. The Journal of Physical Chemistry 2018 122 (39), 22675-22687

[7] L. You, Y. Zhang, S. Zhou, A. Chaturvedi, S. A. Morris, F. Liu, L. Chang, D. Ichinose, H. Funakubo, W. Hu, T. Wu, Z. Liu, S. Dong, J. Wang, Origin of giant negative piezoelectricity in a layered van der Waals ferroelectric. Sci. Adv. 2019 Vol 5, 3780.

[8] Fengmei Wang, Tofik A. Shifa, Peng Yu, Peng He, Yang Liu, Feng Wang, Zhenxing Wang, Xueying Zhan, Xiaoding Lou,* Fan Xia,* and Jun He*. New Frontiers on van der Waals Layered Metal Phosphorous Trichalcogenides. Adv. Funct. Mater 2018 Vol 28, 1802151

[9] Bruker Nano Surfaces, Fundamentals of Contact Mode and TappingMode Atomic Force Microscopy. Nanotechnology | Applications | Nanotechnology Companies (azonano.com) 2012

# Contributions of Parental Control and Self-Regulation Skills to Korean American Children's Behavioral Outcomes.

Hye Jin Park

# Hye Jin Park

**Hye Jin Park graduated from UMBC in May of 2020 with a major in Psychology, with a concentration in Developmental Psychology. While at UMBC, she was a member of Psi Chi for Psychology and a Writing Fellow for the Psychology Department. She is currently pursuing a Ph.D. in Human Development and Family Studies at Michigan State University to continue her work with the Asian immigrant community and conduct culturally sensitive research. After completing her studies, she plans to continue to conduct research with the Asian immigrant communities and educate others through her research.**

**Hye Jin thanks her mentor, Dr. Charissa Cheah and graduate student co-mentor, Hyun Su Cho, for their continued guidance and mentorship throughout the research process. She also thanks all the graduate and undergraduate students in the Culture, Child, and Adolescent Lab at UMBC for their continued support and assistance with the collection of the data. Finally, she thanks her family and friends for always being her motivation and support system. Hye Jin's research was funded by the Undergraduate Research Award.**

“In an effort to learn more about my cultural roots and expand my Korean language skills, I joined the Culture, Child, and Adolescent lab in January 2017. However, being a research assistant throughout my undergraduate years, visiting multiple Korean immigrant families' homes, and observing family dynamics, I became interested in the research process beyond data collection. I discussed my interests in research with my mentor, Dr. Charissa Cheah, and a graduate student in the lab, Hyun SuCho, who both helped me design and conduct my research projects, and received the Undergraduate Research Awards in last and current academic years. In the current project, we explored the association between Korean-American mothers' use of parental control and their preschool-aged children's aggressive behaviors and the mediating role of children's self-regulation. This project gave me the opportunity to experience the research process, from data collection to data analysis and manuscript writing, and better understand an understudied population. I will continue to conduct research on Asian immigrant families as I pursue a Ph.D. in Human Development and Family Studies at Michigan State University and would like to educate people on how to address the unique challenges of Korean-American families through my work.”

**-Hye Jin Park**

**Image 7.**
Puzzle pieces used in the study of American-Korean children and their behavior.

## Abstract

Mothers' use of structured and reason-based control strategies has been found to be associated with their children's better self-regulation, thereby leading to better behavioral outcomes, suggesting mothers' positive control can promote children's autonomy by granting opportunities to make decisions within the appropriate structure. Although perceived as members of a model minority, Korean-American children can be at risk for experiencing social maladjustment and externalizing behavioral problems. Thus, we examined: (1) the association between Korean-American mothers' use of parental control and their preschool-aged children's overall aggressive behaviors, and (2) the mediating role of their children's self-regulation in the association between parental control and children's aggressive behaviors. Korean-American mothers with preschool-aged children (N=38) reported their use of parental control in a semi-structured open-ended interview. Children were given the task of completing a puzzle in a box, and their self-regulative behaviors were recorded and coded. Children's aggressive behaviors were reported by their teachers. Results revealed that children's lack of self-regulation fully mediated the effects of parental control on children's aggressive behaviors. Specifically, higher levels of parental reasoning and negotiation were associated with better self-regulation skills, which in turn were associated with children's lower aggressive behaviors. The significance and implications of these findings for Korean-American children's behavioral outcomes are discussed.



*Keywords: Korean-American, model minority, behavioral adjustment, self-regulation, & cultural values.*

# Introduction

The Asian American population is projected to be the largest and the fastest-growing ethnic minority group in the United States in the next several decades (López et al., 2017). As the fifth-largest group among the Asian population (López et al., 2017), Korean Americans are often perceived as a 'model minority' who are intelligent, capable, hard-working, patient, and self-disciplined (Park, 2011). However, multiple studies found that Asian American children and youths suffer from social stress, low self-esteem, and externalizing problems (Fradkin et al., 2014; Rhee et al., 2003; Zhou et al., 2003), and report a high prevalence of fighting and suicidal ideation (e.g., Grunbaum et al., 2000). Furthermore, Asian American youth, specifically Korean American youth, with lower emotional control (i.e., anger suppression) were found to greater externalizing problems (Park et al., 2010). These negative adjustment outcomes may be reflective of their acculturative challenges, including the need to balance the two different cultures of home and school (Yeh, 2003). However, the potential factors that can influence Korean American children's social and behavioral adjustment, particularly during early childhood when intervention can have a significant impact, have not been systematically examined.

In general, parents are the primary socialization agents who structure and regulate children's behaviors and teach specific beliefs and values during early childhood (Maccoby, 1984). Thus, parenting strategies, specifically parental control, can influence young children's behavioral adjustment. Although Korean mothers with more traditional heritage cultural values are less likely to encourage their children's autonomy and rather control their children due to the Confucian cultural emphasis on interdependence and obedience (Chiu, 1987; Lee et al., 2016; Vinden, 2001), less is known about the systematic relation between Korean American mothers' specific control practices and their children's behavioral outcomes.

The present study focused on children's self-regulation skills, which is defined as their ability to regulate and moderate behavioral and physiological reactivity to environmental stimuli (Baumeister & Vohs, 2013; Rothbart & Bates, 2006). Previous studies have suggested that parental control can shape children's self-regulation skills, which in turn can lead to children's behavioral outcomes (e.g., Pérez & Cumsille, 2012). By the age of two, children began to monitor, plan, and control their own behaviors without their caregivers' assistance (Grolnick & Farkas, 2002). Self-regulation skills are an important predictor of children's social competence, peer relationships, and popularity in school settings (Eisenberg et al., 1997; Grolnick & Farkas, 2002) and serve as a protective factor against externalizing problems, including aggressive behaviors (Kuczynski & Kochanska, 1995; Lee et al., 2012). Furthermore, the lack of self-regulation skills in early childhood can lead to long-term negative

consequences such as academic failure and social difficulties in school (McClelland et al., 2013). However, whether these associations might hold for Korean families in the United States, for whom the construct of control may hold different cultural meanings (e.g., Trommsdorff, 2012) remains unexplored. Therefore, the overall purpose of the current study was to examine the association between Korean American mothers' control strategies and their children's behavioral outcome, specifically their overall aggressive behaviors (e.g., teases other children, hit/kicks/pushes to get what they want), and the mediating role of children's self-regulation skills in this association.

## Parental Control

Parental control refers to parents' attempts to inhibit, regulate, and direct children's thoughts, feelings, and behaviors (Barber, 1996). Parental control can be expressed in several forms and differentially influence child outcomes. Parents may engage in coercive control by using physical punishment, verbal hostility, psychological control, domineering parental strategies (Barber, 1996), and/or use of structured and reason-based parental control strategies such as reasoning, negotiation, and modeling (Baumrind, 2012). Studies across different cultures have consistently found that children of parents who engage in structured and reason-based control strategies are more likely to be competent, well-adjusted, and academically successful (Barber & Xia, 2013; Steinberg, 1990). Mothers' use of parental control through reason-based guidance was predictive of their children having fewer externalizing behavioral problems, including aggression (Lee et al., 2018). On the other hand, harsh and coercive parenting practices (e.g., physical punishment) have been found to be associated with both internalizing and externalizing problems in children (Aunola et al., 2013; Barber, 1996; Baumrind et al., 2010; Lansford et al., 2012; Louie et al., 2013; Nelson et al., 2013). However, the effects of various controlling strategies on East Asian American children were found to be less negative (e.g., Fung & Lau, 2009; Chao & Tseng, 2002; Yu et al., 2018).

Traditionally, Korean parents often emphasize and enforce the importance of interpersonal relationships and respecting the authority of parents and elders, which stems from Confucian values of filial piety (Chao & Tseng, 2002). Reflecting these cultural values, Korean American parents often strictly control their children in order to emphasize the importance of maintaining social harmony and respecting others (Kim & Hong, 2007). Moreover, Asian Americans, including Korean American parents, perceive their role as a primary socialization agent and feel highly responsible for their children's development (Kim et al., 2012). Therefore, these parents may consider coercive control as an important training tool to guide and teach children boundaries and right from wrong (Fung, 1999; Kim & Hong, 2007; Wu et al. 2002).

Korean American parents residing and raising children in the United States have also been found to integrate American values of independence into their established heritage culture (Cheah et al., 2013; Seo et al., 2017). For example, past research found that Korean American mothers learn various non-coercive and structured control strategies (e.g., warning, correction, reasoning) from European American mothers or teachers and use them at home to regulate and control their children (Kim & Hong, 2007). Qualitative studies that have examined mothers' conceptualization of their own parenting practices have revealed culturally-emphasized parenting strategies among East Asian immigrant mothers (Kim & Hong, 2007). Thus, in the current study, Korean American mothers' specific parental control strategies derived using an emic perspective from semi-structured interviews as these strategies may reflect a unique integration of both their heritage and mainstream American cultural values.

## Children's Self-Regulation Skills

Young children with high self-regulation skills can inhibit undesired behaviors and/or promptly activate appropriate behaviors in various situations by regulating their physiological and behavioral reactivity (Baumeister & Vohs, 2013). For instance, when the temptation of instant gratification is present, children with high self-regulation skills can continue and persist to engage in goal-oriented behaviors (Heimpel et al., 2018). In most previous research, children's self-regulation skills were measured with self-, parent-, or teacher-report questionnaires (Hemipel et al., 2018; Ryan & Connell, 1989). However, parents and teachers may have biases when reporting on children's behaviors (Hemipel et al., 2018). In contrast, independent observations of children's actual behaviors that incorporate self-regulation skills can allow researchers to objectively assess various aspects of the skills, including attentional persistence, inhibitory control, and levels of impulsivity (Spinrad et al., 2007).

Although self-regulation is one of the important predictors of positive child outcomes (Eisenberg et al., 1997), the development of self-regulation may be culturally-variable (Trommsdorff, 2009). For instance, independence-oriented cultures (e.g., the United States) emphasize individuality, autonomy, and achievement-orientation, and thus self-regulation skills are valued as a means to appropriately express their unique self and achieve both autonomy and personal goals (Trommsdorff, 2012). In contrast, interdependent-oriented cultures (e.g., Korea), interdependence, social harmony, and filial piety are highlighted, so self-regulation skills are encouraged to maintain and promote social harmony (Trommsdorff, 2012). Therefore, Korean American children may be socialized to internalize these specific cultural values as they display self-regulated behaviors (Trommsdorff, 2009).

## Parental Control and Children's Self-Regulation Skills

Self-determination theory states that harsh and restrictive parental control interferes with children's fulfillment of their fundamental need for autonomy, which can undermine their ability to regulate their own behavior (Gurland & Grolnick, 2005; Ryan & Deci, 2000). When parents use controlling behaviors, they are dictating decisions for their children, restricting the children's opportunity to be autonomous (Deci & Ryan, 1985). When children are unable to obtain autonomy, they cannot regulate their own behavior as they rely on their parents' forceful and domineering instruction (Ryan & Deci, 2000). Past studies found that highly controlling parenting is more likely to lead to poorer self-regulation, whereas structuring and reason-based parental control strategies are associated with better self-regulatory behaviors (Baumrind, 2012). This association is observed in the Western cultures where the value of independence and autonomy is highlighted (Eisenberg et al., 2006). For example, parents' harsh and coercive control was associated with children's poorer self-regulation skills and externalizing problems in Western cultures (Kochanska et al., 2000; Mills & Rubin, 1998).

Furthermore, self-regulation may potentially act as a mediator in the association between parental control and children's behavioral outcomes (Eisenberg et al., 2006). Children who experienced greater non-coercive behavioral parental control were found to have better self-regulation skills, which in turn, was associated with better behavioral outcomes (e.g., self-reliance, work orientation) and school performance (Steinberg et al., 1989). On the other hand, adverse parenting behaviors, such as physical punishment and coercive control and poor development of children's self-regulation skills have been found to be related to aggressive behaviors towards peers (e.g., Olson et al., 2011). In particular, overuse of parental control, including domineering control may lead to greater dysregulation in children (Baker & Hoerger, 2012). As children are unable to regulate their emotions and behaviors due to the lower levels of self-regulation skills, they may display aggressive behaviors (Baker & Hoerger, 2012).

Past studies have found that Korean mothers' parental control may be associated with their children's self-regulation, which may relate to their behavioral adjustment (Lee et al., 2012). However, only a few studies have examined the relation between specific parental control practices and children's self-regulation and behavioral outcomes, and the findings were mixed even among those studies

(Hemipel et al., 2018), suggesting culturally varying meanings of parental control and differing emphasis on self-regulation (Marbell & Grolnick, 2012; Trommsdorff, 2009). Although parents' use of domineering control strategies (i.e., scolding, criticism) can be detrimental to their children's development of self-regulation skills and aggressive behaviors, Korean American mothers' strict control practices may have a less detrimental effect on their children's self-regulation and further adjustment outcomes due to Confucian values of filial piety and interdependence (Chao & Tseng, 2002). As children are socialized to obey their parents and internalize these cultural values, they may not perceive their parents' strict controlling behaviors to be intrusive and negative. Therefore, it is important to examine Korean American mothers' specific parental control practices that may reflect cultural values and its association with their children's self-regulation and behavioral adjustment.

## Present Study Aims and Hypotheses

The goals of the present study were to investigate: (1) the association between Korean American mothers' use of parental control and their preschool-aged children's behavioral outcomes; and (2) the mediating role of their children's self-regulation skills in the association between parental control and children's behavioral outcomes, specifically, their overall aggressive behaviors (see **Figure 1**).

For the first aim of this study, it was expected that more coercive and harsh parental control would be associated with more aggressive behaviors, whereas structured and reason-based parental control would be associated with fewer aggressive behaviors. Regarding the second aim of this study, the association between parental control and children's aggressive behaviors was expected to be mediated by children's self-regulation skills. Coercive and harsh parental control was expected to be positively associated with poorer self-regulation. In turn, poorer self-regulation skills were expected to be associated with higher levels of aggressive behaviors. Alternatively, structured and reason-based parental control was expected to be positively associated with better self-regulation, which in turn would be negatively associated with aggressive behaviors. Child age, gender, and maternal age were included as demographic control variables in this study, as these constructs have been found to be associated with children's behavioral outcomes, including aggressive behaviors, in previous research (e.g., Grusec, 1972; Park et al., 2010; Rubin et al., 2003) but were not of primary interest in this study.

# Methods

## Participants

The sample consisted of 38 first-generation Korean immigrant mothers (Mage = 35.69, SD = 3.20) of preschool-aged children (Mage = 4.43 years old, SD = 0.93; 52% girls) in Maryland, Washington D. C., and Virginia. Both the mothers and children were ethnically Korean. All the mothers had at least a high school education (100%) and the majority of these mothers had at least a standard college degree (52%). All of the mothers were married (100%).

## Procedures

Participants were recruited from local Korean churches, Korean preschools, Asian cultural festivals, and Asian grocery stores in the Washington D.C. Metropolitan area. At each recruiting site, an information session was conducted to provide prospective mothers with opportunities to ask questions, resolve concerns, and voluntarily sign up to participate in the study. Eligibility in participating in the study was determined by an evaluation of whether the mother was the primary caregiver of a healthy child between the ages of 3 and 6 years, and that both parents were ethnically Korean. Data collection was conducted during a home visit by a team of trained research assistants who were fluent in the mothers' and children's preferred language (i.e., Korean or English). Written consent was first obtained from the mothers, who completed the questionnaires in the written language of their preference. Research assistants conducted the interviews in mothers' preferred language. The interviews lasted approximately 30 minutes and were audio-recorded, transcribed, and coded. Children's teachers were asked to rate children's socioemotional and behavioral difficulties in the school about six months after the initial data collection.

## Measures

All the measures originally available in English were translated into Korean and back-translated into English by bilingual researchers (Peña, 2007). All discrepancies were resolved through discussions between two translators.

**Family demographic information.** The Family Description Measure (FDM; Bornstein, 1991) was used to obtain demographic information on maternal age, level of education, years of U.S. residency, and child's age and gender.

**Parental control.** A semi-structured open-ended interview (Interview on Parenting – Parent Report; Cheah et al., 2018) was conducted to obtain mothers' perceptions of maternal control, specifically, their control strategies. Mothers were asked, "What do you do when you are controlling, regulating, or being strict with your child?" Mothers were asked to provide specific examples of strategies and prompted

and probed "Could you describe how you are being strict?" during the interviews. The interview lasted 20 minutes on average.

**Coding of maternal control strategies**. Mothers' responses were coded using the Maternal Expressions of Strictness Coding Scheme (Cheah et al., 2015; Cheah et al., 2018; Li, 2002, 2003; Vu et al., 2018). To assess inter-rater agreement of the coding, the coding teams coded the same 20% of transcripts which was selected randomly (Shaver et al., 1987; Yamamoto & Li, 2012). Cohen's Kappa for maternal control strategies was .89. Among the specific strategy categories, the mothers' structured and reason-based control strategies included discussing reasons, giving oral instruction, negotiating, whereas coercive control strategies included using physical means (e.g., spanking), threatening, and scolding. The coded categories are presented in **Table 1** with examples of mother's responses for each code. As the number of responses varied among mothers due to the open-ended nature of the interview questions, proportion scores were calculated for each reason and strategy category. Proportion scores were created by dividing the total number of responses in each category by the total number of reasons or strategies across all categories.

**Children's dysregulation**. The Puzzle Box Persistence Task (Eisenberg et al., 2001) was used to assess children's dysregulation. Children were given the task of completing a shapes puzzle presented in a box with a curtain. Children were instructed not to look behind the curtain (cheat) while they were left alone with no adult or other child present in the room. The task was intentionally made to be very difficult to complete without cheating. Two coders independently coded for time (in seconds) for how long the child did not regulate their desire to look at the puzzle as they complete it (i.e., cheating). Interrater reliability calculated on 38% of the sample was 94.29%.

**Children's aggressive behaviors.** The Social Skills Questionnaire (SSQ-A; Hart & Robinson, 1996) was administered to children's teachers to obtain data on the children's behavior. The SSQ-A consisted of 58 questions (e.g., "teases other children just to be mean; laughs at other children in derogatory ways"), which can be answered with a score of zero for never, one for sometimes, and two for very often. The overall aggressive behavior score was created by summing the 58 items. Cronbach's $\alpha$ was .88.

## Results

Correlations among the main study variables are presented in **Table 2**. Mothers' use of reasoning and negotiation was significantly and negatively correlated with children's dysregulation and overall aggressive behaviors. However, mothers' coercive control was not significantly correlated with children's dysregulation nor children's overall aggressive behaviors. Children's dysregulation and overall aggressive behaviors were significantly negatively correlated with child's age (**Table 2**). However, child's age, gender, and maternal age were not examined as a covariate in the final mediation

analysis due to the small sample size.

Mediation analyses were conducted using PROCESS bootstrapping procedures. Children's dysregulation (b = -9.01, SE = 5.71, 95% CI [-22.68, -0.58]) fully mediated the effects of the mother's use of reasoning and negotiation on children's overall aggressive behaviors. Mother's use of reasoning and negotiation was negatively associated with children's dysregulation (b = -0.66, SE = 0.27, 95% CI [-1.20, -0.12]). However, the association between maternal coercive control and child aggressive behaviors was not mediated by child dysregulation (b = 2.41, SE = 3.37, 95% CI [-5.08, 8.76])

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# Discussion

The present study examined the association between Korean parents' use of parental control strategies and their young children's overall aggressive behaviors, and the mediating role of children's self-regulation skills in this association. The results revealed that Korean immigrant mothers' use of parental control was indirectly associated with their children's overall aggressive behaviors with peers through their children's dysregulation during a challenging behavioral task. In particular, structure and reason-based parental control (i.e., reason and negotiation) was found to be associated with children's fewer engagement in overall aggressive behaviors with peers, as reported by their teachers, as expected. However, coercive and harsh parental control was not significantly associated with children's overall aggressive behaviors, contrary to our expectations and previous research.

Korean American mothers reported the use of reasoning and negotiation strategies as a way to minimize misbehaviors and to teach proper behaviors to their children during open-ended interviews. Mothers' use of reasoning and negotiation strategies was associated with less time that children spent cheating during the challenging puzzle-box task; these cheating behaviors, an indicator of children's dysregulation and inability to "follow the rules," was in turn associated with their engagement in more aggressive behaviors with peers, as reported by their teachers. Given that the puzzle-box task itself was designed to be highly challenging and allowed the child access to cheat during the task (i.e., lifting the curtain to see the puzzle) (Eisenberg et al., 2001), less time spent cheating was indicative of a high level of self-regulation.

According to Korean Confucian traditional values, parents are believed to have full responsibility for their children's behaviors as it is their duty to train and teach their children proper social behaviors (Choi et al., 2013). Thus, Korean

American mothers often guide and correct their children's misbehaviors rather than ignore them (Kim et al., 2012). When their children misbehave, Korean American mothers' provision of the reasoning behind corrective measures appears to facilitate children's ability to correct their own misbehavior (i.e. cheating). As mothers explain why they are being strict and directive, children are able to gain an understanding of the mother's intention for the guidance. During an interview, a Korean American mother stated, "I usually convince them by trying to be at the same level with my child and ask them to think in my perspective as well... and 99% of the time, my child understands my thoughts and intention." Korean immigrant mothers often explain and persuade their child orally so that their child can understand the mother's actions. When the child knows the reason why their behavior was inappropriate, children may feel heard as parents take the time to give an explanation and negotiate with them about their actions (Kim, 2005). According to the Self-determination Theory, individuals can obtain a greater sense of autonomy and internalize the messages more easily when one's thoughts and feelings are acknowledged by others (Ryan & Deci, 2000). Therefore, children may be less likely to repeat this misbehavior in the future and self-regulate their own behaviors, as they have an understanding that the behavior is not socially appropriate (Liew et al., 2011). Young children with greater abilities to regulate their physiological, cognitive, behavioral reactivity across various situations are better able to understand and internalize the socialization messages of their parents, and more promptly activate appropriate behaviors in various situations (Baumeister & Vohs, 2013). Once socialization messages are internalized, these children may extend their understanding of regulating their behaviors towards peers and thus act less aggressively in social contexts (Terwogt & Olthof, 1989).

Our findings are that Korean American mothers' use of coercive control (i.e., physical punishment and verbal hostility) was not related to their children's self-regulation and aggressive behaviors was unexpected and contrary to previous research (Kim et al., 2010). The less detrimental effect of strict control practices on child outcomes may be due to Korean cultural values of filial piety, which is defined by children's strict obedience to their parents and elders (Chao & Tseng, 2002). As children are socialized to obey their parents' guidance and consider parental control as the way parents show their care and affection, children may not view parental control, to an extent, to be intrusive and negative. Rather, children may be more accepting of the direction that their parents provide as a way of honoring filial piety to their parents (Kim & Rohner, 2002). Furthermore, as some coercive control (e.g., physical punishment) is considered common practice amongst Korean Americans, children may not perceive it as negative (Rohner & Pettengill, 1985).

## Limitations and Future Directions

Several limitations of the present study need to be noted. First, due to the small sample size, our sample may not properly represent Korean American families in the United States and our findings cannot be generalized to the larger ethnic, immigrant Korean American population. Furthermore, the small sample size limited our statistical analyses as we were unable to statistically control for various demographic variables (e.g., child age, gender, mothers' age, education level), which have been shown to be associated with parental control in previous research (e.g., Grusec, 1972; Rubin et al., 2003). Future researchers should examine this relation with a larger and, perhaps, more representative sample to increase the validity of the findings and generalize to other communities of Korean immigrant parents with young children. Additionally, the direction of causality among the variables cannot be inferred due to the cross-sectional nature of the study. Although we proposed that dysregulation mediates the relation between mother's use of reasoning/negotiation skills and children's aggressive behaviors, children who display less aggressive behaviors may be a result of their temperaments rather than their mother's use of reasoning and negotiation with them (Yaman et al., 2010). Longitudinal studies are therefore necessary in the future to allow researchers to have more confidence in the temporal relations among the variables. Third, self-reported maternal control strategies reflect perceived parenting and thus may not accurately reflect actual parenting practices and behaviors. Therefore, researchers should conduct observational studies to more objectively assess parenting behaviors.

## Conclusion and Implications

Despite these limitations, this study advances our understanding of parenting, children's self-regulation skills, and overall aggressive behaviors in immigrant contexts within the United States. The use of interviews allowed us to capture mothers' own conceptualizations of the strategies they use to control and regulate their children. Instead of simply reporting their parental control strategies, a semi-structured interview allowed us to understand culturally derived control strategies and mothers' underlying reasons for using these various control strategies with their children. Additionally, a direct behavioral assessment of the skills that children utilized to self-regulate their emotions and actions during a challenging task was another strength of the study design, which provided a more objective assessment of children's self-regulation skills. Additionally, children's aggressive behaviors were reported by their teachers who directly observed children's behaviors in social environments with their peers. Moreover, teachers' reports are less likely to be biased because unlike parents,

they do not feel the societal pressure to present their students in a positive light (i.e., better self-regulation skills).

The present study is among the first studies to assess specific parental control strategies and their effects on children's dysregulation skills and overall aggressive behaviors. The study's results highlight the importance of promoting reason-based parental control among Korean immigrant mothers to minimize children's overall aggressive behaviors through the facilitation of the development of children's self-regulation skills. Our findings can inform the design of family-based intervention programs for Korean American families to promote the use of structure and reason-based parental control that can support their children's development of self-regulation skills and more positive behavioral outcomes.

# Appendix:

**Table 1.**
*Maternal Control Strategies Coding Categories, Definitions, and Direct Quotes*

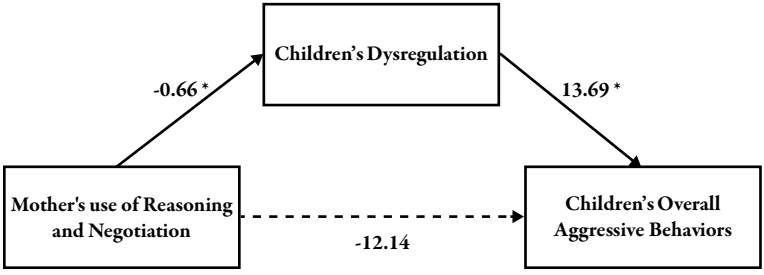
| Coding Category | Description | Direct Quote |
|---|---|---|
| Reasoning | Gives verbal instructions, discuss reasonings, explains what will happen if the behavior does not stop | "Because you didn't keep your promise, you're not doing this. Think well about what you did. I told you (the child) multiple times, right? I told you multiple times but you (the child) didn't listen. Because of your actions, we're not going to Korean school. Understand?" |
| Negotiation/ Compromise/ Distraction | Postpones request or asks for something from the child, offer something else | "I say 'You can't do this because this' instead I give them an alternative." |
| Physical Coercion/ Physical Punishment | Forces child to do something using physical means or power assertion | "I have my child face the wall with raised arms." |
| Warn or threaten | Gives warnings or threatens child | "I first give a warning. If you don't do this, I will give you a punishment." |
| Scold | Yells at the child in anger | "I yell a lot too." |

**Table 2.**
*Descriptive statistics of Main Variables*

| | 1 | 2 | 3 | 4 | 5 | Mean | Standard Deviation | Ranges |
|---|---|---|---|---|---|---|---|---|
| 1. Mothers' Reasoning & Negotiation | – | | | | | 0.10 | 0.15 | 0.00-0.50 |
| 2. Mothers' Coercive Control | -.28 | – | | | | 0.30 | 0.24 | 0.00-0.75 |
| 3. Time Cheating | - .33* | .12 | – | | | 39.24 | 16.59 | 5.50-85.00 |
| 4. Children's Overall Aggression | - .31* | .14 | .41** | – | | 19.80 | 10.24 | 2.00-41.00 |
| 5. Child's age | .13 | -.11 | -.48** | -.44** | – | 4.43 | 0.93 | 3.11-6.47 |

Note.
*p < .05. **p < .01.

**Figure 1.**
*A full mediation effect of parental control on children's overall aggressive behaviors through children's dysregulation skills.*




Note.
*$p$ < .05. Unstandardized path coefficients and the significance levels are indicated

# References


Aunola, K., Tolvanen, A., Viljaranta, J., & Nurmi, J. E. (2013). Psychological control in daily parent–child interactions increases children's negative emotions. *Journal of Family Psychology*, *27*, 453-462. https://doi.org/10.1037/a0032891

Baker, C. N., & Hoerger, M. (2012). Parental child-rearing strategies influence self-regulation, socio-emotional adjustment, and psychopathology in early adulthood: Evidence from a retrospective cohort study. *Personality and individual differences*, *52*(7), 800-805. https://doi.org/10.1016/j.paid.2011.12.034

Barber, B. K. (1996). Parental psychological control: Revisiting a neglected construct. *Child Development, 67*, 3296–3319. https://doi.org/10.1111/j.1467-8624.1996.tb01915.x

Barber, B. K., & Xia, M. (2013). The centrality of control to parenting and its effects. In R. E. Larzelere, A. S. Morris, & A. W. Harrist (Eds.), *Authoritative parenting: Synthesizing nurturance and discipline for optimal child development* (p. 61–87). American Psychological Association. https://doi.org/10.1037/13948-004

Baumeister, R. F., & Vohs, K. D. (Eds.). (2013). *Handbook of self-regulation: research, theory and applications* (2nd ed.). New York: The Guilford Press.

Baumrind, D. (2012). Differentiating between confrontive and coercive kinds of parental power-assertive disciplinary practices. *Human Development*, *55*(2), 35-51. https://doi.org/10.1159/000337962

Baumrind, D., Larzelere, R. E., & Owens, E. B. (2010). Effects of preschool parents' power assertive patterns and practices on adolescent development. *Parenting: Science and Practice*, *10*, 157-201. https://doi.org/10.1080/15295190903290790

Bornstein, M. H. (1991). Approaches to parenting in culture. In M. H. Bornstein (Ed.), *Cultural approaches to parenting* (p. 3-19). Hillsdale, NJ: Lawrence Erlbaum Press.

Chao, R., & Tseng, V. (2002). Parenting of Asians. In M. H. Bornstein (Ed.), *Handbook of parenting: Social conditions and applied parenting* (pp. 59-93). Mahwah, NJ: Lawrence Erlbaum Associates.

Cheah, C. S., Leung, C. Y., & Zhou, N. (2013). Understanding "tiger parenting" through the perceptions of Chinese immigrant mothers: Can Chinese and US parenting coexist?. *Asian American Journal of Psychology*, *4*(1), 30-40. https://doi.org/10.1037/a0031217.

Cheah, C. L., Li, J., Zhou, N., Yamamoto, Y., & Leung, C. Y. (2015). Understanding Chinese immigrant and European American mothers' expressions of warmth. *Developmental Psychology, 51*, 1802-1811. https://doi.org/10.1037/a0039855

Cheah, C. S. L., Zhou, N., Leung, C. Y. Y., & Vu, K. T. T. (2018). Understanding parental control among Chinese immigrant mothers in the U.S. In S. S. Chuang & C. L. Costigan (Eds.), *An international approach to parenting and parent-child relationships in immigrant families* (pp. 31–49). New York, NY: Springer Science +Business Media.

Chiu, L. H. (1987). Child-rearing attitudes of Chinese, Chinese-American, and Anglo-American mothers. *International Journal of Psychology, 22*, 409-419. https://doi.org/10.1080/00207598708246782

Choi, Y., Kim, Y. S., Kim, S. Y., & Park, I. J. K. (2013). Is Asian American parenting controlling and harsh? Empirical testing of relationships between Korean American and Western parenting measures. *Asian American Journal of Psychology*, *4*(1), 19–29. https://doi.org/10.1037/a0031220

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior.* New York: Plenum.

Eisenberg, N., Damon, W., & Lerner, R. M. (Eds.). (2006). *Handbook of child psychology: Social, emotional, and personality development., (Vol. 3, 6th ed.),* Hoboken, NJ: John Wiley & Sons Inc.

Eisenberg, N., Guthrie, I. K., Fabes, R. A., Reiser, M., Murphy, B. C., Holgren, R., Maszk, P. & Losoya, S. (1997). The relations of regulation and emotionality to resiliency and competent social functioning in elementary school children. *Child Development*, *68*, 259–311. https://doi.org/10.2307/1131851

Eisenberg, N., Thompson Gershoff, E., Fabes, R. A., Shepard, S. A., Cumberland, A. J., Losoya, S. H., Guthrie, I. K., & Murphy, B. C. (2001). Mothers' emotional expressivity and children's behavior problems and social competence: Mediation through children's regulation. *Developmental Psychology, 37*, 475- 490. https://doi.org/10.1037//0012-1649.37.4.475

Fradkin, C., Wallander, J. L., Yamakawa, Y., Schwebel, D. C., Chien, A., Le, Y. C. L., ... & Schuster, M. (2014). Quality of life among Asian American youth. *Asian American Journal of Psychology*, *5*(1), 13-21. https://doi.org/10.1037/a0029822.

Fung, H. (1999). Becoming a moral child: The socialization of shame among young Chinese children. *Ethos, 27*, 180-209. https://doi.org/10.1525/eth.1999.27.2.180

Fung, J. J., & Lau, A. S. (2009). Punitive discipline and child behavior problems in Chinese-American immigrant families: The moderating effects of indigenous child-rearing ideologies. *International Journal of Behavioral Development, 33*, 520-530. https://doi.org/10.1177/0165025409343749

Grolnick, W. S., & Farkas, M. (2002). Parenting and the development of children's self-regulation. In M. H. Bornstein (Ed.), *Handbook of Parenting: Practical issues in parenting*, *Vol. 5*, *2nd ed.* (pp. 89-110). Lawrence Erlbaum Associates Publishers

Grunbaum, J. A., Lowry, R., Kann, L., & Pateman, B. (2000). Prevalence of health risk behaviors among Asian American/Pacific Islander high school students. *Journal of Adolescent Health*, *27*, 322-330. https://doi.org/10.1016/S1054-139X(00)00093-8

Grusec, J. E. (1972). Demand characteristics of the modeling experiment: Altruism as a function of age and aggression. *Journal of Personality and Social Psychology, 22*(2), 139–148. https://doi.org/10.1037/h0032700

Gurland, S. T., & Grolnick, W. S. (2005). Perceived threat, controlling parenting, and children's achievement orientations. *Motivation and Emotion*, *29*, 103-121. https://doi.org/10.1007/s11031-005-7956-2

Hart, C. H., & Robinson, C. C. (1996). "Teacher Behavior Rating Scale." [Unpublished teacher questionnaire.] Bringham Young University, Provo, UT.

Heimpel, N. F., Qian, X., & Song, W. (2018). Parenting and Child Self-Regulation in Chinese Families: A Multi-Informant Study. *Journal of Child and Family Studies*, *27*, 2343-2353. https://doi.org/10.1007/s10826-018-1063-y

Kim, E. (2005). Korean American Parental Control: Acceptance or Rejection? *Ethos*, *33*(3), 347–366. https://doi.org/10.1525/eth.2005.33.3.347

Kim, E., Guo, Y., Koh, C., & Cain, K. C. (2010). Korean immigrant discipline and children's social competence and behavior problems. *Journal of pediatric nursing*, *25*(6), 490-499.

Kim, E., & Hong, S. (2007). First-generation Korean-American parents' perceptions of discipline. *Journal of Professional Nursing*, *23*(1), 60-68. https://doi.org/10.1016/j.profnurs.2006.12.002

Kim, E., Im, H., Nahm, E., & Hong, S. (2012). Korean American parents' reconstruction of immigrant parenting in the United States. *Journal of cultural diversity*, *19*(4), 124.

Kim, K., & Rohner, R. P. (2002). Parental warmth, control, and involvement in schooling: Predicting academic achievement among Korean American adolescents. *Journal of Cross-Cultural Psychology*, *33*(2), 127–140. https://doi.org/10.1177/0022022102033002001

Kochanska, G., Murray, K. T., & Harlan, E. T. (2000). Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. *Developmental Psychology*, *36*, 220-232. https://doi.org/KM037//0O12-1649.36.2.220

Kuczynski, L., & Kochanska, G. (1995). Function and content of maternal demands: Developmental significance of early demands for competent action. *Child Development, 66,* 616–628. https://doi.org/10.2307/1131938

Lansford, J. E., Wager, L. B., Bates, J. E., Dodge, K. A., & Pettit, G. S. (2012). Parental reasoning, denying privileges, yelling, and spanking: Ethnic differences and associations with child externalizing behavior. *Parenting: Science and Practice*, *12*(1), 42–56. https://doi.org/10.1080/15295192.2011.613727

Lee, B., Keown, L. J., & Brown, G. T. L. (2018). Relationships between parenting practices and perceptions of child behaviour among Korean immigrant mothers and fathers. *International Journal of Psychology*, *53*(5), 402–410. https://doi.org/10.1002/ijop.12398

Lee, S., Lee, K., Yi, S.-H., Park, H. J., Hong, Y.-J., & Cho, H. (2016). Effects of parental psychological control on child's school life: Mobile phone dependency as mediator. *Journal of Child and Family Studies*, *25*, 407–418. https://doi.org/10.1007/s10826-015-0251-2

Lee, J., Yu, H., & Choi, S. (2012). The influences of parental acceptance and parental control on school adjustment and academic achievement for South Korean children: The mediation role of self-regulation. *Asia Pacific Education Review*, *13*, 227–237. https://doi.org/10.1007/s12564-011-9186-5

Li, J. (2002). A cultural model of learning: Chinese 'heart and mind for wanting to learn'. *Journal of Cross-Cultural Psychology, 33*, 248-269. https://doi.org/10.1177/0022022102033003003

Li, J. (2003). U.S. and Chinese cultural beliefs about learning. *Journal of Educational Psychology, 95*, 258-267. https://doi.org/10.1037/0022-0663.95.2.258

Liew, J., Castillo, L. G., Chang, B. W., & Chang, Y. (2011). Temperament, self-regulation, and school adjustment in Asian American children. In F. Leong, L. Juang, D. B. Qin, & H. E. Fitzgerald (Eds.), *Asian American and Pacific Island Children's Mental Health, Volume 1: Development and Context.* Westport, CT: Praeger Publishers.

Louie, J. Y., Oh, B. J., & Lau, A. S. (2013). Cultural differences in the links between parental control and children's emotional expressivity. *Cultural Diversity and Ethnic Minority Psychology, 19*, 424-434. https://doi.org/10.1037/a0032820

López, G., Ruiz, N. G., & Patten, E. (2017, September 08). Key facts about Asian Americans. Retrieved from http://www.pewresearch.org/fact-tank/2017/09/08/key-facts-about-asian-americans/

Maccoby. E. E. (1984). Socialization and Developmental Change. *Child Development*, *55*, 317-328. https://doi.org/10.2307/1129945

Marbell, K. N., & Grolnick, W. S. (2012). Correlates of parental control and autonomy support in an interdependent culture: A look at Ghana. *Motivation and Emotion*, *37*(1), 79-92. https://doi.org/10.1007/s11031-012-9289-2

McClelland, M. M., Acock, A. C., Piccinin, A., Rhea, S. A., & Stallings, M. C. (2013). Relations between preschool attention span-persistence and age 25 educational outcomes. *Early Childhood Research Quarterly*, *28*, 314-324. https://doi.org/10.1016/j.ecresq.2012.07.008

Mills, R. S., & Rubin, K. H. (1998). Are behavioural and psychological control both differentially associated with childhood aggression and social withdrawal?. *Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement*, *30*, 132-136. https://doi.org/10.1037/h0085803

Nelson, D. A., Yang, C., Coyne, S. M., Olsen, J. A., & Hart, C. H. (2013). Parental psychological control dimensions: Connections with Russian preschoolers' physical and relational aggression. *Journal of Applied Developmental Psychology*, *34*(1), 1–8. https://doi.org/10.1016/j.appdev.2012.07.003

Olson, S. L., Lopez-Duran, N., Lunkenheimer, E. S., Chang, H., & Sameroff, A. J. (2011). Individual differences in the development of early peer aggression: Integrating contributions of self-regulation, theory of mind, and parenting. *Development and Psychopathology*, *23*(1), 253–266. https://doi.org/10.1017/S0954579410000775

Park, G. C. (2011). Becoming a "model minority": Acquisition, construction and enactment of American identity for Korean immigrant students. *The Urban Review*, *43*, 620–635. https://doi.org/10.1007/s11256-010-0164-8

Park, I. J. K., Kim, P. Y., Cheung, R. Y. M., & Kim, M. (2010). The role of culture, family processes, and anger regulation in Korean American adolescents' adjustment problems. *American Journal of Orthopsychiatry, 80*, 258–266. https://doi.org/10.1111/j.1939-0025.2010.01029.x

Peña, E. D. (2007). Lost in translation: Methodological considerations in cross-cultural research. *Child Development, 78(4),* 1255–1264. https://doi.org/10.1111/j.1467-8624.2007.01064.x

Pérez, J. C., & Cumsille, P. (2012). Adolescent temperament and parental control in the development of the adolescent decision making in a Chilean sample. *Journal of Adolescence*, *35*, 659–669. https://doi.org/10.1016/j.adolescence.2011.09.002

Rhee, S., Chang, J., & Rhee, J. (2003). Acculturation, Communication Patterns, and Self-Esteem among Asian and Caucasian American Adolescents. *Adolescence*, *38*, 749–768.

Rohner, R. P., & Pettengill, S. M. (1985). Perceived parental acceptance-rejection and parental control among Korean adolescents. *Child Development*, *56*(2), 524–528. https://doi.org/10.2307/1129739

Rothbart, M. K., & Bates, J. E. (2006). Temperament. In W. Damon & R. M. Lerner (Series Eds.) & N. Eisenberg (Vol. Ed.), *Handbook of Child Psychology* (6th ed., pp. 99 – 166). New York: Wiley.

Rubin, K. H., Burgess, K. B., Dwyer, K. M., & Hastings, P. D. (2003). Predicting preschoolers' externalizing behaviors from toddler temperament, conflict, and maternal negativity. *Developmental psychology*, *39*(1), 164

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology*, *57*, 749-761. https://doi.org/10.1037/0022-3514.57.5.749

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Seo, Y. J., Cheah, C. S., & Hart, C. H. (2017). Korean Immigrant Mothers' Praise and Encouragement, Acculturation, and Their Children's Socioemotional and Behavioral Difficulties. *Parenting*, *17*, 143-155. https://doi.org/10.1080/15295192.2017.1304786

Shaver, P., Schwartz, J., Kirson, D., & O'Connor, C. (1987). Emotion knowledge: Further exploration of a prototype approach. *Journal of Personality and Social Psychology, 52*, 1061–1086. https://doi.org/10.1037/0022-3514.52.6.1061

Spinrad, T. L., Eisenberg, N., & Gaertner, B. M. (2007). Measures of effortful regulation for young children. *Infant Mental Health Journal*, *28*, 606–626. https://doi.org/10.1002/imhj.20156

Steinberg, L. (1990). Autonomy, conflict, and harmony in the family relationship. In S. S. Feldman & G. R. Elliott (Eds.), *At the threshold: The developing adolescent.* (pp. 255–276). Cambridge, MA: Harvard University Press.

Steinberg, L., Elmen, J. D., & Mounts, N. S. (1989). Authoritative parenting, psychosocial maturity, and academic success among adolescents. *Child Development*, *60*, 1424-1436. https://doi.org/10.2307/1130932

Terwogt, M. M., & Olthof, T. (1989). Awareness and self-regulation of emotion in young children. *Children's understanding of emotion*, 209-237.

Trommsdorff, G. (2009). Culture and development of self-regulation. *Social and Personality Psychology Compass*, *3*, 687-701. https://dx.doi.org/10.1111/j.1751-9004.2009.00209.x

Trommsdorff, G. (2012). Development of "agentic" regulation in cultural context: the role of self and world views. *Child Development Perspectives*, *6*(1), 19-26. https://doi.org/10.1111/j.1750-8606.2011.00224.x

Vinden, P. G. (2001). Parenting attitudes and children's understanding of mind. A comparison of Korean American and Anglo-American families. *Cognitive Development, 16,* 793–809. https://doi.org/10.1016/S0885-2014(01)00059-4.

Vu, K. T. T., Cheah, C. S. L., Zhou, N., Leung, C. Y. Y., Li, J., & Yamamoto, Y. (2018). The socialization areas in which European American and Chinese immigrant mothers express warmth and control. *Parenting: Science and Practice, 18*, 262-280. https://doi.org/10.1080/15295192.2018.1524244

Wu, P., Robinson, C. C., Yang, C., Hart, C. H., Olsen, S. F., Porter, C. L., ... Wu, X. (2002). Similarities and differences in mothers' parenting of preschoolers in China and the United States. *International Journal of Behavioral Development, 26,* 481–491. https://doi.org/10.1080/01650250143000436.

Yamamoto, Y., & Li, J. (2012). What makes a high-quality preschool? Similarities and differences between Chinese immigrant and European American parents' views. *Early Childhood Research Quarterly, 27*, 306-315. https://doi.org/10.1016/j.ecresq.2011.09.005

Yaman, A., Mesman, J., van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2010). Parenting and toddler aggression in second-generation immigrant families: The moderating role of child temperament. *Journal of Family Psychology*, *24*(2), 208–211. https://doi.org/10.1037/a0019100

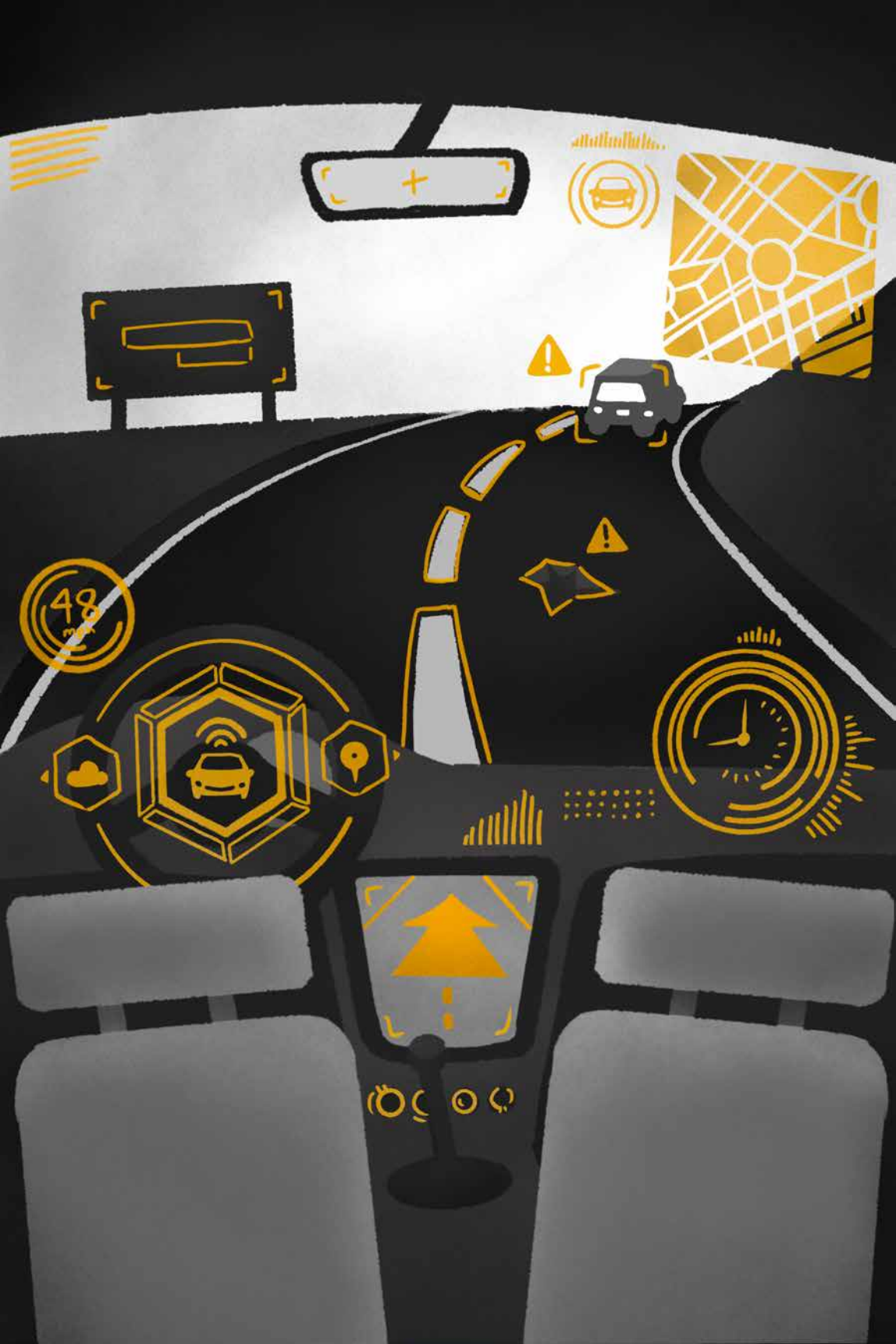
Yeh, C. J. (2003). Age, acculturation, cultural adjustment, and mental health symptoms of Chinese, Korean, and Japanese immigrant youths. *Cultural Diversity and Ethnic Minority Psychology*, *9*(1), 34–48. https://doi.org/10.1037/1099-9809.9.1.34

Yu, J., Cheah, C. S. L., Hart, C. H., & Yang, C. (2018). Child inhibitory control and maternal acculturation moderate effects of maternal parenting on Chinese American children's adjustment. *Developmental Psychology*, *54*, 1111–1123. https://doi.org/10.1037/dev0000517

Zhou, Z., Peverly, S. T., Xin, T., Huang, A. S., & Wang, W. (2003). School adjustment of first-generation Chinese-American adolescents. *Psychology in the Schools*, *40*(1), 71–84. https://doi.org/10.1002/pits.100

# Stability Analysis of Model Predictive Control-Based Car-Following Control Under Linear Vehicle Dynamics

Ben Hyatt



# Ben Hyatt

**Ben Hyatt is a mathematics major with minors in physics and philosophy. He is also a member of the Honors College. After graduating in Spring 2021, he intends to continue doing research at the interface of mathematics and physics by pursuing a Ph.D. in Applied Mathematics. His current research interests involve dynamical systems, partial differential equations, and numerical analysis and their applications in astrophysics and the study of other physical systems. Ben would like to recognize the guidance of two professors in the Department of Mathematics and Statistics: his mentor for this research, Dr. Jinglai Shen, who made this opportunity possible, and his advisor, Dr. Muruhan Rathinam, for his continued support.**

“My academic interests derive from over two years spent as an intern and temporary staff at the Johns Hopkins University Applied Physics Laboratory as well as two subsequent research projects in applied mathematics conducted at UMBC. The former experience –in the field of space exploration –carried over from high school into my sophomore year at UMBC, whereas my independent work in applied mathematics didn't begin until fall 2018 of my sophomore year after approaching my advisor, Dr. Muruhan Rathinam. This first project was supported by a 2019 Undergraduate Research Award and culminated in a thesis written in fall 2019 and a presentation at UMBC's Undergraduate Research and Creative Achievement Day in spring 2020. I learned about the opportunity to do my current research upon sharing this presentation with one of my mathematics professors, Dr. Jinglai Shen, who introduced me to his ongoing work in control theory and optimization regarding car-following control in transportation systems. The close connection of this topic with dynamical systems and mathematical analysis –areas of personal interest –prompted me to learn more. Thus far, I have presented this research at UMBC's 2020 Summer Undergraduate Research Fest and will continue this project for the foreseeable future.

**-Ben Hyatt**”

**Image 8.**
An image of what a smart self-driving car in the future could look like.

## Abstract

The continued advancement of autonomous vehicle technologies in recent years provides a unique opportunity to correct poor traffic dynamical performance resulting from irregular human driving behavior. To this end, car-following control schemes have been designed to regulate the motions of a platoon of autonomous vehicles as an interconnected system, thereby reducing undesired congestion and oscillations in traffic flow. In the development of such algorithms, it is important to verify dynamical stability to ensure optimal control is consistently maintained. We studied a linear discrete-time dynamical system modeling the kinematics of a platoon of connected and autonomous vehicles (CAVs) driving on a straight roadway behind an uncontrolled leading vehicle. The acceleration of each CAV was treated as a control. At each discrete time step, the unique optimal solution of a general p-horizon model predictive control (MPC) optimization problem was computed to determine the next control input. We employed stability theory and matrix analysis to prove asymptotic stability of the linear closed-loop dynamics up to an MPC horizon of p=3p=3. We further used numerical methods to select appropriate penalty weights for the optimization problem to achieve desired transient and asymptotic performance. These results help illuminate and support the development of car-following MPC schemes.



*Keywords: connected and autonomous vehicles (CAV), interconnected system, traffic flow, algorithm, model predictive control (MPC), stability theory & matrix analysis.*

# Introduction

Most are familiar with the experience of sitting in traffic, wondering when the long line of vehicles ahead of them will finally begin to move forward. Sometimes, it appears that the gridlock is finally over, only for another wave of brake lights to bring everything to another standstill. Such common traffic jams, largely brought about by poor and irregular human driving behavior, have negative social and environmental effects. Traffic congestion pressures motorists with the unnecessary financial losses that come from excessivetraneous fuel consumption and negatively impacts the environment in terms of increased carbon dioxide emissions [13][24]. Such issues can be addressed through the continued innovation of autonomous vehicle technologies and their rising prevalence in everyday life. Several studies present unique approaches to the design and implementation of various algorithms to control and direct car-following behaviors of connected and autonomous vehicles (CAVs), while using a variety of mathematical methods to ensure the stability of their control schemes. For instance, Sun et al. and Zhou et al. explore two primary lenses through which stability of a car-following control scheme can be established: local stability, when small perturbations from platoon equilibrium traffic flow simply dissipate as time passes, and string stability, when the propagation of the disturbance towards the back of the platoon is strictly decreasing in size [32][45]. These types of stability criteria are important to the control of subtle deviations in CAV traffic flow, but they don't establish the global stability properties necessary to ensure that large transgressions from equilibrium traffic flow can be corrected. To this end, Gong et al. considers a control scheme for which the CAV dynamics can be shown to maintain this desired global stability [51]. Motivated by this approach, this research shares improved stability analysis results for the control scheme initially developed by Gong et al., contributing to its the further refinement of its control scheme.

Limiting our focus to the car-following control scheme and linear model for vehicle dynamics presented in Gong et al., we address whether the system is dynamically stable. We consider the motion of a platoon of CAVs, whose accelerations are treated as a control, following behind an uncontrolled leading vehicle on a straight roadway. In this context, the dynamics of the vehicles are entirely linear, allowing for the complete description of the system in terms of the positions, speeds, and accelerations of each vehicle, which have known relationships through elementary one-dimensional kinematics. The desired traffic flow is then formulated in terms of a desired constant spacing between adjacent vehicles, and we further stipulate that this spacing should be achieved as quickly, comfortably, and safely as possible. Moreover, in this state of equilibrium, we want for the relative speeds and accelerations of adjacent vehicles to reduce to zero, thereby ensuring the desired spacing between vehicles is

maintained. However, since the leading vehicle is not under the model's control – it may be driven by a human or simply be disconnected from the communication structure – the system must be capable of dealing with unwanted disturbances. This is the purpose of the control input, i.e., the ability to adjust the accelerations of the CAVs. For a given change in the leading vehicle's motion and the initial conditions of the motions of the CAVs at that time, an effective control scheme efficiently manipulates the accelerations of each CAV in order to smoothly adjust their relative distances and speeds to achieve the desired equilibrium traffic flow.

The control scheme in Gong et al. makes use of a model predictive control (MPC) optimization problem. Although the linear vehicle dynamics can be studied in a continuous manner, it nicely lends itself to being studied as a discrete-time dynamical system. At each discrete time step, the collective computing power of each CAV is used in a distributed manner to compute the optimal collaborative adjustment of their accelerations based on the available information about the motions of each other vehicle at that time. This paper differs from the study in Gong et al. by considering a general p-horizon MPC scheme. This approach has the benefit of considering how the system evolves from one time point to, not just its successor, but rather up to p time steps into the future. In principle, taking additional time steps into account should lead to more efficient dynamical control, but the challenge of proving dynamical stability also becomes much more pronounced. While the asymptotic stability of the one-horizon MPC approach has already been proven in Gong et al., we here establish the foundation for formulating the general p-horizon model approach and present the proof for its asymptotic stability up to an MPC horizon of p=3. Moreover, still working through the lens of this stability analysis, we present some numerical results that motivate discussion about how our approach can achieve desirable transient dynamics, i.e., how it can decrease unwanted oscillations and disturbances in traffic flow in the short-term. Furthermore, the numerical work motivates stronger conclusions about asymptotic stability for larger p-horizons. Overall, this paper showcases the mathematical rigor of the stability proof and demonstrates its contribution to the development of this particular control scheme for CAVs.

## Methods

Following the approach used in Gong et al., the linear vehicle dynamics were formulated based on the one-dimensional kinematic motions of each vehicle in the platoon. Whereas Gong et al. additionally considers inequality constraints on vehicle motions, e.g., safety distance constraints, speed constraints, and acceleration constraints, we focused on the unconstrained case. This simplification was adopted since it allows for the system to be concisely expressed as a linear closed-loop system

that accurately describes the vehicle dynamics for a wide range of driving scenarios. Of course, in future work, it will be important to study asymptotic and transient stability when such constraints are active.

The proof of asymptotic stability was developed by means of proving that the matrix A, which effectively defines the linear closed-loop vehicle dynamics, is Schur stable. From linear stability theory, this property of a matrix is understood to be equivalent to asymptotic stability. Hence, proving A is Schur stable amounts to ensuring that the MPC scheme produces car-following behaviors that allow the platoon of CAVs to converge to desired equilibrium traffic flow as time passes. However, the form of the matrix A is shown to be dependent upon the choice of $p$-horizon for the control scheme, so the proof of A's Schur stability is different for each $p$. Using this approach, we extended the results of Gong et al. by showing that A is Schur stable up to a horizon of $p$=3. Moreover, through simulations produced by numerical computations performed in MATLAB, we studied the linear vehicle dynamics for several values of $p$, including $p$=1,2, and 3, as well as several p≥4, for suitable choices of penalty weights in the MPC optimization problem. This experimentation gave useful insight into the asymptotic stability of the linear vehicle dynamics and further assured that desirable transient dynamics could be maintained for larger $p$-horizons.

## Vehicle Dynamics and MPC Problem Formulation

To establish the control scheme, we first develop a model for the linear vehicle dynamics, following the procedure used in Gong et al. Consider a platoon of controlled vehicles following behind a single uncontrolled vehicle on a straight roadway. The positions, velocities, and accelerations of each vehicle are denoted $x_i$, $v_i$, and $u_i$ respectively, where the index $i$ refers to the $i^{\text{th}}$ vehicle in the platoon and the index of 0 corresponds to the leading vehicle. Note that the accelerations $u_i$ of the vehicles in the platoon are also referred to as their "control inputs" since they serve as the means by which the car-following motions of the platoon are adjusted. Adopting a discrete-time perspective of the system, we express how the dynamics evolve from the $k^{\text{th}}$ timepoint to the $(k+1)^{\text{th}}$ timepoint, where $k \in \mathbb{Z}_+$. Let $\tau > 0$ be the sampling time and impose that on each time interval $[k\tau, (k+1)\tau]$ the control inputs $u_i$ are constant for each $k \in \mathbb{Z}_+$ and $i = 1, \dots, n$. Then the discrete linear vehicle dynamics are given by

$$x_i(k+1) = x_i(k) + \tau v_i(k) + \frac{\tau^2}{2} u_i(k),\ v_i(k+1) = v_i(k) + \tau u_i(k), \forall k \in \mathbb{Z}_+ \tag{1.1}$$

for each $i = 1. \dots . n$. where the time $k\tau$ is now written as $k$ for brevity.

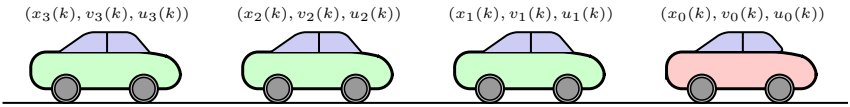



**Figure 1**. An example with n=3, where there are three controlled CAVs shown in green, and one uncontrolled leading vehicle shown in red.

Next, in order to determine the appropriate choice for the control inputs $u_i(k)$ at each time $k$, we develop an optimization problem whose solution gives rise to the desired traffic flow. For any time $k \in \mathbb{Z}_+$ and suitable constant separation between adjacent vehicles $\Delta > 0$, define the vectors

$$z(k) \coloneqq (x_0 - x_1 - \Delta, \dots, x_{n-1} - x_n - \Delta)(k) \in \mathbb{R}^n$$
$$z'(k) \coloneqq (v_0 - v_1, \dots, v_{n-1} - v_n)(k) \in \mathbb{R}^n$$
$$w(k) \coloneqq (u_0 - u_1, \dots, u_{n-1} - u_n)(k) \in \mathbb{R}^n$$

which represent the respective deviations in separation, speed, and acceleration between adjacent vehicles in the platoon that we would like to minimize. That is, we would like for $z(k)$, $z'(k)$, and $w(k)$ to converge to zero as the time $k$ increases.

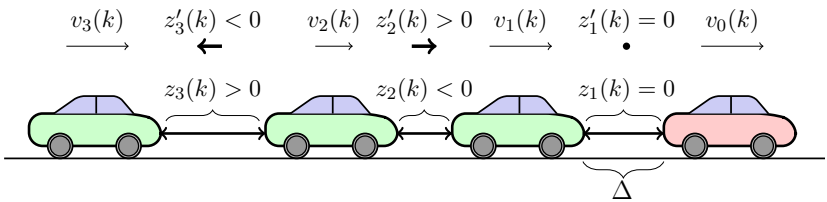



**Figure 2**. An example with *n*=3, where some of the possible stats of *z(k)* and *z'(k)* have been visibly represented.

**Figure 2** depicts the system at some time $k$ when equilibrium traffic flow has not yet been reached. The separations between each vehicle $z_i(k)$, their velocities $v_i(k)$, and the differences in their velocities $z'_i(k)$ are labeled for emphasis. Note that when the separation between two adjacent vehicles equals the desired separation constant $\Delta$, then $z(k)$=0; otherwise, the sign of $z(k)$ changes depending on whether the vehicles are too close or too far apart. Likewise, the sign of $z'(k)$ depends on the difference between the velocities of adjacent vehicles.

In this notation, it follows from (1.1) that we can express the vehicle dynamics as

$$z(k+1) = z(k) + \tau z'(k) + \frac{\tau^2}{2} w(k),\ z'(k+1) = z'(k) + \tau w(k), \forall k \in \mathbb{Z}_+. \tag{1.2}$$

Moreover, we can express the control input in terms of $w(k)$ as

$$u(k) = -S_n w(k) + u_0(k) \cdot \mathbf{1} \tag{1.3}$$

where $\mathbf{1} := (1, \dots, 1)^T \in \mathbb{R}^n$, and $S_n$ and its inverse $S_n^{-1}$ have the forms

$$S_n := \begin{bmatrix} 1 & 0 & 0 & \cdots & 0 \\ 1 & 1 & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 1 & 1 & \cdots & 1 & 0 \\ 1 & 1 & \cdots & 1 & 1 \end{bmatrix} \in \mathbb{R}^{n \times n}, \qquad S_n^{-1} = \begin{bmatrix} 1 & & & & \\ -1 & 1 & & & \\ & -1 & \ddots & & \\ & & \ddots & \ddots & \\ & & & -1 & 1 \end{bmatrix} \in \mathbb{R}^{n \times n}. \tag{1.4}$$

For our purposes, it will prove useful to extend this depiction of the dynamics to capture how the motions of the system will evolve over any integer number of time intervals. From (1.2), it immediately follows that

$$\begin{aligned} z(k+s) &= z(k) + s\tau z'(k) + \frac{\tau^2}{2} \sum_{j=0}^{s-1} (2(s-j)-1) w(k+j), \\ z'(k+s) &= z'(k) + \tau \sum_{j=0}^{s-1} w(k+j), \qquad \forall k \in \mathbb{Z}_+ \end{aligned} \tag{1.5}$$

for each $s = 1, \dots, p$. This perspective allows us to construct a control scheme that considers how the dynamics of the system will progress over $p$ consecutive time intervals, i.e. an MPC scheme with a general MPC $p$-horizon where $p \in \mathbb{N}$. In order to avoid unwanted oscillations in traffic flow and excessively large control inputs, we let $\boldsymbol{\alpha} := (\alpha^1, \dots, \alpha^p)$, $\boldsymbol{\beta} := (\beta^1, \dots, \beta^p)$, and $\boldsymbol{\zeta} := (\zeta^1, \dots, \zeta^p)$ be penalty weights, where $\boldsymbol{\alpha}^s = (\alpha_i^s)_{i=1}^n$, $\boldsymbol{\beta}^s = (\beta_i^s)_{i=1}^n$, and $\boldsymbol{\zeta}^s = (\zeta_i^s)_{i=1}^n$. We then define the objective function

$$J\big(u(k),\dots,u(k+p-1)\big) \coloneqq$$
$$\frac{1}{2}\sum_{s=1}^{p}\Big(\tau^2 u^T(k+s-1)S_n^{-T}Q_{w,s}S_n^{-1}u(k+s-1) + z^T(k+s)Q_{z,s}z(k+s) + \big(z'(k+s)\big)^T Q_{z',s}z'(k+s)\Big) \tag{1.6}$$

where $Q_{z,s} \coloneqq diag(\alpha^s)$, $Q_{z',s} \coloneqq diag(\beta^s)$, and $Q_{w,s} \coloneqq diag(\zeta^s)$ are $n \times n$ diagonal (and thereby symmetric) weight matrices for each $s = 1, \dots, p$. Then the MPC optimization problem consists of minimizing $J$ with respect to the control inputs $u(k), \dots, u(k+p-1)$ at each time $k$.

In this context, it is clear that $\boldsymbol{\alpha}$ determines the penalty on the deviations of the separations between adjacent vehicles from the desired value of $\Delta > 0$, $\boldsymbol{\beta}$ determines the penalty on the differences in speed between adjacent vehicles, and $\boldsymbol{\zeta}$ determines the restriction on the sizes of the control inputs. Furthermore, assume that the penalty weights will be selected as follows for a general $p$:

$$\alpha^1, \beta^1, \zeta^1 > 0, \text{ and } \alpha^s, \beta^s \geq 0, \zeta^s > 0, \text{ for each } s = 2, \dots, p. \tag{1.7}$$

Then it follows that $Q_{z,s}$ and $Q_{z',s}$ are positive definite (PD) for $s = 1$ and otherwise positive semidefinite (PSD) for $s = 2, \dots, p$ and $Q_{w,s}$ is PD for each $s = 1, \dots, p$. We also recognize from the form of $S_n^{-1}$ in (1.4) that the matrix $S_n^{-T}Q_{w,s}S_n^{-1}$ is symmetric and PD for each $s = 1, \dots, p$. It is then apparent that the objective function $J$ in (1.6) is quadratic. To this end, defining the vector $\widetilde{w}(k+s-1) \coloneqq w(k+s-1) - u_0(k) \cdot \boldsymbol{e_1}$ for each $s = 1, \dots, p$ and some $k \in \mathbb{Z}_+$ such that $\widetilde{w}(k+s-1) = -S_n^{-1}u(k+s-1)$, it follows that $\tau^2 u^T(k+s-1)S_n^{-T}Q_{w,s}S_n^{-1}u(k+s-1) = \tau^2 \widetilde{w}^T(k+s-1)Q_{w,s}\widetilde{w}(k+s-1)$. Hence, we now write $J$ from (6) in terms of $w(k), \dots, w(k+p-1)$ as

$$J\underbrace{\big(w(k),\dots,w(k+p-1)\big)}_{\boldsymbol{w}} \coloneqq$$
$$\frac{1}{2}\sum_{s=1}^{p}\Big(\tau^2 \widetilde{w}^T(k+s-1)Q_{w,s}\widetilde{w}(k+s-1) + z^T(k+s)Q_{z,s}z(k+s) + \big(z'(k+s)\big)^T Q_{z',s}z'(k+s)\Big) \tag{1.8}$$

where $\boldsymbol{w} \coloneqq \big(w(k), \dots, w(k+p-1)\big)^{'} \in \mathbb{R}^{pn}$. From here, it can be shown that $J$ has the insightful quadratic form

$$J(\boldsymbol{w}) \coloneqq \frac{1}{2}\boldsymbol{w}^{\boldsymbol{T}}\boldsymbol{H}\boldsymbol{w} + \boldsymbol{w}^{\boldsymbol{T}}\left(\boldsymbol{G}\begin{bmatrix} z(k) \\ z'(k) \end{bmatrix} - u_0(k)\boldsymbol{g}\right) + \tilde{\boldsymbol{\gamma}} \tag{1.9}$$

and $\boldsymbol{H}$, $\boldsymbol{G}$, and $\boldsymbol{g}$ have the forms

$$\boldsymbol{H} \coloneqq \begin{bmatrix} \boldsymbol{H}_{1,1} + \tau^2 Q_{w,1} & \boldsymbol{H}_{1,2} & \boldsymbol{H}_{1,3} & \cdots & \boldsymbol{H}_{1,p} \\ \boldsymbol{H}_{2,1} & \boldsymbol{H}_{2,2} + \tau^2 Q_{w,2} & \boldsymbol{H}_{2,3} & \cdots & \boldsymbol{H}_{2,p} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \boldsymbol{H}_{p,1} & \boldsymbol{H}_{p,2} & \boldsymbol{H}_{p,3} & \cdots & \boldsymbol{H}_{p,p} + \tau^2 Q_{w,1} \end{bmatrix} \in \mathbb{R}^{pn \times pn},$$

$$\boldsymbol{G} \coloneqq \begin{bmatrix} \boldsymbol{G}_{1,1} & \boldsymbol{G}_{1,2} \\ \vdots & \vdots \\ \boldsymbol{G}_{p,1} & \boldsymbol{G}_{p,2} \end{bmatrix} \in \mathbb{R}^{pn \times 2n}, \text{ and } \boldsymbol{g} \coloneqq \tau^2 \begin{bmatrix} Q_{w,1}\boldsymbol{e_1} \\ Q_{w,2}\boldsymbol{e_1} \\ \vdots \\ Q_{w,p}\boldsymbol{e_1} \end{bmatrix} \in \mathbb{R}^{pn}, \tag{1.10}$$

where we define

$$\begin{aligned} &\boldsymbol{H}_{i,j} \coloneqq \sum_{s=max(i,j)}^{p} \left(\frac{\tau^4}{4}[2(s-i)+1]\cdot[2(s-j)+1]Q_{z,s} + \right. \\ &\left.\tau^2 Q_{z',s}\right) \in \mathbb{R}^{\mathrm{n}\times\mathrm{n}}, \\ &\boldsymbol{G}_{i,1} \coloneqq \frac{\tau^2}{2}\sum_{s=i}^{p}(2(s-i)+1)Q_{z,s} \in \mathbb{R}^{\mathrm{n}\times\mathrm{n}}, \text{ and} \\ &\boldsymbol{G}_{i,2} \coloneqq \frac{\tau^3}{2}\sum_{s=i}^{p} s(2(s-i)+1)Q_{z,s} + \tau\sum_{s=i}^{p} Q_{z',s} \in \mathbb{R}^{\mathrm{n}\times\mathrm{n}}. \end{aligned} \tag{1.11}$$

The quadratic form of $J$ in (1.9) allows us to easily determine the optimal solution to the MPC optimization problem. The necessary conditions for a minimum $\boldsymbol{w}_*$ of $J$ are satisfied when

$$\frac{\partial J}{\partial \boldsymbol{w}}\Big|_{\boldsymbol{w}=\boldsymbol{w}_*} = \boldsymbol{H}\boldsymbol{w}_* + \boldsymbol{G}\begin{bmatrix} z(k) \\ z'(k) \end{bmatrix} - u_0(k)\boldsymbol{g} = 0,$$

i.e.,

$$\boldsymbol{w}_* \coloneqq \big(w_*(k), \dots, w_*(k+p-1)\big) = -\boldsymbol{H}^{-1}\left(\boldsymbol{G}\begin{bmatrix} z(k) \\ z'(k) \end{bmatrix} - u_0(k)\boldsymbol{g}\right) \in \mathbb{R}^{pn}. \tag{1.12}$$

Moreover, it is straightforward to verify that $\boldsymbol{H}$ in (1.10) is PD by the assumptions stated in (1.7) regarding the selection of penalty weights. (Also, note that since $\boldsymbol{H}$ is both PD and symmetric, it is invertible, so the use of $\boldsymbol{H}^{-1}$ in (1.12) is valid.) It follows from $\boldsymbol{H}$ being PD that the sufficient conditions for $\boldsymbol{w}_*$ to be the unique minimum of $J$ are also satisfied. Thus, $\boldsymbol{w}_*$ in (1.12) is the unique closed-form solution to the MPC optimization problem. Hence, the MPC scheme involves taking the first component of $\boldsymbol{w}_*$, i.e. $w_*(k)$, at each time $k$ and updating the control inputs of each CAV accordingly, where

$$w_*(k) = -[I_n \quad 0 \quad \cdots \quad 0]\boldsymbol{H}^{-1}\left(\boldsymbol{G}\begin{bmatrix} z(k) \\ z'(k) \end{bmatrix} - u_0(k)\boldsymbol{g}\right). \tag{1.13}$$

Finally, substituting this expression for $w_*(k)$ from (1.13) into the vehicle dynamics equations in (1.2), we obtain the discrete closed-loop linear vehicle dynamical system

$$\begin{bmatrix} z(k+1) \\ z'(k+1) \end{bmatrix} = \underbrace{\left\{\begin{bmatrix} I_n & \tau I_n \\ 0 & I_n \end{bmatrix} + \begin{bmatrix} \frac{\tau^2}{2} I_n \\ \tau I_n \end{bmatrix}\boldsymbol{K}\right\}}_{A} \begin{bmatrix} z(k) \\ z'(k) \end{bmatrix} + \begin{bmatrix} \frac{\tau^2}{2} I_n \\ \tau I_n \end{bmatrix} u_0(k) \cdot \boldsymbol{d} \tag{1.14}$$

where

$\boldsymbol{K} \coloneqq -[I_n \quad 0 \quad \cdots \quad 0]\boldsymbol{H}^{-1}\boldsymbol{G} \in \mathbb{R}^{n\times 2n}$ and $\boldsymbol{d} \coloneqq [I_n \quad 0 \quad \cdots \quad 0]\boldsymbol{H}^{-1}\boldsymbol{g} \in \mathbb{R}^n$.

Here, the newly defined matrix $A$ plays a pivotal role in determining the asymptotic stability of the vehicle dynamics as it dictates the evolving relationship between $z(k), z'(k), z(k+1)$, and $z'(k+1)$. It is also worth noting that the term on the right of (1.14) captures the influence of the uncontrolled leading vehicle on the system through the term $u_0(k)$ which can give rise to transient disturbances. That being said, the asymptotic stability of the closed-loop dynamics remains completely determined by the matrix $A$. We continue this discussion in the following section.

## Stability Analysis

The asymptotic stability of the linear closed-loop dynamics stated in (1.14) depends on the spectral radius of the matrix $A$. In particular, the matrix $A$ is said to be Schur stable if the spectral radius of $A$ is strictly less than 1, i.e. for any eigenvalue $\mu \in \sigma(A)$ (where $\sigma(A)$ denotes the spectrum of $A$), whether real or complex, $|\mu| < 1$. When this property of $A$ is satisfied, the vehicle dynamics will approach the desired traffic flow as time proceeds, i.e., the system is asymptotically stable.

Prior work has already established such stability for an MPC horizon of $p = 1$, but it is unknown whether this property holds for a general $p$-horizon. In this research, we used brute force methods to prove that $A$ is additionally Schur stable for MPC horizons of $p = 2$ and $p = 3$, laying the foundation for proving stability for the general case. As the procedures for $p = 2$ and $p = 3$ are similar, we here focus on the proof for the case where $p = 3$.

First, consider a general $p$ and an arbitrary $\tau > 0$. In order to learn about the eigenvalues of $A$, we perform a similarity transformation on $A$ which preserves its eigenvalues. Note that there exists a permutation matrix $E \in \mathbb{R}^{2n\times 2n}$ such that $\tilde{A} \coloneqq E^T AE = \mathrm{diag}\big(\tilde{A}_1, \tilde{A}_2, \dots, \tilde{A}_n\big)$ is a block diagonal matrix with the same eigenvalues as $A$, i.e. $\sigma\big(\tilde{A}\big) = \sigma(A)$. In particular, $E$ is the permutation matrix for the coordinate transformation

$$\tilde{z} = E\begin{bmatrix} z \\ z' \end{bmatrix} \text{ where } \tilde{z} \coloneqq (z_1, z_1', z_2, z_2', \dots, z_n, z_n') \in \mathbb{R}^{2n} \text{ for any } \begin{bmatrix} z \\ z' \end{bmatrix} = (z_1, z_2, \dots, z_n, z_1', z_2', \dots, z_n')^T \in \mathbb{R}^{2n}. \tag{2.1}$$

Recalling the definitions of $\boldsymbol{H}$ and $\boldsymbol{G}$ in (1.10), note we can write $A$ as (2.2)

$$A = \begin{bmatrix} I_n & \tau I_n \\ 0 & I_n \end{bmatrix} - \begin{bmatrix} \frac{\tau^2}{2} I_n \\ \tau I_n \end{bmatrix} [I_n \quad 0 \quad \cdots \quad 0]\boldsymbol{H}^{-1}\boldsymbol{G} = \begin{bmatrix} I_n & \tau I_n \\ 0 & I_n \end{bmatrix} - \begin{bmatrix} \frac{\tau^2}{2} I_n & 0 & \cdots & 0 \\ \tau I_n & 0 & \cdots & 0 \end{bmatrix} \boldsymbol{H}^{-1}\boldsymbol{G}$$

by definition of $\boldsymbol{K}$. Further note that there exists another permutation matrix $\hat{E} \in \mathbb{R}^{pn\times pn}$ such that $\tilde{H} \coloneqq \hat{\mathrm{E}}^T \boldsymbol{H}\hat{E} = \mathrm{diag}\big(\widetilde{\boldsymbol{H}}_1, \widetilde{\boldsymbol{H}}_2, \dots, \widetilde{\boldsymbol{H}}_n\big)$ is a $pn \times pn$ block diagonal matrix. Here, $\hat{E}$ is instead the permutation matrix for the coordinate transformation

$$\hat{z} = \hat{E}\begin{bmatrix} z^1 \\ \vdots \\ z^p \end{bmatrix} \text{ where } \hat{z} \coloneqq \big(z_1^1, z_1^2, \dots, z_1^p, \dots, z_n^1, z_n^2, \dots, z_n^p\big) \in \mathbb{R}^{pn} \text{ for any } \begin{bmatrix} z^1 \\ \vdots \\ z^p \end{bmatrix} = \big(z_1^1, z_2^1, \dots, z_n^1, \dots, z_1^p, z_2^p, \dots, z_n^p\big) \in \mathbb{R}^{pn}. \tag{2.3}$$

Noting that $\hat{E}^{-1} = \hat{E}^T$, it follows that

$$E^T AE = E^T \begin{bmatrix} I_n & \tau I_n \\ 0 & I_n \end{bmatrix} E - E^T \begin{bmatrix} \frac{\tau^2}{2} I_n & 0 & \cdots & 0 \\ \tau I_n & 0 & \cdots & 0 \end{bmatrix} \big(\hat{E}\widetilde{\boldsymbol{H}}\hat{E}^T\big)^{-1} \boldsymbol{GE},$$

such that

$$\tilde{A} = E^T \begin{bmatrix} I_n & \tau I_n \\ 0 & I_n \end{bmatrix} E - E^T \begin{bmatrix} \frac{\tau^2}{2} I_n & 0 & \cdots & 0 \\ \tau I_n & 0 & \cdots & 0 \end{bmatrix} \hat{E}\tilde{H}^{-1}\hat{E}^T \boldsymbol{GE}. \tag{2.4}$$

Then, computing these matrix products directly yields

$$E^T \begin{bmatrix} I_n & \tau I_n \\ 0 & I_n \end{bmatrix} E = \begin{bmatrix} 1 & \tau & & & & & & \\ 0 & 1 & & & & & & \\ & & 1 & \tau & & & & \\ & & 0 & 1 & & & & \\ & & & & \ddots & & & \\ & & & & & & 1 & \tau \\ & & & & & & 0 & 1 \end{bmatrix},$$

$$E^T \begin{bmatrix} \frac{\tau^2}{2} I_n & 0 & \cdots & 0 \\ \tau I_n & 0 & \cdots & 0 \end{bmatrix} \hat{E} =$$

$$\begin{bmatrix} \frac{\tau^2}{2} & 0 & \cdots & 0 & & & & & & & & \\ \tau & 0 & \cdots & 0 & & & & & & & & \\ & & & & \frac{\tau^2}{2} & 0 & \cdots & 0 & & & & \\ & & & & \tau & 0 & \cdots & 0 & & & & \\ & & & & & & & & \ddots & & & \\ & & & & & & & & & \frac{\tau^2}{2} & 0 & \cdots & 0 \\ & & & & & & & & & \tau & 0 & \cdots & 0 \end{bmatrix}, \text{ and}$$

$$\hat{E}^T \boldsymbol{G} E = \underbrace{\begin{bmatrix} (\boldsymbol{G}_{1,1})_{1,1} & (\boldsymbol{G}_{1,2})_{1,1} & & & & & & \\ \vdots & \vdots & & & & & & \\ (\boldsymbol{G}_{p,1})_{1,1} & (\boldsymbol{G}_{p,2})_{1,1} & & & & & & \\ & & (\boldsymbol{G}_{1,1})_{2,2} & (\boldsymbol{G}_{1,2})_{2,2} & & & & \\ & & \vdots & \vdots & & & & \\ & & (\boldsymbol{G}_{p,1})_{2,2} & (\boldsymbol{G}_{p,2})_{2,2} & & & & \\ & & & & \ddots & & & \\ & & & & & & (\boldsymbol{G}_{1,1})_{n,n} & (\boldsymbol{G}_{1,2})_{n,n} \\ & & & & & & \vdots & \vdots \\ & & & & & & (\boldsymbol{G}_{p,1})_{n,n} & (\boldsymbol{G}_{p,2})_{n,n} \end{bmatrix}}_{\tilde{\boldsymbol{G}}}.$$

It follows that

$$\tilde{A} = \begin{bmatrix} 1 & \tau & & & & & \\ 0 & 1 & & & & & \\ & & 1 & \tau & & & \\ & & 0 & 1 & & & \\ & & & & \ddots & & \\ & & & & & 1 & \tau \\ & & & & & 0 & 1 \end{bmatrix} - \begin{bmatrix} \frac{\tau^2}{2} & 0 & \cdots & 0 & & & & & & & & \\ \tau & 0 & \cdots & 0 & & & & & & & & \\ & & & & \frac{\tau^2}{2} & 0 & \cdots & 0 & & & & \\ & & & & \tau & 0 & \cdots & 0 & & & & \\ & & & & & & & & \ddots & & & \\ & & & & & & & & & \frac{\tau^2}{2} & 0 & \cdots & 0 \\ & & & & & & & & & \tau & 0 & \cdots & 0 \end{bmatrix} \widetilde{\boldsymbol{H}}^{-1}\widetilde{\boldsymbol{G}} \tag{2.5}$$

where $\tilde{A} = \mathrm{diag}(\tilde{A}_1, \tilde{A}_2, \dots, \tilde{A}_n) \in \mathbb{R}^{2n\times 2n}$, $\widetilde{\mathbf{H}}^{-1} = \mathrm{diag}(\widetilde{H}_1^{-1}, \widetilde{H}_2^{-1}, \dots, \widetilde{H}_n^{-1}) \in \mathbb{R}^{pn\times pn}$, and $\widetilde{\boldsymbol{G}} \in \mathbb{R}^{pn\times 2n}$ is defined as indicated above. Thus, each block $\widetilde{A}_\iota \in \mathbb{R}^{2\times 2}$ is given by

$$\tilde{A}_i = \begin{bmatrix} 1 & \tau \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} \frac{\tau^2}{2} I_n & 0 & \cdots & 0 \\ \tau I_n & 0 & \cdots & 0 \end{bmatrix} \widetilde{H}_i^{-1}\widetilde{\boldsymbol{G}}_i = \begin{bmatrix} 1 & \tau \\ 0 & 1 \end{bmatrix} + \begin{bmatrix} \frac{\tau^2}{2} \\ \tau \end{bmatrix} \widetilde{\boldsymbol{K}}_i, \quad (i = 1, \dots, n) \tag{2.6}$$

where

$$\widetilde{\boldsymbol{K}}_i := -e_1^T \widetilde{\mathbf{H}}^{-1}\widetilde{\boldsymbol{G}}_i \in \mathbb{R}^{1\times 2}, \tag{2.7}$$

$$\widetilde{\boldsymbol{H}}_i := \begin{bmatrix} \left(\boldsymbol{H}_{1,1} + \tau^2 Q_{w,1}\right)_{i,i} & (\boldsymbol{H}_{1,2})_{i,i} & (\boldsymbol{H}_{1,3})_{i,i} & \cdots & (\boldsymbol{H}_{1,p})_i \\ (\boldsymbol{H}_{2,1})_{i,i} & \left(\boldsymbol{H}_{2,2} + \tau^2 Q_{w,2}\right)_{i,i} & (\boldsymbol{H}_{2,3})_{i,i} & \cdots & (\boldsymbol{H}_{2,p})_i \\ \cdots & \cdots & \cdots & & \cdots \\ (\boldsymbol{H}_{p,1})_{i,i} & (\boldsymbol{H}_{p,2})_{i,i} & (\boldsymbol{H}_{p,3})_{i,i} & \cdots & \left(\boldsymbol{H}_{p,p} + \tau^2 Q\right. \end{bmatrix} \tag{2.8}$$

$\mathbb{R}^{p\times p}$,

and

$$\widetilde{\boldsymbol{G}}_i \coloneqq \begin{bmatrix} \left(\boldsymbol{G}_{1,1}\right)_{i,i} & \left(\boldsymbol{G}_{1,2}\right)_{i,i} \\ \vdots & \vdots \\ \left(\boldsymbol{G}_{p,1}\right)_{i,i} & \left(\boldsymbol{G}_{p,2}\right)_{i,i} \end{bmatrix} \in \mathbb{R}^{p\times 2}. \tag{2.9}$$

Now, in order to prove that $A$ is Schur stable for $p = 3$, the argument is divided into two cases. First, consider an arbitrary $p \geq 3$ and make the following simplified assumptions for each $i = 1, \dots, n$:

$$\begin{aligned} \alpha_i^1, \beta_i^1, \zeta_i^1 > 0, \qquad & \alpha_i^2, \beta_i^2 \geq 0, \zeta_i^2 > 0, \\ & \alpha_i^s = \beta_i^s = 0,\ \zeta_i^s > 0\ (\forall s = 3, \dots, p). \end{aligned} \tag{2.10}$$

Since $\alpha_i^s = \beta_i^s = 0$ for each $i = 1, \dots, n$ and $s = 3, \dots, p$, it follows from (1.10) and (1.11) that

$$\widetilde{\boldsymbol{H}}_i = \begin{bmatrix} \left(\boldsymbol{H}_{1,1} + \tau^2 Q_{w,1}\right)_{i,i} & \left(\boldsymbol{H}_{1,2}\right)_{i,i} & 0 & \cdots & 0 \\ \left(\boldsymbol{H}_{2,1}\right)_{i,i} & \left(\boldsymbol{H}_{2,2} + \tau^2 Q_{w,2}\right)_{i,i} & 0 & \cdots & 0 \\ 0 & 0 & \left(\tau^2 Q_{w,3}\right)_{i,i} & & \vdots \\ \vdots & \vdots & & \ddots & 0 \\ 0 & 0 & \cdots & 0 & \left(\tau^2 Q_{w,p}\right)_{i,i} \end{bmatrix}$$

and

$$\widetilde{\boldsymbol{G}}_i = \begin{bmatrix} \left(\boldsymbol{G}_{1,1}\right)_{i,i} & \left(\boldsymbol{G}_{1,2}\right)_{i,i} \\ \left(\boldsymbol{G}_{2,1}\right)_{i,i} & \left(\boldsymbol{G}_{2,2}\right)_{i,i} \\ 0 & 0 \\ \vdots & \vdots \\ 0 & 0 \end{bmatrix}.$$

Then, using (1.11) and the definitions of $Q_{z,s}$, $Q_{z',s}$, and $Q_{w,s}$ as $n \times n$ diagonal matrices whose diagonal entries are precisely the penalty weights $\alpha^s$, $\beta^s$, and $\zeta^s$, $\widetilde{\boldsymbol{H}}_i$ and $\widetilde{\boldsymbol{G}}_i$ can be written as

$$\widetilde{\boldsymbol{H}}_i = \begin{bmatrix} \frac{\tau^4}{4}\alpha_i^1 + \frac{9\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^1 + \tau^2\beta_i^2 + \tau^2\zeta_i^1 & \frac{3\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^2 \\ \frac{3\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^2 & \frac{\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^2 + \tau^2\zeta_i^2 \\ & \tau^2\zeta \end{bmatrix} \tag{2.11}$$

and

$$\widetilde{\boldsymbol{G}}_i = \begin{bmatrix} \frac{\tau^2}{2}\alpha_i^1 + \frac{3\tau^2}{2}\alpha_i^2 & \frac{\tau^3}{2}\alpha_i^1 + 3\tau^3\alpha_i^2 + \tau\beta_i^1 + \tau\beta_i^2 \\ \frac{\tau^2}{2}\alpha_i^2 & \tau^3\alpha_i^2 + \tau\beta_i^2 \\ 0 & 0 \\ \vdots & \vdots \\ 0 & 0 \end{bmatrix}. \tag{2.12}$$

Observe that $\widetilde{\boldsymbol{H}}_i$ in (2.11) is a block diagonal matrix of the form $\widetilde{\boldsymbol{H}}_i = \operatorname{diag}\left(\widetilde{\boldsymbol{H}}_{i,1}, \widetilde{\boldsymbol{H}}_{i,2}\right)$ where $\widetilde{\boldsymbol{H}}_{i,1} \in \mathbb{R}^{2\times 2}$ and $\widetilde{\boldsymbol{H}}_{i,2} \in \mathbb{R}^{(p-2)\times(p-2)}$. From this perspective, it is easy to see that the inverse of $\widetilde{\boldsymbol{H}}_i$ is given by the block diagonal matrix $\widetilde{\boldsymbol{H}}_i^{-1} = \operatorname{diag}\left(\widetilde{\boldsymbol{H}}_{i,1}^{-1}, \widetilde{\boldsymbol{H}}_{i,2}^{-1}\right)$. Moreover, since $\widetilde{\boldsymbol{H}}_{i,1}$ is $2 \times 2$ and $\widetilde{\boldsymbol{H}}_{i,2}$ is diagonal, their inverses are easily computed.

Let $\tilde{d} := \det \widetilde{\boldsymbol{H}}_{i,1}$. Then

$$\widetilde{\boldsymbol{H}}_i^{-1} = \begin{bmatrix} \frac{1}{\tilde{d}}\left(\frac{\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^2 + \tau^2\zeta_i^2\right) & \frac{-1}{\tilde{d}}\left(\frac{3\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^2\right) \\ \frac{-1}{\tilde{d}}\left(\frac{3\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^2\right) & \frac{1}{\tilde{d}}\left(\frac{\tau^4}{4}\alpha_i^1 + \frac{9\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^1 + \tau^2\beta_i^2 + \tau \right. \\ & \end{bmatrix} \tag{2.13}$$

Hence, we can immediately compute the product $\widetilde{\boldsymbol{H}}_i^{-1}\widetilde{\boldsymbol{G}}_i$ in the expression for $\widetilde{\boldsymbol{K}}_i$ in (2.7) to obtain the new expression

$$\widetilde{\boldsymbol{K}}_i := -\boldsymbol{e}_1^T \begin{bmatrix} k_{1,1} & k_{1,2} \\ k_{2,1} & k_{2,2} \\ 0 & 0 \\ \vdots & \vdots \\ 0 & 0 \end{bmatrix} \in \mathbb{R}^{1\times 2} \tag{2.14}$$

where

$$
\begin{aligned}
&k_{1,1} = \tfrac{1}{\tilde{d}}\left(\tfrac{\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^2 + \tau^2\zeta_i^2\right)\left(\tfrac{\tau^2}{2}\alpha_i^1 + \tfrac{3\tau^2}{2}\alpha_i^2\right) + \tfrac{-1}{\tilde{d}}\left(\tfrac{3\tau^4}{4}\alpha_i^2 + \right.\\
&\left.\tau^2\beta_i^2\right)\left(\tfrac{\tau^2}{2}\alpha_i^2\right),\\
&k_{1,2} = \tfrac{1}{\tilde{d}}\left(\tfrac{\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^2 + \tau^2\zeta_i^2\right)\left(\tfrac{\tau^3}{2}\alpha_i^1 + 3\tau^3\alpha_i^2 + \tau\beta_i^1 + \tau\beta_i^2\right) +\\
&\tfrac{1}{\tilde{d}}\left(\tfrac{3\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^2\right)(\tau^3\alpha_i^2 + \tau\beta_i^2),\\
&k_{2,1} = \tfrac{-1}{\tilde{d}}\left(\tfrac{3\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^2\right)\left(\tfrac{\tau^2}{2}\alpha_i^1 + \tfrac{3\tau^2}{2}\alpha_i^2\right) + \tfrac{1}{\tilde{d}}\left(\tfrac{\tau^4}{4}\alpha_i^1 + \tfrac{9\tau^4}{4}\alpha_i^2 + \right.\\
&\left.\tau^2\beta_i^1 + \tau^2\beta_i^2 + \tau^2\zeta_i^1\right)\left(\tfrac{\tau^2}{2}\alpha_i^2\right), \text{ and}\\
&k_{2,2} = \tfrac{-1}{\tilde{d}}\left(\tfrac{3\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^2\right)\left(\tfrac{\tau^3}{2}\alpha_i^1 + 3\tau^3\alpha_i^2 + \tau\beta_i^1 + \tau\beta_i^2\right) +\\
&\tfrac{1}{\tilde{d}}\left(\tfrac{\tau^4}{4}\alpha_i^1 + \tfrac{9\tau^4}{4}\alpha_i^2 + \tau^2\beta_i^1 + \tau^2\beta_i^2 + \tau^2\zeta_i^1\right)(\tau^3\alpha_i^2 + \tau\beta_i^2).
\end{aligned}
\tag{2.15}
$$

Next, let $d' := \frac{\tilde{d}}{\tau^4} = \frac{\det \tilde{\boldsymbol{H}}_{i,1}}{\tau^4}$ and $d_s := \frac{\tau^2}{4}\alpha_i^s + \beta_i^s + \zeta_i^s$ (for each $s = 1, \ldots, p$). Then after making some simplifications, we importantly have that

$$
\underbrace{k_{1,1} = \frac{d_2\alpha_i^1 + \alpha_i^2(2\beta_i^2 + 3\zeta_i^2)}{2d'}}_{-c_1}
$$

and

$$
k_{1,2} = \underbrace{\frac{d_2\left(\frac{\tau^2}{2}\alpha_i^1 + \beta_i^1\right) + \frac{3\tau^2}{2}\alpha_i^2\beta_i^2 + \zeta_i^2(3\tau^2\alpha_i^2 + \beta_i^2)}{\tau d'}}_{-c_2},
\tag{2.16}
$$

where we have let $c_1 := -k_{1,1}$ and $c_2 := -k_{1,2}$. It follows from (2.14) that

$$
\widetilde{\boldsymbol{K}}_i = [c_1 \quad c_2].
\tag{2.17}
$$

At this point, our goal is to leverage the form of $c_1$ and $c_2$ to show that the eigenvalues of $\tilde{A}_i$ satisfy $|\mu| < 1$. Since $\tilde{A}_i$ is a $2 \times 2$ real matrix, it has a pair of two eigenvalues, say $(\mu_{i,1}, \mu_{i,2})$, which are either both complex (in which case $\mu_{i,1} = \bar{\mu}_{i,2}$) or both real. In prior iterations of this research, it has been shown that if there exist strictly positive numbers $\alpha', \beta'$, and $\gamma'$ such that $d' = \frac{\tau^2}{4}\alpha' + \beta' + \gamma' > 0$ and

$$\tilde{A}_i = \begin{bmatrix} 1 - \frac{\alpha'\tau^2}{4d'} & \tau\left(1 - \left(\frac{\alpha'\tau^2}{4} + \frac{\beta'}{2}\right)\frac{1}{d'}\right) \\ -\frac{\alpha'\tau}{2d'} & 1 - \left(\frac{\alpha'\tau^2}{2} + \beta'\right)\frac{1}{d'} \end{bmatrix}, \tag{2.18}$$

then $|\mu_{i,1}| < 1$ and $|\mu_{i,2}| < 1$, whether real or complex. Interested readers can consult Gong et al. for a proof of this intermediate result.

Note that, by virtue of (2.6) and (2.17), we have that

$$\begin{aligned} \tilde{A}_i &= \begin{bmatrix} 1 & \tau \\ 0 & 1 \end{bmatrix} + \begin{bmatrix} \frac{\tau^2}{2} \\ \tau \end{bmatrix} \begin{bmatrix} c_1 & c_2 \end{bmatrix} = \begin{bmatrix} 1 & \tau \\ 0 & 1 \end{bmatrix} + \begin{bmatrix} \frac{\tau^2}{2}c_1 & \frac{\tau^2}{2}c_2 \\ \tau c_1 & \tau c_2 \end{bmatrix} \\ &= \begin{bmatrix} 1 + \frac{\tau^2}{2}c_1 & \tau + \frac{\tau^2}{2}c_2 \\ \tau c_1 & 1 + \tau c_2 \end{bmatrix}. \end{aligned} \tag{2.19}$$

Then, substituting the definitions of $c_1$ and $c_2$ from (2.16) and letting

$$\begin{aligned} &\alpha' \coloneqq d_2\alpha_i^1 + \alpha_i^2(2\beta_i^2 + 3\zeta_i^2) > 0, \\ &\beta' \coloneqq d_2\beta_i^1 + \frac{\tau^2}{2}\alpha_i^2\beta_i^2 + \zeta_i^2\left(\frac{3\tau^2}{2}\alpha_i^2 + \beta_i^2\right) > 0, \text{ and} \\ &\gamma' \coloneqq d_2\zeta_i^1 > 0, \end{aligned} \tag{2.20}$$

one can directly compute $d' = \frac{\det \tilde{\boldsymbol{H}}_{i,1}}{\tau^4}$ and verify that $d' = \frac{\tau^2}{4}\alpha' + \beta' + \gamma' > 0$ is satisfied. Thus, since $\sigma(A)$, the set of the eigenvalues of $A$, is precisely the union of the eigenvalue pairs of each $\tilde{A}_i$, it follows that $A$ is Schur stable for $p = 3$ (and in fact for each $p \geq 3$) under the simplified assumptions stated in (2.10).

However, the assumptions on the penalty weights in (2.10) do not generally apply. In particular, it is usually not assumed that $\alpha_i^s = \beta_i^s = 0$ for each $s = 3, \dots, p$. Rather, we want to prove asymptotic stability when these are nonnegative, i.e. they are zero *or* strictly positive. Thus, to complete the proof for $p = 3$, we must consider the second case where $\alpha_i^3, \beta_i^3 > 0$.

Let $p = 3$ and consider penalty weights satisfying

$$\alpha_i^1, \beta_i^1, \zeta_i^1 > 0, \qquad \alpha_i^2, \beta_i^2 \geq 0, \zeta_i^2 > 0, \qquad \alpha_i^3, \beta_i^3, \zeta_i^3 > 0 \tag{2.21}$$

for each $i = 1, \dots, n$. In this setting, $\boldsymbol{H}$ and $\boldsymbol{G}$ have the forms

$$\boldsymbol{H} = \begin{bmatrix} \boldsymbol{H}_{1,1} + \tau^2 Q_{w,1} & \boldsymbol{H}_{1,2} & \boldsymbol{H}_{1,3} \\ \boldsymbol{H}_{2,1} & \boldsymbol{H}_{2,2} + \tau^2 Q_{w,2} & \boldsymbol{H}_{2,3} \\ \boldsymbol{H}_{3,1} & \boldsymbol{H}_{3,2} & \boldsymbol{H}_{3,3} + \tau^2 Q_{w,3} \end{bmatrix} \in \mathbb{R}^{3n \times 3n}$$

and

$$\boldsymbol{G} = \begin{bmatrix} \boldsymbol{G}_{1,1} & \boldsymbol{G}_{1,2} \\ \boldsymbol{G}_{2,1} & \boldsymbol{G}_{2,2} \\ \boldsymbol{G}_{3,1} & \boldsymbol{G}_{3,2} \end{bmatrix} \in \mathbb{R}^{3n \times 2n}$$

Moreover, using $E$ and $\hat{E}$ as introduced in (2.1) and (2.3), except where the value of $p$ is now specified to be 3 for $\hat{E}$, the similarity transformation $\tilde{A} \coloneqq E^T A E = \operatorname{diag}(\tilde{A}_1, \tilde{A}_2, \dots, \tilde{A}_n)$ again yields block $\tilde{A}_i$'s of the form

$$\tilde{A}_i = \begin{bmatrix} 1 & \tau \\ 0 & 1 \end{bmatrix} + \begin{bmatrix} \frac{\tau^2}{2} \\ \tau \end{bmatrix} \widetilde{\boldsymbol{K}}_i \in \mathbb{R}^{2\times 2}, \qquad (i = 1, \dots, n)$$

where

$$\widetilde{\boldsymbol{K}}_i \coloneqq -e_1^T \widetilde{\mathbf{H}}^{-1} \widetilde{\boldsymbol{G}}_i \in \mathbb{R}^{1\times 2},$$

$$\widetilde{\boldsymbol{H}}_i \coloneqq \begin{bmatrix} \left(\boldsymbol{H}_{1,1} + \tau^2 Q_{w,1}\right)_{i,i} & \left(\boldsymbol{H}_{1,2}\right)_{i,i} & \left(\boldsymbol{H}_{1,3}\right)_{i,i} \\ \left(\boldsymbol{H}_{2,1}\right)_{i,i} & \left(\boldsymbol{H}_{2,2} + \tau^2 Q_{w,2}\right)_{i,i} & \left(\boldsymbol{H}_{2,3}\right)_{i,i} \\ \left(\boldsymbol{H}_{3,1}\right)_{i,i} & \left(\boldsymbol{H}_{3,2}\right)_{i,i} & \left(\boldsymbol{H}_{3,3} + \tau^2 Q_{w,3}\right)_{i,i} \end{bmatrix} \in \mathbb{R}^{3\times 3},$$

and

$$\widetilde{\boldsymbol{G}}_i \coloneqq \begin{bmatrix} \left(\boldsymbol{G}_{1,1}\right)_{i,i} & \left(\boldsymbol{G}_{1,2}\right)_{i,i} \\ \left(\boldsymbol{G}_{2,1}\right)_{i,i} & \left(\boldsymbol{G}_{2,2}\right)_{i,i} \\ \left(\boldsymbol{G}_{3,1}\right)_{i,i} & \left(\boldsymbol{G}_{3,2}\right)_{i,i} \end{bmatrix} \in \mathbb{R}^{3\times 2}$$

for each $i = 1, \dots, n$.

In particular, $\widetilde{\boldsymbol{H}}_i$ and $\widetilde{\boldsymbol{G}}_i$ can be written in terms of the penalty weights as

$$\widetilde{\boldsymbol{H}}_i = \begin{bmatrix} \frac{\tau^2}{4}\alpha_i^1 + \frac{9\tau^2}{4}\alpha_i^2 + \frac{25\tau^2}{4}\alpha_i^3 + \beta_i^1 + \beta_i^2 + \beta_i^3 + \zeta_i^1 & \frac{3\tau^2}{4}\alpha_i^2 + \frac{15\tau^2}{4}\alpha_i^3 + \beta_i^2 + \beta_i^3 & \frac{5\tau^2}{4}\alpha_i^3 + \beta_i^3 \\ \frac{3\tau^2}{4}\alpha_i^2 + \frac{15\tau^2}{4}\alpha_i^3 + \beta_i^2 + \beta_i^3 & \frac{\tau^2}{4}\alpha_i^2 + \frac{9\tau^2}{4}\alpha_i^3 + \beta_i^2 + \beta_i^3 + \zeta_i^2 & \frac{3\tau^2}{4}\alpha_i^3 + \beta_i^3 \\ \frac{5\tau^2}{4}\alpha_i^3 + \beta_i^3 & \frac{3\tau^2}{4}\alpha_i^3 + \beta_i^3 & \frac{\tau^2}{4}\alpha_i^3 + \beta_i^3 + \zeta_i^3 \end{bmatrix} \in \mathbb{R}^{3\times 3},$$

And

$$\widetilde{\boldsymbol{G}}_i = \begin{bmatrix} \frac{\tau^2}{2}\alpha_i^1 + \frac{3\tau^2}{2}\alpha_i^2 + \frac{5\tau^2}{2}\alpha_i^3 & \frac{\tau^3}{2}\alpha_i^1 + 3\tau^3\alpha_i^2 + \frac{15\tau^3}{2}\alpha_i^3 + \tau\beta_i^1 + \tau\beta_i^2 + \tau\beta_i^3 \\ \frac{\tau^2}{2}\alpha_i^2 + \frac{3\tau^2}{2}\alpha_i^3 & \tau^3\alpha_i^2 + \frac{9\tau^3}{2}\alpha_i^3 + \tau\beta_i^2 + \tau\beta_i^3 \\ \frac{\tau^2}{2}\alpha_i^3 & \frac{3\tau^3}{2}\alpha_i^3 + \tau\beta_i^3 \end{bmatrix} \in \mathbb{R}^{3\times 2}.$$

We then directly compute $\widetilde{\boldsymbol{H}}_i^{-1}$ to be of the form

$$\widetilde{\boldsymbol{H}}_i^{-1} = \frac{\tau^4}{\det \widetilde{\boldsymbol{H}}_i}\begin{bmatrix} h_{1,1} & -h_{2,1} & h_{3,1} \\ -h_{1,2} & h_{2,2} & -h_{3,2} \\ h_{1,3} & -h_{2,3} & h_{3,3} \end{bmatrix}$$

where each $h_{i,j}$ is the determinant of the corresponding determinant of the $2 \times 2$ matrix obtained by deleting the $i^{\text{th}}$ row and $j^{\text{th}}$ column of $\widetilde{\boldsymbol{H}}_i$ except that a factor of $\tau^4$ has been factored out after computing the determinants. While not *all* of the entries of $\widetilde{\boldsymbol{H}}_i^{-1}$ are relevant to subsequent parts of the proof, we importantly note that

$$\begin{aligned}
h_{1,1} &= \tfrac{\tau^4}{16}\alpha_i^2\alpha_i^3 + \tfrac{\tau^2}{4}\alpha_i^3\beta_i^2 + \tau^2\alpha_i^3\beta_i^3 + \tfrac{\tau^2}{4}\alpha_i^3\zeta_i^2 + \tfrac{\tau^2}{4}\alpha_i^2\beta_i^3 + \beta_i^2\beta_i^3 + \\
&\beta_i^3\zeta_i^2 + \tfrac{\tau^2}{4}\alpha_i^2\zeta_i^3 + \tfrac{9\tau^2}{4}\alpha_i^3\zeta_i^3 + \beta_i^2\zeta_i^3 + \beta_i^3\zeta_i^3 + \zeta_i^2\zeta_i^3, \\
h_{1,2} &= \tfrac{3\tau^4}{16}\alpha_i^2\alpha_i^3 + \tfrac{\tau^2}{4}\alpha_i^3\beta_i^2 + 2\tau^2\alpha_i^3\beta_i^3 + \tfrac{3\tau^2}{4}\alpha_i^2\beta_i^3 + \beta_i^2\beta_i^3 + \tfrac{3\tau^2}{4}\alpha_i^2\zeta_i^3 + \\
&\tfrac{15\tau^2}{4}\alpha_i^3\zeta_i^3 + \beta_i^2\zeta_i^3 + \beta_i^3\zeta_i^3, \text{ and} \\
h_{1,3} &= \frac{4\tau^4}{16}\alpha_i^2\alpha_i^3 + \frac{2\tau^2}{4}\alpha_i^2\beta_i^3 + \tau^2\alpha_i^3\beta_i^3 - \frac{2\tau^2}{4}\alpha_i^3\beta_i^2 - \frac{5\tau^2}{4}\alpha_i^3\zeta_i^2 - \beta_i^3\zeta_i^2,
\end{aligned} \tag{2.23}$$

where $h_{1,2} = h_{2,1}$ and $h_{1,3} = h_{3,1}$ by symmetry of $\widetilde{\boldsymbol{H}}_i$.

Subsequently, we again compute $\widetilde{\boldsymbol{K}}_i$ to be

$$\begin{aligned}
\widetilde{\boldsymbol{K}}_i &= -[1 \quad 0 \quad 0]\left(\frac{\tau^4}{\det \widetilde{\boldsymbol{H}}_i}\begin{bmatrix} h_{1,1} & -h_{2,1} & h_{3,1} \\ -h_{1,2} & h_{2,2} & -h_{3,2} \\ h_{1,3} & -h_{2,3} & h_{3,3} \end{bmatrix}\right)\widetilde{\boldsymbol{G}}_i \\
&= \frac{-\tau^4}{\det \widetilde{\boldsymbol{H}}_i}[h_{1,1} \quad -h_{2,1} \quad h_{3,1}]\widetilde{\boldsymbol{G}}_i,
\end{aligned}$$

that is,

$$\widetilde{\boldsymbol{K}}_i = \tfrac{-\tau^4}{det\, \widetilde{\boldsymbol{H}}_i}[h_{1,1} \quad -h_{1,2} \quad h_{1,3}]\widetilde{\boldsymbol{G}}_i \in \mathbb{R}^{1\times 2}. \tag{2.24}$$

Next, again denoting the two elements of $\widetilde{\boldsymbol{K}}_i$ as $c_1$ and $c_2$ respectively, we directly compute from (2.22), (2.23), and (2.24) that

$$\begin{aligned}
c_1 = -\frac{1}{2d'}\Bigg[&\left(d_2d_3 + \frac{\tau^2\alpha_i^3}{4}(4\beta_i^3 + 9\zeta_i^3) + \beta_i^3\zeta_i^3\right)(\alpha_i^1) \\
&+ \left(d_3(2\beta_i^2 + 3\zeta_i^2) + \frac{\tau^2\alpha_i^3}{4}(2\beta_i^3 + 8\zeta_i^3) + 2\beta_i^3\zeta_i^3\right)(\alpha_i^2) \\
&+ (4\beta_i^3\zeta_i^2 + 2\beta_i^2\beta_i^3 + 2\beta_i^2\zeta_i^3 + 2\beta_i^3\zeta_i^3 + 5\zeta_i^2\zeta_i^3)(\alpha_i^3)\Bigg]
\end{aligned} \tag{2.25}$$

$$
\begin{aligned}
c_2 = -\frac{1}{\tau d'}\Bigg[&\left(d_2 d_3 + \frac{\tau^2 \alpha_i^3}{4}(4\beta_i^3 + 9\zeta_i^3) + \beta_i^3 \zeta_i^3\right)\left(\frac{\tau^2}{2}\alpha_i^1 + \beta_i^1\right) \\
&+ \left(d_3\left(\frac{3\beta_i^2}{2} + 3\zeta_i^2\right) + \frac{\tau^2 \alpha_i^3}{4}(\beta_i^3 + 6\zeta_i^3) + \frac{3}{2}\beta_i^3 \zeta_i^3\right)(\tau^2 \alpha_i^2) \\
&+ (d_3 \zeta_i^2)(\beta_i^2) \\
&+ (10\beta_i^3 \zeta_i^2 + 3\beta_i^2 \beta_i^3 + 3\beta_i^2 \zeta_i^3 + 3\beta_i^3 \zeta_i^3 + 15\zeta_i^2 \zeta_i^3)\left(\frac{\tau^2 \alpha_i^3}{2}\right) \\
&+ \left(\frac{2\tau^4}{16}\alpha_i^2 \alpha_i^3 + \zeta_i^2 \zeta_i^3\right)(\beta_i^3)\Bigg]
\end{aligned}
$$

where $d_s$ has the same definition as before, and we now define $d' := \frac{det\, \tilde{\boldsymbol{H}}_i}{\tau^6}$. As before, our goal is to find positive numbers $\alpha', \beta'$, and $\gamma' > 0$ such that $d' = \frac{\tau^2}{4}\alpha' + \beta' + \gamma' > 0$ and the block matrix $\tilde{A}_i$ has the same form as in (2.18). While the process is the same, the work required to determine $d'$ is quite extensive. A direct computation and several rounds of simplification yield

$$
\begin{aligned}
d' = &\frac{\tau^2}{4}\alpha_i^1 d_2 d_3 + \frac{3\tau^2}{4}\alpha_i^2 \beta_i^2 d_3 + \frac{9\tau^2}{4}\alpha_i^2 \zeta_i^2 d_3 + \frac{15\tau^2}{4}\alpha_i^3 \beta_i^3 \zeta_i^2 + \frac{25\tau^2}{4}\alpha_i^3 \zeta_i^2 \zeta_i^3 \\
&+ \beta_i^1 d_2 d_3 + \frac{\tau^2}{4}\alpha_i^2 \beta_i^2 d_3 + \beta_i^2 \zeta_i^2 d_3 + \frac{\tau^2}{4}\alpha_i^3 \beta_i^3 \zeta_i^2 + \beta_i^3 \zeta_i^2 \zeta_i^3 \\
&+ \zeta_i^1 d_2 d_3 + \frac{\tau^4}{4}\alpha_i^1 \alpha_i^3 \beta_i^3 + \tau^2 \alpha_i^3 \beta_i^1 \beta_i^3 + \tau^2 \alpha_i^3 \beta_i^2 \beta_i^3 \\
&+ \tau^2 \alpha_i^3 \beta_i^3 \zeta_i^1 + \frac{9\tau^4}{16}\alpha_i^1 \alpha_i^3 \zeta_i^3 + \frac{9\tau^2}{4}\alpha_i^3 \beta_i^1 \zeta_i^3 + \tau^2 \alpha_i^3 \beta_i^3 \zeta_i^3 \\
&+ \frac{9\tau^2}{4}\alpha_i^3 \zeta_i^1 \zeta_i^3 + \frac{\tau^2}{4}\alpha_i^1 \beta_i^3 \zeta_i^3 + \beta_i^1 \beta_i^3 \zeta_i^3 + \beta_i^3 \zeta_i^1 \zeta_i^3 \\
&+ \frac{2\tau^4}{16}\alpha_i^2 \alpha_i^3 \beta_i^3 + \tau^4 \alpha_i^2 \alpha_i^3 \zeta_i^3 + \tau^2 \alpha_i^2 \beta_i^3 \zeta_i^3 + \frac{2\tau^4}{16}\alpha_i^2 \alpha_i^3 \beta_i^3 \\
&+ \tau^2 \alpha_i^3 \beta_i^2 \zeta_i^3 > 0.
\end{aligned} \tag{2.26}
$$

Then, in order to determine $\alpha', \beta'$, and $\gamma'$ we again use the connection between $c_1$ and $c_2$ and $\alpha'$ and $\beta'$ implied by (2.18) and (2.19). In particular, note that $\alpha' = 2d'c_1$ and $\beta' = -\frac{\tau^2}{2}\alpha' - \tau d' c_1$. It follows that

$$
\begin{aligned}
\alpha' = &\left(d_2 d_3 + \frac{\tau^2 \alpha_i^3}{4}(4\beta_i^3 + 9\zeta_i^3) + \beta_i^3 \zeta_i^3\right)(\alpha_i^1) \\
&+ \Bigg(d_3(2\beta_i^2 + 3\zeta_i^2) + \frac{\tau^2 \alpha_i^3}{4}(2\beta_i^3 + 8\zeta_i^3) \\
&+ 2\beta_i^3 \zeta_i^3\Bigg)(\alpha_i^2) \\
&+ (4\beta_i^3 \zeta_i^2 + 2\beta_i^2 \beta_i^3 + 2\beta_i^2 \zeta_i^3 + 2\beta_i^3 \zeta_i^3 \\
&+ 5\zeta_i^2 \zeta_i^3)(\alpha_i^3) > 0
\end{aligned} \tag{2.27}
$$

and

$$\beta' = \left(d_2 d_3 + \frac{\tau^2 \alpha_i^3}{4}(4\beta_i^3 + 9\zeta_i^3) + \beta_i^3 \zeta_i^3\right)(\beta_i^1) + \left(d_3\left(\frac{1}{2}\beta_i^2 + \frac{3}{2}\zeta_i^2\right) + \frac{2\tau^2}{4}\alpha_i^3 \zeta_i^3 + \beta_i^3 \zeta_i^3\right)(\tau^2 \alpha_i^2) + (d_3 \zeta_i^2)(\beta_i^2) + (6\beta_i^3 \zeta_i^2 + \beta_i^2 \beta_i^3 + \beta_i^2 \zeta_i^3 + \beta_i^3 \zeta_i^3 + 10\zeta_i^2 \zeta_i^3)\left(\frac{\tau^2 \alpha_i^3}{2}\right) + \left(\frac{2\tau^4}{16}\alpha_i^2 \alpha_i^3 + \zeta_i^2 \zeta_i^3\right)(\beta_i^3) > 0.$$

Finally, we use the anticipated relationship $d' = \frac{\tau^2}{4}\alpha' + \beta' + \gamma'$, (2.26), and (2.27) to find that

$$\gamma' = d' - \frac{\tau^2}{4}\alpha' - \beta' = \zeta_i^1 d_2 d_3 + \tau^2 \alpha_i^3 \beta_i^3 \zeta_i^1 + \frac{9\tau^2}{4}\alpha_i^3 \zeta_i^1 \zeta_i^3 + \beta_i^3 \zeta_i^1 \zeta_i^3 > 0. \tag{2.28}$$

Once again, it then follows from the results of Gong et al. discussed earlier that $A$ is always Schur stable for $p = 3$ when $\alpha_i^1, \beta_i^1, \zeta_i^1 > 0,\ \alpha_i^2, \beta_i^2 \geq 0, \zeta_i^2 > 0,$ $\alpha_i^3, \beta_i^3 \geq 0,\ \zeta_i^3 > 0$ for each $i = 1, \ldots, n$. That is, for penalty weights selected under these constraints, it is mathematically certain that the linear vehicle dynamics will converge to the desired equilibrium traffic flow as time passes. Since this style of proof has been successfully applied to horizons of $p = 1, p = 2,$ and $p = 3$, we speculate that a similar procedure would prevail for horizons of $p \geq 4$ investigated one-by-one. However, as the computations become exponentially denser and more complex, this cannot be considered an efficient process for proving Schur stability for a general $p$-horizon on its own. Nevertheless, future work could focus on making use of the results presented in this section to construct a proof by induction for the general case.

# Numerical Work

In lieu of an analytical proof for the asymptotic stability of the vehicle dynamics for a general $p$-horizon, we opted to gain additional insight through numerical simulation of the system. This exploration not only provided helpful observations of the asymptotic stability of the vehicle dynamics, ; it also served to confirm whether the transient dynamics, i.e., the short-term driving behaviors of the vehicle platoon, were satisfactory for appropriately chosen penalty weights. If the simulations of the vehicle dynamics for larger p-horizons showed worsening transient dynamics, then there would be cause

to make significant revisions to the model. In this sense, the numerical findings were especially relevant to the control scheme's practical implementation.

We considered a platoon of $n = 10$ CAVs following behind an uncontrolled leading vehicle on a straight roadway subject to the closed-loop dynamics as stated in (1.14) with a sampling time of $\tau = 1$ second. Since the focus of this study is primarily the stability of the linear closed-loop vehicle dynamics, we simplified this numerical work by performing simulations for the case when $u_0(k) = 0$ for all times $k$. This simplification is tantamount to supposing that the leading vehicle does not accelerate, the effect of which is captured by the term independent of $z(k)$ and $z'(k)$ on the right-hand side of (1.14). In this sense, these simulations emphasize the role of the matrix $A$ in controlling the vehicle dynamics. However, it would be prudent to simulate vehicle dynamics for nonzero $u_0(k)$ in future work.

In particular, we simulated the closed-loop dynamics for a period of 100 seconds for basic initial conditions of the form $\big(z(0), z'(0)\big) = (\pm\mathbf{1}, \pm 0.1 \cdot \mathbf{1})$, where $\mathbf{1}$ is again the vector of ones in $\mathbb{R}^n$. Performing computations in MATLAB, we chose values for the penalty weights $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, and $\boldsymbol{\zeta}$ such that $z(k)$ and $z'(k)$ converged to zero in under 50 seconds while preventing the control input $u(k)$ from exceeding a peak value of 0.85. Satisfying these criteria was tricky, but by testing a variety of penalty weights – starting with $p = 1$ – certain patterns emerged that guided the selection of penalty weights to yield desirable vehicle dynamics. Subsequently, for larger values of $p$, the penalty weights were chosen in such a way that similar dynamics to the $p = 1$ case were maintained. Since the resulting dynamics were so alike, only the vehicle dynamics for $p = 3$ under the initial conditions $\big(z(0), z'(0)\big) = (\mathbf{1}, 0.1 \cdot \mathbf{1})$ need be shown on the next page in **Figure 3.**

**Figure 3A** depicts $z_i(k)$ for each $i = 1, \ldots, 10$, representing the ten CAVs' spacing from the vehicle in front of them. Similarly, to its right, **Figure 3B** depicts $z_i'(k)$ for each $i = 1, \ldots, 10$, representing the ten CAVs' speeds relative to the vehicle in front of them. **Figure 3C** depicts $u_i(k)$ for each $i = 1, \ldots, 10$, representing the control inputs (i.e. accelerations) for each CAV in the platoon. Convergence of $z_i(k)$ and $z_i'(k)$ to zero is seen to be achieved in approximately 40 seconds with no apparent oscillations, and $u_i(k)$ is seen to be most active in the early seconds of adjustments after which it quickly dissipates. These observations are considered satisfactory in terms of both transient and asymptotic performance. Moreover, while only the dynamics for $p = 3$ are shown here, it should be reemphasized that the simulations for $p = 1$, $p = 2$ *and* $p \geq 4$ remain virtually unchanged for appropriate choices of penalty weights. The dynamics shown in **Figure 3** were produced with the penalty weights shown below in **Table 1.**

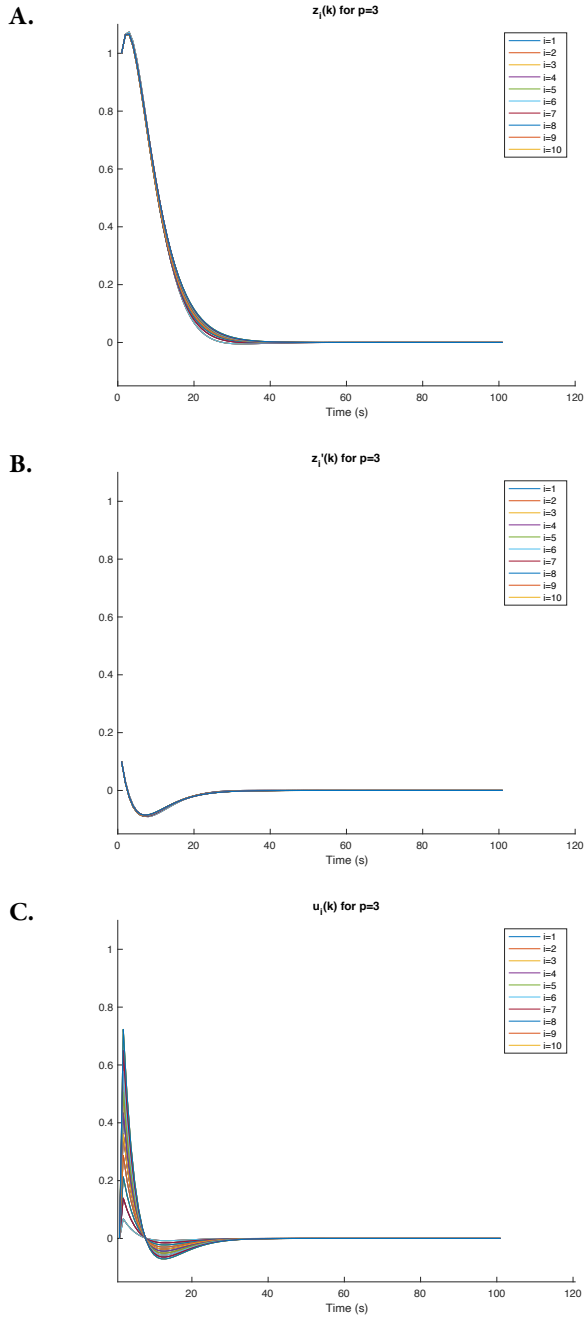



**Figure 3.** Numerical Simulation of Vehicle Platoon Dynamic for an MPC *p*- horizon of *p*=3.

| | Penalty Weights |
|---|---|
| $s = 1$ | $\alpha^1 = (4, 4.4, 4.8, 5.2, 5.6, 6.0, 6.4, 6.8, 7.2, 7.6)$<br>$\beta^1 = (16, 18, 20, 22, 24, 26, 28, 30, 32, 34)$<br>$\zeta^1 = (40, 41, 43, 46, 50, 55, 60, 64, 67, 69)$ |
| $s = 2$ | $\alpha^2 = (0.04, 0.044, 0.048, 0.052, 0.056, 0.060, 0.064, 0.068, 0.072, 0.076)$<br>$\beta^2 = (0.16, 0.18, 0.20, 0.22, 0.24, 0.26, 0.28, 0.30, 0.32, 0.34)$<br>$\zeta^2 = (0.40, 0.41, 0.43, 0.46, 0.50, 0.55, 0.60, 0.64, 0.67, 0.69)$ |
| $s = 3$ | $\alpha^3$<br>$= (0.004, 0.0044, 0.0048, 0.0052, 0.0056, 0.0060, 0.0064, 0.0068, 0.0072, 0.0076)$<br>$\beta^3 = (0.016, 0.018, 0.020, 0.022, 0.024, 0.026, 0.028, 0.030, 0.032, 0.034)$<br>$\zeta^3 = (0.040, 0.041, 0.043, 0.046, 0.050, 0.055, 0.060, 0.064, 0.067, 0.069)$ |

**Table 1.** Penalty Weights for $p$=3 Numerical Simulations

Interestingly, different choices of penalty weights are capable of yielding somewhat faster convergence of $z(k)$ and $z'(k)$ to zero, especially when simulating the closed-loop dynamics of larger $p$-horizons, at the expense of the desired size limit on $\mu(k)$. However, since large control inputs are undesirable for driver comfort and safety, such choices of penalty weights are avoided for the time being. Future work may address this issue by adjusting aspects of the model to achieve more efficient convergence of $z(k)$ and $z'(k)$ while preventing the over-saturation of control inputs for larger values of $p$. Moreover, at some point, it may be prudent to simulate a greater variety of initial conditions as well as scenarios when $\mu(k)$ is nonzero to assess the performance of the general MPC $p$-horizon model to the fullest extent possible. That being said, the numerical results shown in **Figure 3** serve as strong indicators that the linear closed-loop dynamics are Schur stable for a general $p$ as they do not seem to worsen for larger values of $p$. As such, it would be sensible to work towards devising analytical means of proving this stability result in a general setting.

# Discussion

The model from Gong et al. considered in this research uses a one-horizon MPC approach in order to control the linear dynamics of a platoon of CAVs driving behind an uncontrolled leading vehicle on a straight roadway. However, in hopes of achieving improved model performance, this research looked at an extension of this model to a general $p$-horizon MPC approach. At each discrete time step, the control inputs – the accelerations of the CAVs – are determined through the application of an optimization problem presented in (1.6). Its solution is dependent upon the current state of the linear platoon dynamics in addition to the prior selection of penalty weights. As such, it is important to establish that the solution gives rise to stable

vehicle dynamics for a wide range of possible penalty weights and for any state of the system. We demonstrated that for penalty weights satisfying the conditions in (2.21), the vehicle dynamics are globally asymptotically stable up to a $p$-horizon of $p$=3. This was accomplished by mathematically verifying that the matrix $A$ which describes the closed-loop linear vehicle dynamics is Schur stable for $p$-horizons up to $p$=3.

Our methods for establishing the Schur stability of $A$ could be described as being direct and brute force. The advantage of this approach is that the steps of the mathematical argument are transparent and relatively easy to trace back and verify. However, it would be impractical to continue this approach indefinitely for arbitrarily larger $p$-horizons, as the algebraic component of the argumentation would become increasingly dense and convoluted. For this reason, it would be prudent to devote future efforts towards finding patterns in our proofs of Schur stability for $p$=1,$p$=2, and $p$=3 so as to possibly develop a proof by induction for the general case. This result would be unquestionably stronger, signifying that any choice of a finite integer $p$-horizon MPC model would have asymptotically stable vehicle dynamics.

It should also be noted that while this research established the Schur stability criterion for asymptotic stability, it hasn't considered the rate of convergence of the linear vehicle dynamics to equilibrium traffic flow. This is unlike Gong et al. which verifies that its algorithms are able to achieve fast numerical performance [51]. In principle, the extension to a $p$-horizon MPC model should allow for further refinement of the rate of convergence as compared to the one-horizon case studied in Gong et al. since the $p$-horizon-based control scheme better anticipates how the vehicle motions will evolve at more distant time steps. The results of our numerical simulations verify that the penalty weights can be chosen appropriately to at least obtain performance comparable to what the one-horizon model achieves for the first several $p$-horizons, indicating this likely holds true for a general $p$-horizon. But this still needs to be proven rigorously. Ideally, future work should therefore also consider the rate of convergence of the $p$-horizon MPC model, and it should endeavor to achieve improved performance as compared to the one-horizon case. That being said, the first objective should be to demonstrate asymptotic stability for a general $p$-horizon, and to that end, this research certainly gets us one step closer.

# Conclusion

This paper promotes the discussion of the asymptotic stability of linear closed-loop vehicle dynamics whose car-following behaviors are determined by an MPC scheme with a general p-horizon. In particular, the matrix A which plays a crucial role in determining both closed-loop stability and transient dynamical performance is shown to be Schur stable for a horizon of p=3. This result mathematically ensures that the linear vehicle dynamics will converge to the desired equilibrium traffic flow for p-horizons up to at least p=3. We have further presented numerical results to lend visibility to the asymptotic and transient dynamics of the system and to provide evidence that we can likely establish asymptotic stability for a general p-horizon. Hence, this paper promotes the extension of the one-horizon MPC model into a general p-horizon model for controlling the car-following behaviors of connected and autonomous vehicles. In doing so, for an appropriate selection of penalty weights, it would likely be possible to achieve faster convergence to desired traffic flow – without sacrificing transient stability – than the one-horizon approach is capable of achieving. This would make the improved control scheme discussed here more desirable in practice. Future work may use the results of the stability analysis presented here to formulate an analytical proof for the general case. Achieving this result would pave the way towards making the implementation of a general p-horizon MPC model a reality. Such an advancement in automated vehicle technologies has the potential to improve driving conditions for motorists by removing erratic human driving behaviors from the equation. By improving the efficiency of traffic flow, it becomes possible to achieve further social and environmental benefits such as lowering the amount of time and money spent on driving and reducing harmful vehicle emissions. It is therefore important that we see this challenge through and use the results of this research to continue to study the stability of the linear vehicle dynamics under model predictive control for a general p-horizon.

# References


[1] Yu Yang, Fangwu Ma, Jiawei Wang, Sheng Zhu, Sukru Yaren Gelbal, Ozgenur Kavas-Torris, Bilin Aksun-Guvenc, and Levent Guvenc. Cooperative ecological cruising using hierarchical control strategy with optimal sustainable performance for connected automated vehicles on varying road conditions. *Journal of Cleaner Production,* Vol. 275, 2020, 123056.

[2] Zhihong Yao, Bin Zhao, Tengfei Yuan, Haoran Jiang, and Yangsheng Jiang. Reducing gasoline consumption in mixed connected automated vehicles environment: A joint optimization framework for traffic signals and vehicle trajectory. *Journal of Cleaner Production*, Vol. 265, 2020, 121836.

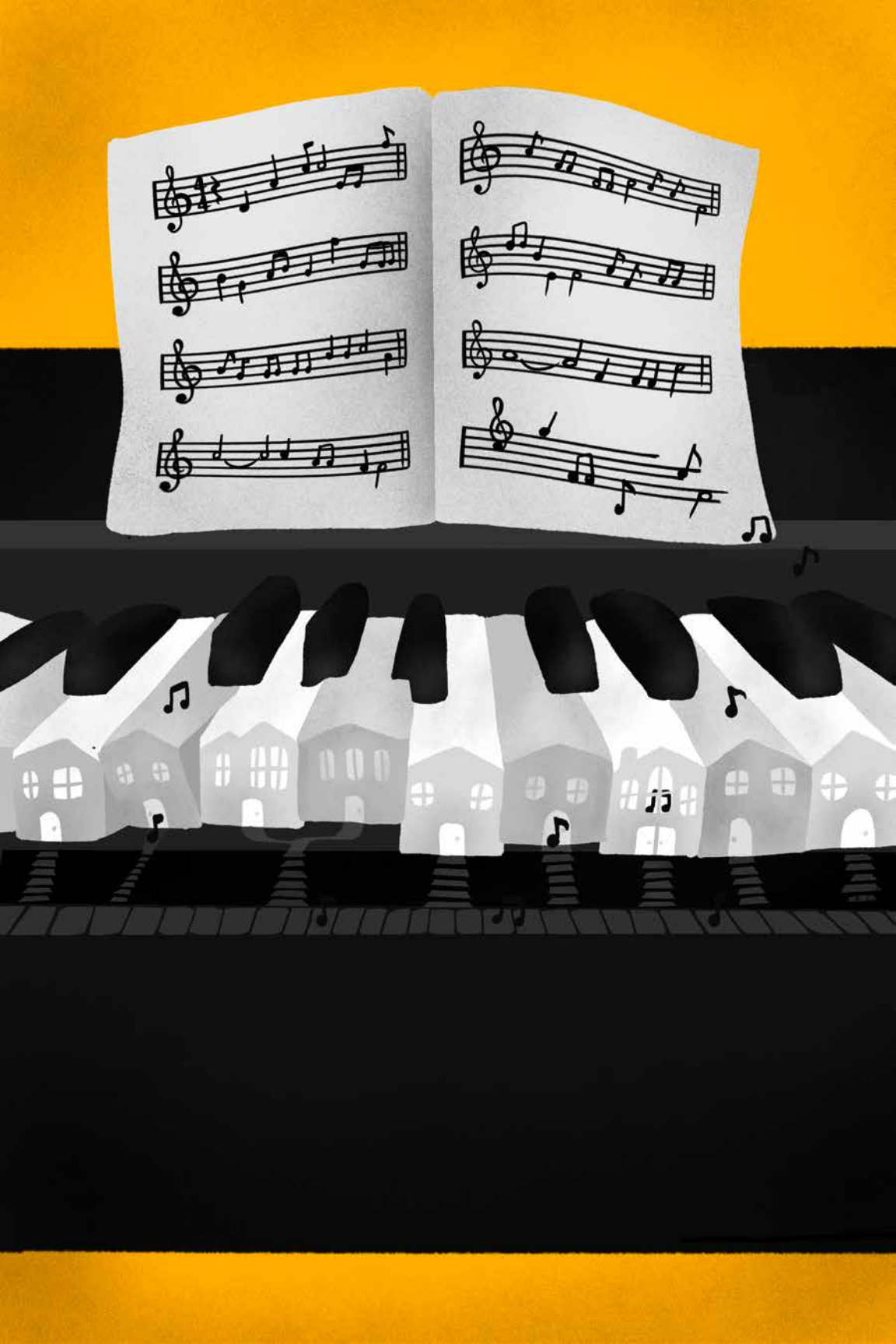
[3] Jie Sun, Zuduo Zheng, and Jian Sun. Stability analysis methods and their applicability to car-following models in conventional and connected environments. *Transportation Research Part B: Methodological,* Vol. 109, 2018, pp. 212-237.

[4] Yang Zhou, Meng Wang, Soyoung Ahn, Distributed model predictive control approach for cooperative car-following with guaranteed local and string stability. *Transportation Research Part B: Methodological*, Vol. 128, 2019, pp. 69-86

[5] Siyuan Gong, Jinglai Shen, and Lili Du. Constrained optimization and distributed computation based car following control of a connected and autonomous vehicle platoon. *Transportation Research Part B: Methodological*, Vol. 94, 2016, pp. 314-334.

# The Domestic Pianist: The Impact of the Parlor Piano on Middle Class Domestic Life in Nineteenth Century America

Sarah Driver



# Sarah Driver

**Sarah Driver graduated from UMBC magna cum laude in December of 2019 with a B.A in History. While at UMBC, Sarah took part in a number of on-campus organizations. From the Spring of 2018 through the Fall of 2018, she was president of the History Student Council. In 2019, Sarah received the Undergraduate Research Award for her research on the impact of the parlor piano on middle class domestic life in nineteenth century America. In 2020, the history department awarded her the John D. Reese Memorial Prize forher paper "The Domestic Pianist".**

**She would like to thank her advisor, Dr. Amy Froide, and her mentor, Dr. Melissa Blair, for their invaluable help with the researching and writing of this paper. Sarah is now applying to graduate schools to pursue a master's degree in the history field. Career wise, she is interested in public history. She hopes to work with the public to further history education, whether that be through writing, film, or with a museum.**

"In the Fall of 2018 I began working on my Honor's Thesis. When it came to choosing a topic, I knew I wanted to do something music related. I am a musician and have always had a passion for music history. With the help of my advisor, Prof. Amy Froide, I considered a number of possible subjects. These included the history of entertainment in Jewish-American communities and the history of music in Baltimore. At the time I was taking a course taught by Dr. Melissa Blair, who specializes in material culture. The course, the history of American architecture, combined my love of American history with my new found interest in material history. With both these topics in mind, I thought about the material history of music. In the past I had always noticed the omnipresence of pianos in nineteenth century middle-class homes. I decided to further explore this pattern and eventually chose the topic, the impact of the parlor piano on middle class domestic life in nineteenth century America. I quickly discovered just how influential pianos were and uncovered intimate stories of everyday life."

**-Sarah Driver**

**Image 9.**
A fantastical representation of nineteenth century family structure surrounding the piano.

## Abstract

In the nineteenth century, the United States experienced dramatic growth in the middle class. These Americans had more disposable income which, when paired with new mass manufacturing, meant that commercialism was on the rise. Possessions had meaning and few carried as much meaning as the piano. In the middle class American home of the nineteenth century, the piano was central to family dynamics, interior design, and gender roles. The purpose of this paper is to uncover how the piano entered middle class homes and then simultaneously influenced and absorbed period societal expectations. In the past, historians have published extensive research on the piano's physical evolution, from the simple clavichord to the modern concert grand, as well as its manufacturing history. However, little work has been done on the instrument's social history. This paper looks at the piano as not merely an object, but as the centerpiece for family bonding, a symbol of wealth and sophistication, and a cornerstone in the lives of ordinary women. Through the examination of nineteenth century home journals, advice books, company catalogs, and advertisements, this piece illustrates the overwhelming influence that pianos had on peoples' lives, impacting their interests, decisions, social image, and how they saw one another.



*Keywords: piano, commercialism, family dynamics, societal expectations, manufacturing & mass consumerism.*

# Introduction

Every single day, humans are bombarded with and affected by the external influences around them. Anything from friends and family or commercial advertisements to social custom can impact the way people act. When trying to name these influences it is easy to point out those that are most obvious. However, it is what goes unnoticed that affects people most of all. The things people take for granted are often the things that have impacted them the most, in a deeper and more meaningful way than those that leap out with pomposity and spectacle. Among these are the objects people interact with on a daily basis. A comfy chair, the family dining table, or a decorative souvenir do not necessarily stand out in one's life, but can nonetheless carry great significance. They not only impact the moment, but, years later, they can inform historians on the lives of those who have long passed. The piano is one of these things. Somehow, this large, cumbersome, and obvious instrument aligned itself with the most influential, but intangible aspects of everyday American life. Today, pianos sit in countless homes, sometimes at center-stage, but quite often reserved to the home's most formal rooms. It is overlooked, collecting dust, and seldom used for its true purpose, to create music. Instead, it acts as a pedestal for family photos and other mementos. With this in mind, one may ask, why is it there at all? Why would a family with no pianists own a piano? It is because they do not own it for utility or practicality. They own it for what it represents. For over the last two hundred years the piano has sown itself into the fabric of middle class American life. In the nineteenth century, the parlor piano changed American commercialism, inspired new kinds of music, created a business around the writing and publishing of songs, transformed the home parlor, and became an indispensable tool in the cultivation of feminine virtues.

In the past fifty years there has been a moderate amount of research done on the history of the piano. Early works focused mainly on the technical development of the instrument. However, over time the piano's cultural significance has garnered more attention from researchers. While books like Arthur Loesser's Men, Women, and Pianos details the history of piano manufacturing, A Natural History of the Piano by Stuart Isacoff concentrates on the social aspects of the piano and how it mixes with business, art, and society. The parlor piano, or any compact piano that could fit in the average parlor, impacted many aspects of American life in the nineteenth century. It can be difficult to focus on one part alone. As a result, historical research on the piano has split between the technical and the cultural.

One of the earliest works on the parlor piano is Loesser's Men, Women, and Pianos, published in 1954. Loesser's book follows the development of the piano throughout most of Europe and the United States. In the section on the United States, Loesser is most interested in American piano manufacturers. His focus is primarily

on the 1800s, which is undeniably the most important century for the acoustic piano. Loesser's strategy is to approach the piano from a business point of view. His chapter on the piano as a household good is informative and revealing. He clearly outlines the role of the home piano and how it became synonymous with other household necessities, like a couch or a desk. However, at only three pages long, this chapter is short compared to the others. Loesser quickly moves on to more manufacturing history in the next section. He clearly believes that manufacturing was the centerpiece for all American piano activity.

Another major work in the study of piano history is Cyril Ehrlich's The Piano: A History. The format of Ehrlich's book, published in 1976, is very similar to Men, Women, and Pianos. Ehrlich even cites Loesser on multiple occasions. Like Loesser, The Piano: A History is categorized by country. Ehrlich agrees with Loesser that piano manufacturing is the pivotal part of the American piano story. However, he veers from Loesser in his addition of information on automatic, or "player" pianos of the nineteenth century, as well as the birth of ragtime, "the first black music to be extensively written and published." Ehrlich also discusses the cultural impacts of the piano. This portion is brief, yet illuminating. Ehrlich achieves this with a slightly more narrative style to his writing, as opposed to Loesser's academic approach. The inclusion of pictures also does a great deal to further engage the reader. In general, Ehrlich offers different stories with the same material.

Stuart Isacoff's A Natural History of the Piano from 2011 focuses less on business and manufacturing and more on music. Books like Men, Women, and the Piano, among others, exhausted the topic of technical piano history, leading someone like Isacoff to study the instrument's past through a new lens. Isacoff's history follows the artistic, cultural, and social endeavors surrounding the piano. His chapters concentrate on composers, performers, and playing styles instead of factory output. A major difference from Men, Women, and the Piano and The Piano: A History is Isacoff's look at non-classical music. Loesser and Ehrlich focus solely on classical music, except for Ehrlich's quick mention of ragtime. Jazz and rock n' roll have both featured the piano as a core instrument of their genres, and Isacoff makes sure to include them. A Natural History of the Piano wants to uncover how humans have used the piano, not how they made it.

Historians who have concentrated on the piano's domestic purpose have focused their attention on women. Writers like Ruth Solie, in her article "Gender, Genre and the Parlor Piano," have analyzed the underlying meaning of the parlor piano and its relationship to middle class women. Solie's article charts the evolution of the domestic piano as it came to represent femininity in the nineteenth century. "Gender, Genre and the Parlor Piano" is a standout among the previously discussed works as it never mentions piano construction. The business of making and selling

pianos is not of any interest to Solie in this piece. She instead dives deeper into the lives of the domestic pianists.

As this short overview indicates, the written history of the piano has changed over the years. What started out as a technical history has developed into a cultural one. The construction of acoustic pianos has, for the most part, stayed the same for the last one hundred years. Consequently, there is little more to be said for the evolution of piano design. What additional historians can talk about is how the piano impacted people's lives. The piano was a staple of middle-class life in the nineteenth century, becoming as customary as a couch or a cabinet. This part of the piano's history has not yet been researched to its full extent, but this paper hopes to shed some light on the subject and uncover the instrument's far-reaching influence.

The piano, as people understand it today, was born in the nineteenth century. Few instruments have experienced such rapid evolution in such a short period of time. In just one hundred years, the common keyboard grew from a quiet, fragile, and expensive clavichord to a loud and dynamic piano. Advances in construction, manufacturing, marketing, and music printing created the perfect storm for accessible, high-quality home music. For the first time, a large, sophisticated instrument was available to relatively average Americans at prices they could afford and with plenty of newly printed sheet music to read. The piano made its major developmental strides in the nineteenth century allowing the instrument to enter the middle-class home and stake its place in the household.

## The Birth of the Piano

Before one can begin to understand why the nineteenth century was a turning point in piano history, one must understand the evolution of the instrument. The earliest version of a keyboard was the clavichord. Believed to have originated prior to the thirteenth century, the clavichord was the next generation of string instrumentation. Instruments such as the dulcimer required the use of hand-held mallets to strike the taught strings, but the clavichord replaced the hand-held mallets with a keyboard mechanism. Now, the musician could play as many as ten notes at one time. Although the clavichord was a sign of great progress, the keyboard was still far from its ideal form. The first clavichords were not chromatic, so they lacked many of the twelves notes found in Western music. However, the major downfall for the clavichord was that it was a very quiet instrument. It was so quiet that it could only truly be enjoyed by the player and a couple people standing close by. The emergence of the harpsichord would come to fix some of these issues, but still leave much to be desired.

The harpsichord was first introduced in the mid fifteenth-century. The significant difference between the clavichord and the harpsichord is that the

harpsichord was plucked rather than struck. Pressing a key activated a mechanism that would raise a small piece of wood with a plectrum attached, thus plucking the string associated with the chosen key. This gave the harpsichord a very distinct sound and made it a much louder instrument. However, what the harpsichord gained in volume, it lacked in nuance. Delicate tones were difficult to produce, so the instrument left one with a single sound that could be described as very harsh. Great composers like Bach and Handel wrote beautiful pieces for the harpsichord. Nevertheless, musical tastes began to shift in the eighteenth century and the harpsichord could not produce the sound the new compositions required. A different instrument was needed to facilitate the changes taking place in music.

The instrument that would eventually become the modern piano was first built in the early 1700s. The new piano was incredibly dynamic with more sustaining power than any of its keyboard predecessors. The piano was also much more complex. A series of hammers and dampeners activated by the push of a key meant a return to the struck string rather than a plucked one, as such was the case with the harpsichord. The square piano was the first form of the instrument. Structurally and mechanically, it was very similar to the clavichord and was popular in Europe. The square piano had many faults, but piano makers of the day were constantly experimenting with new designs, trying desperately to improve the instrument. After 1770, the piano entered "a phase of rapid technical and commercial advance." Square, grand, and upright models experienced unrivaled progress as the nineteenth century began, and it was an American piano manufacturer that would rocket the instrument to its greatest heights.

## The Piano in America

In Europe and the United States, the nineteenth century marked a boom in manufacturing and consumerism. The industrial revolution introduced enormous factories with the sole interest of producing goods in mass quantities. With such a vast amount of available, cheaply made products, members of the middle class could indulge themselves in the decorative and ornamental. "A large segment of the country's mighty economic machinery started into motion to serve the parlor and its refined surroundings." A factory could be in the business of producing just about anything the consumer was willing to buy, including pianos.

The perfection of piano construction and mass consumerism just happened to meet at the same point in time. Now, the piano was a loud, expressive, and easy-to-understand instrument whose production could be applied to the new factory system. At the start of the nineteenth century, the United States had numerous small piano-making firms. As the century progressed, the demand for pianos soared and the most successful companies, found mainly in Boston, New York, and Philadelphia, grew to

meet the need. In 1860, the United States had 110 piano manufactures with a total value of 5 million dollars. In 1900, there were 263 American piano manufacturers with a total value of 35 million dollars. Companies such as Kimball, Sterling, and Steinway and Sons would lead the way for a competitive American piano market.

Steinway and Sons would quickly become America's premier piano manufacturer. In 1853, Henry Steinway and his sons, all German immigrants, began making high quality pianos that toppled the competition. An 1856 advertisement features the company's success in recent piano showcases. In 1856, the company won first prize for the best square piano at both the Maryland Institute in Baltimore and the American Institute Exhibition in New York. There is no question that Steinway and Sons was one of the world's finest and most successful piano manufacturers in the nineteenth century. The fact that they were an American company was surprising at the time, but it makes perfect sense when one considers the United States' ability to produce mass consumer goods. Steinway and Sons achieved their success by blending output with artistry and close attention to detail. They created the perfect instrument for the middle class, one that was high in quality and unequivocally American.

The pianos sold by Steinway and Sons and other such companies were well suited to the middle-class home. Nineteenth-century pianos were smaller and could sustain more tension from the strings, allowing for a better, richer tone. By this time, the piano was "an essential component in the homes of America's cultured class." However, a Steinway and Sons piano, whose uprights cost as much as $1,000, was too expensive for most Americans. Manufacturer Joseph P. Hale was the first to produce affordable pianos. In 1881, one could purchase a Hale baby grand, a model far larger and more elegant than an upright, for $800 dollars. Hale began manufacturing pianos in the 1860s and implemented a number of schemes to lower prices. The pianos were constructed based on the assembly system using pre-made parts. As expressed in an 1881 Joseph P. Hale Catalog, "[Hale] proposed a revolution in the manufacture and sale of pianos. He would throw on the market an excellent instrument at popular prices. The industrial and middle-classes should have a piano equal to the best, at a low cost – one that should meet the wants of the American people." However, other manufactures offered even lower prices. A Montgomery Ward catalog from 1895 prices its uprights between $350 and $400. Even the outer reaches of the western frontier experienced "piano fever." W. W. Kimball, owner of the Kimball Piano Company, focused on supplying pianos to those beyond the cities and suburbs. He believed everyone, including the farmer, the miner, and the fisherman ought to own a piano. This is no surprise considering his business, but availability on this scale would have been impossible a hundred years earlier.

Over the course of the century the price of pianos plummeted. The piano, along with many other objects, had come to represent upper-class refinement and there

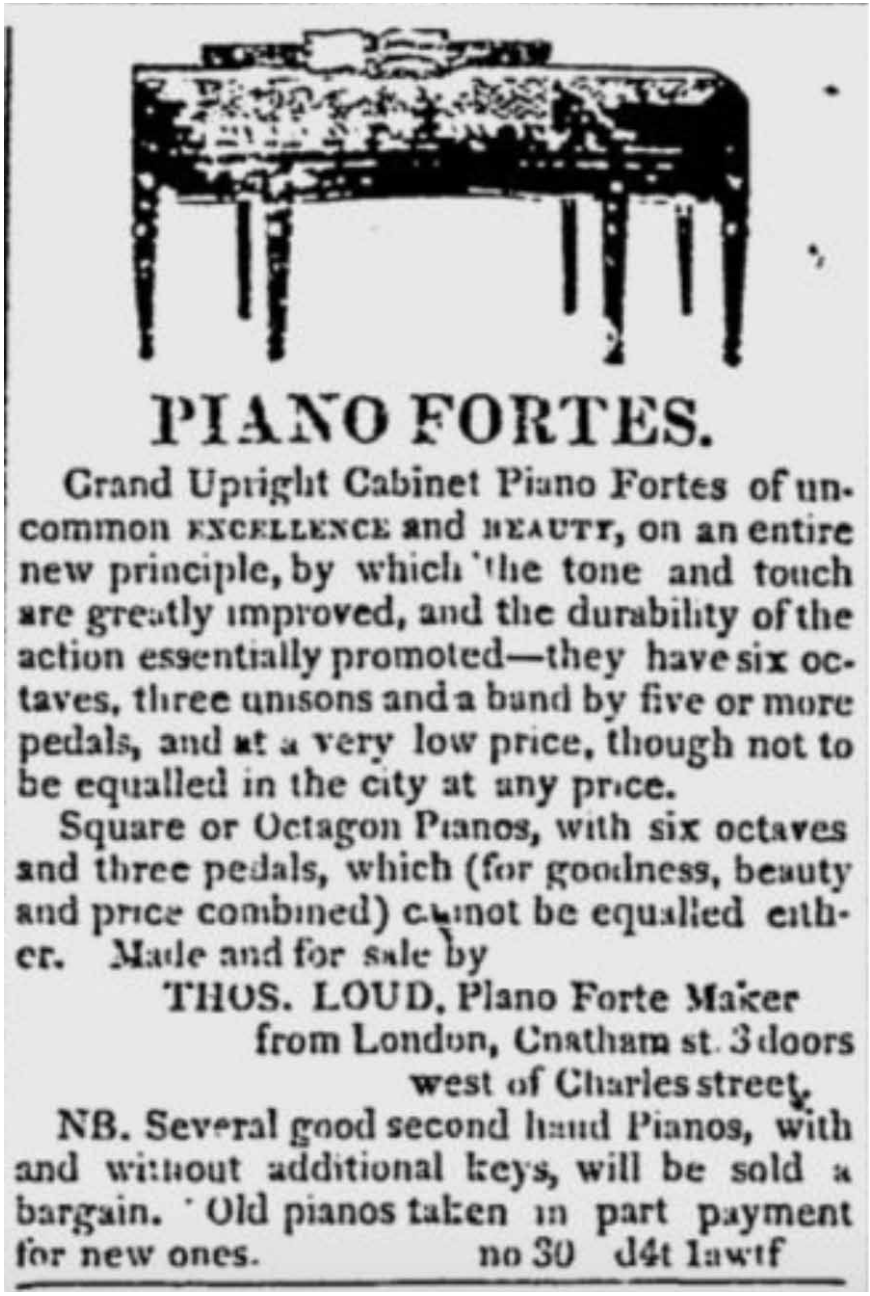
was an increasingly high demand for cheap items that could imply sophistication, but were accessible to the less wealthy. Manufacturers lowered the cost of production by having various parts made at separate, specialized plants and many companies adopted the upright style as their main product since it required fewer materials than a square or grand. With more pianos came more pianists, which meant more teachers and more sheet music. Fortunately, the growth of the consumer goods market brought new developments in printing and offered plenty of music for every household.

The mass production of sheet music was the last piece in this musical puzzle. With evolved, affordable pianos and heaps of sheet music, the middle-class American had everything a skilled domestic musician required. Every step of the process was necessary to the popularity and veneration of the parlor piano. Had the keyboard not progressed beyond the clavichord, if there had not been a boom in American manufacturing, and if lithography had not allowed for almost endless amounts of sheet music the piano would not hold the lauded place it commands today.

## The Pop Songs of the Day

The parlor piano was also pivotal to the kind of music people made. Music has always been a part of human life, but it was not until the nineteenth century that music became a staple in the lives of middle class Americans. It meant that ordinary people could become musicians and popular songs could have more exposure than ever before. As the United States developed as a world center for instrument manufacturing, new genres and songwriting styles emerged. Just like with the piano itself, songs became a consumer good in the nineteenth century, and they were bought and sold just like anything else. As the middle-class appetite for new songs increased, there came the creation of an entire business centered on the distribution and sale of music.

In the eighteenth and early nineteenth century, most of the music heard by Americans came from Britain. Following the Revolutionary War, many English musicians recognized economic potential in the growing American cities, so they left a crowded London to pursue success in the United States. The newcomers tended to perform on and write for the piano-forte, a new instrument that was then taking the U.S., Britain, and Europe by storm. During this period, there was no such thing as high-quality, American-made pianos. All "good" pianos came from Europe. Advertisements for the instrument touted European craftsmanship and, more often than not, included a London address to further emphasize quality and prestige. However, by the second half of the nineteenth century the U.S. would be manufacturing some of the most sought after pianos on Earth.



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Square or Octagon Pianos, with six octaves and three pedals, which (for goodness, beauty and price combined) cannot be equalled either. Made and for sale by

THOS. LOUD, Piano Forte Maker
from London, Chatham st. 3 doors
west of Charles street.

NB. Several good second hand Pianos, with and without additional keys, will be sold a bargain. Old pianos taken in part payment for new ones. no 30 d4t 1awtf

**Figure 1**. Advertisement for piano-fortes from London.

In the 1840s, a new kind of entertainment swept the U.S. In February of 1843, the very first, full-length minstrel show was performed in New York City by the Virginia Minstrels. Soon, countless minstrel groups were showing up all over the country and troupes like the Ethiopian Serenades garnered national attention. Many of the early minstrel tunes borrowed melodies from English or Irish songs, but themes of the American frontier and slave stereotypes fueled the lyrics. As the years passed, the demand for minstrel shows and their music continued to grow. Northern citizens had a particular interest in minstrel shows, as they presented what viewers believed was an accurate description of southern slaves, when, of course, they were only being fed a cruel and derogatory picture of African-Americans. Songwriter Stephen Foster, who experienced incredible, cross-class success in the late 1800s, made a name for himself writing both minstrel and non-minstrel tunes. Songs considered "plantation melodies," like "My Old Kentucky Home, Good Night," and those outside the minstrel genre, like "Jeanie with the Light Brown Hair," were both popular in the middle class parlor. The minstrel song was the first attempt at creating purely American music, and it led to the writing of more songs by more Americans. However, many of the new songwriters veered away from minstrelsy and cleared the way for all the American pop music yet to come.

In order for Americans of the nineteenth century to have home entertainment, they had to create it themselves. With so many households outfitted with a piano, music became a favorite domestic pastime. Songwriters began writing simple tunes with catchy melodies that could be reasonably reproduced by amateur pianists and singers. These songs became known as "parlor songs," because they existed to be performed in home parlors. Songwriters and publishers used melodic repetition and simple song structure to ensure quick and pleasing results for the musician. The songs lacked unnecessary melodic ornamentation and often featured very little, if any, musical direction. Some people believed that this form of composition was harmful to the art of music. In an article from the London Morning Chronicle featured in the American publication, The World of Music, the undisclosed writer states that if the old masters are pushed aside for the flimsy fancies of the day "the change, we suspect, will not conduce to the advancement of music, or extend its influence as a source of pleasure... and the consequence is, that drawing-room piano-forte playing, instead of being an elegant and delightful entertainment, is now becoming a nuisance." Lyrically, songwriters employed familiar themes of love, longing, and hardship. One of the most popular songs of the period was "Annie Laurie," a Scottish ballad sung from the point of view of an admirer expressing his devotion to Annie. There was also a high demand for comedic tunes. One such song was "The Scientific Frog" about an especially intelligent amphibian.


**Figure 2.** The cover of "The Scientific Frog" sheet music for piano and voice.

These were the pop songs of the day, meant to please large groups of people for pure entertainment.

In the first half of the nineteenth century printing music was a laborious and time-consuming process. Printing houses often needed to hire a specialist to work solely on sheet music. This antiquated system could not keep up with the wants of the piano-crazy public, so printers required something different, and lithography was the key. Lithography allowed for relatively quick and easy-to-control musical printing at a fraction of the cost. Over time, printers had the opportunity to improve the lithography process because they were printing so much sheet music.

The introduction of lithography led to the birth of the music publishing business. For the first time music could be purchased in bulk like any other consumer product. To this day, publishers, those who own the rights to certain songs and control their distribution, hold the most monetary power in the music business. By 1860 there were ninety major music publishers in the U.S. The overwhelming demand for sheet music tripled between 1840 and 1850, so the market became flooded with new material. Despite the large amount of money that could be made, music publishing was still a very risky trade. Very few songs sold well enough to be considered a success, and their profits had to make up for the lost investments of thousands of other tunes. In many instances, a publisher would not print a song unless all the expenses were paid by the songwriter, who would additionally have to forfeit many, if not all, of the royalties the song procured. For example, Stephen Foster only received $1,647 in royalties for "The Old Folks at Home." The average cost for piece of sheet music 1850 was twenty-five cents. Foster made two cents for every copy of music sold, so in order for him to receive $1,647 from his publishing company, Firth, Pond & Co., he would need to make a profit of roughly $20,500. This was, sadly, the beginning of something worrisome in the music world. The days of music as a purely artistic endeavor were over. Now, the business attracted greedy businessmen who cared all about the profits and nothing for artistry. However, at the end of the day most Americans were consumers and they now had a seemingly bottomless supply of new songs to enjoy in the comfort of their homes.

## Music in the Home

At this time, Victorian America was a place with many expectations. How one behaved, dressed, worked, ate, and socialized was, at least for the affluent, guided by strict rules of society. The home was no exception. The house in which one resided was expected to follow the guidelines laid out by the era's top architects, plan-book writers, and housing reformers. Each room of the home served a specific purpose, one that was often not simply material, but also moral. One of the most important rooms

was the parlor. The parlor represented a family's social standing, religious devotion, and consumer status. The piano, along with furniture, artwork, and other pieces, were symbols of a family's wealth and taste. However, the parlor also served as a place for family bonding and moral instruction, and music was an important part of that. For the piano, the nineteenth-century parlor acted as both a public stage and a private hall. Without such a space, the piano could never have achieved the domestic status it eventually acquired.

The Victorian parlor was, as described by author and historian Katherine C. Grier, the "comfortable theater." Much like the modern living room, the parlor was a place for numerous events, both public and private. Families held everything from club meetings and holiday parties to weddings and wakes in the parlor. Even the word "parlor" comes from the French term "parler," or to speak. However, what one saw was just as important as what one did. Never before had "good taste" been so important to general society as it was in the nineteenth century. Even the most modest of homes could have a parlor, for it was not the grandeur of a parlor, but the sheer lack of one that could be one's social undoing. The influential architect Andrew Jackson Downing believed that "as soon as he can afford it, [every man] deserves a parlor where he can receive his guests with propriety, as well as his wealthiest neighbor."

The parlor was worth far more than its face value. It was meant to represent the domesticity and moral standing of its residents. In the Victorian era, the roles of the men and women were specified and magnified. The man's world was outside the home, battling nature or the brutality of the free market in order to provide for his family. Meanwhile, the home was the woman's domain. All housewives were expected to keep a tidy, organized home, but their jobs extended far beyond mere cleanliness. Middle-class society expected women to be both mothers and teachers, especially in the realm of faith. It was up to the mother to instruct her children on how to lead clean, Christian lives. Keeping a proper home was considered as much a part of this teaching as was reading the bible. According to Catherine Beecher and Harriet Beecher Stowe, the parlor could be used as a home chapel, but even when it was not, the Christian house "is the aptest earthly illustration of the heavenly kingdom, and in it woman is the chief minister." The fact that weddings and wakes also took place in the parlor furthers the idea that there was a religious quality to the room. However, despite how pious a family would want to appear, that did not stop anyone from indulging in the newly available commercial goods flooding the market.

In her 1877 book Art Decoration Applied to Furniture, Harriet Prescott Spofford declared, "There is no reason for simplifying or abating the splendor of the drawing room but the insufficiency of one's purse." As previously discussed, the nineteenth century brought a boom in middle class consumerism. Now, one could express one's self with carefully chosen ornaments while taking part in the

consumer market. With more money to spend and more things to buy, taste and refinement, once kept exclusively for the rich, entered middle-class culture. Even the relatively modest cottage was expected to have a stylishly sophisticated parlor. There was supposed to be a "simple elegance about the entry and parlor" and it was not unreasonable that the parlor take-up a swelled amount of space in the home to accommodate "elegant entertainment." Among Mrs. Spofford's many suggestions, she is as adamant about the piano as she is about anything else, stating frankly, "unless one has a separate music room, there is to be a piano in the drawing room." The piano represented everything the Victorian family was supposed to be. Social status, spiritual devotion, and consumer relevancy could all be extracted from one's piano. A piano also meant that the women living there, both the mother and daughters, could play the instrument, one of the most essential feminine skills of the period.

Playing the piano was central to both private and public entertainment in the home. In private, the family could entertain each other with song and dance. "The family circle which has learned three or four instruments, the brothers who can sing part songs, are to be envied. They can never suffer a dull evening." Music gave the family the opportunity to reconnect and share an enjoyable experience. Smaller homes also used the parlor for public events. Guests attending a party could be entertained through the evening by the family pianist and others with musical abilities. The guests themselves could also take part in the music making. In the parlor, if anyone could make music, they did.

Music was also an important part of a child's religious upbringing. It was acceptable for a young girl to be trained in piano or voice for the purpose of performing simple "parlor songs" and hymns. Hymns were especially common in the home on Sundays, but faith was supposed to be a part of everyday domestic life. The popular Protestant tradition of the period was for the father to lead the household (servants included) in prayer. He would read passages from the Bible and sometimes conduct the singing of hymns with his wife at the piano or organ. By simply learning to play the piano a child could internalize many Christian values. Playing the piano required patience, discipline, and the ability to recognize authority. Additionally, a young girl would be acquiring the necessary skills so that one day, when she was married with children of her own, she could continue the tradition of accompanying her husband in spiritual song.

In 1880, the top 125 American piano-makers were manufacturing 30,000 pianos a year, a number that would continue to rise during the remainder of the century. As with other purchased items of the parlor, the piano underwent similar scrutiny. Taste-makers at the time considered the piano to be ugly and visually displeasing. In the words of Mrs. Spofford, "there is hardly anything uglier or elephantine than the modern piano, whether grand or square." A piano is indeed

large, bulky, and usually brown or black. One could see how such an item might clash with the Victorian parlor ideal involving color, variety, and beauty. The solution was to adorn one's piano with a piano scarf. Such scarves could often be found side-by-side in piano advertisements.

The nineteenth-century parlor was more about show than it was about use. Its purpose was not to comfort the family, but to represent them for the outside world. The items in one's parlor were meant to illustrate a family's social, spiritual, and economic status. The piano, while one of these items also demonstrated every desirable trait in one object. An observant visitor could, theoretically, estimate a family's social place, spiritual devotion, and income by simply looking at their piano. In this way, the piano was far more to Victorian Americans than just a musical instrument. It was a symbol of their place in the world.

## The Piano and Women: More than Music

While the piano was symbolic of the entire household, it was most prominent in the lives of the women. To be a middle-class woman in nineteenth-century America meant living by strict guidelines. Society had certain expectations for the wives and daughters of the growing American middle class. The responsibilities a woman carried as wife, mother, or daughter represented what it meant to be a nineteenth-century lady. Women were expected to do certain things like sew, decorate, or play the piano. Of all these activities and responsibilities, the piano came to signify all the essential feminine traits. After many years of evolution and mass manufacturing, the piano became an integral part of nineteenth-century womanhood. For the nineteenth-century middle-class American woman, the piano was both a tool and a symbol. It was vital to a young girl's education and symbolized the virtues and the discipline required of every respectable woman.

Women of the nineteenth century held very little power outside the home. However, rhetoric of the period insisted that the home and family were the cornerstones of success. Since women controlled most things domestic, they were considered the true backbone of the nation. Anna Ferguson encouraged this sentiment in her 1848 book The Young Lady's Guide to Knowledge and Virtue, stating that "as many rivers make up the ocean's water, so the conjunction of many homes makes up the world; and therefore, in performing her duties at home, she is performing her part in the world at large." Of course, these were only words. In reality, men (and women) viewed women as weaker and many of the responsibilities a wife shouldered were mainly in service to the husband. Men spent their days in the cold, harsh world of business. Since they had no time to cultivate the calm and sensitive

parts of life, that task was left to the man's wife or daughter. This can further be seen in the poem below by George Birdseye published in Godey's Lady's Book in 1887.

**"I came because you wished me to,**
**To hear this concert famous;**
**I can't appreciate like you,**
**I'm such an ignoramus.**

**This music's well enough to hear,**
**And suits you to the letter;**
**But there's a kind that, to my ear,**
**Is sweeter far and better.**

**In fact, for all this sort of thing**
**I wouldn't give a feather;**
**When I hear wife and baby sing**
**There home-duets together!"**

Her music offered him peace and solace at the end of a rough day, replenishing his spirit and rewarding his hard work. In this way the piano was a tool. A necessary implement for any married woman, for without one she could never be the perfect wife.

The piano served to not only make one a good wife, but also a good mother. The nineteenth-century mother had to be a teacher as well as a caretaker. In her 1868 book Manners: Or Happy Homes and Good Society, Sarah Josepha Hale declared, "... God placed upon the mother the duty and responsibility of tending or training her children." According to Mrs. Hale, motherly expectations came not only from society, but from the Lord himself. Such rhetoric was common at the time. In an 1860 edition of Godey's Lady's Book an undisclosed writer states, "Of the many interesting aspects under which we may regard the female character, there is none more striking and beautiful than that of the mother... And no less excellent is she when, blessed in her husband's support, she trains her children with instinctive love in the ways of purity and happiness." Learning to play the piano was one of many domestic skills a mother had to pass down to her daughters. Correct manners at the dinner table, appropriate interaction with guests, and managing a tasteful appearance were foundational in maintaining one's lady-like qualities. If a young girl failed to display the proper manners in public, it would reflect poorly on the mother. The middle-class mother did not have the nannies or governesses to train her children in polite etiquette, so it was up to her to do so. Although a young girl would have been criticized for any

unflattering behavior, it would have been viewed as a failure on the mother's part, for she was not raising her daughter to be polite woman of society.

As a wife, the woman brought her husband peace, and as a mother she gave her children discipline. On Sunday, the two roles intertwined. As historian Nancy M. Theriot explores in her book Mothers and Daughters, the nineteenth century brought more responsibilities for men outside the home, so they relinquished some of their domestic power to women. Theriot explains, "The new needs and expectations of men allowed women to assert their power in the home, and then outside the home in the schools and churches." Although women did have more control in such matters, it was because men believed that their traditionally feminine qualities gave them an edge. Feminine virtues, like a heightened moral compass and self-sacrificing nature, made women the perfect candidates for overseeing the family's faith. Women would fill the home with religious art, which could be homemade or purchased from the commercial market. In the words of Harriet Beecher Stowe and her sister, Catherine Beecher, "the best end for a woman to seek is the training of God's children for their eternal home, by guiding them to intelligence, virtues, and true happiness." While most popular parlor songs of the era were secular, religious songs were also quite common. One such publication was The Concordia, a collection of songs with words from well-known hymn-texts set to new music written by Reverend Augustus Fillmore. While it was still the husband's job to lead the family in prayer, the woman was expected to decorate the home so as to offer constant, but subtle reminders of the family's faith.

As the parlor piano rose in popularity among the middle class, the instrument was simultaneously expected and accepted. While the piano was seen as a necessary skill for most sophisticated women, it was also an acceptable activity for women and girls. It was not "manlike" or "indecent" like the oboe and, in the words of Reverend H. R. Haweis, revealing misogynistic attitudes of the time, "a good play on the piano has not infrequently taken the place of a good cry upstairs." One defining characteristic of the middle-class family was that the wife did not need to work. Her unemployment was another symbol of wealth and prosperity. This meant that a woman required something to do when she was not caring for the children or actively running the household. Practicing or learning a new song on the piano was a suitable way for a woman to spend her free time. Mrs. Hale encouraged such pastimes, stating that "instead of heavenly harmonies, as 'when the morning stars sang together', musical instruments, the inventions of men, must be used..." Reading was also a common leisure activity. By reading the right books a woman could improve herself and potentially become a better wife, as long she avoided those which threw "the allurements of taste and genius around vice and crime..." Needle-work, gardening, and various home crafts were also acceptable, but such pastimes were indeed just that, ways to pass the time. Reading, gardening, and playing the piano were not entirely useless

activities. To this day, people are encouraged to take up the same hobbies as they are shown to positively exercise the mind.

The piano was also important in the lives of young daughters. In the nineteenth century, adults expected most girls to learn at least the basics on piano. By the latter half of the century, the instrument almost completely left the adult world and was seen as a tool in the training of young ladies. The discipline and patience required of a piano student were traits that all young women were expected to possess. An 1880 beginner's guide to the piano entitled The First Twenty Hours of Music outlines the behaviors required of a young a student and they closely mirror societal expectations. The rules include taking "great care to cultivate a smooth, clean, yet delicate touch." Also, one was expected to "never throw the hands" or "allow any movement of the head or the body, nor any change in the facial expression." Music as a building block in moral character was also a popular idea. Not only would the technique make them politer, but the songs they memorized could ground them later on. In short, teaching a girl to play the piano could furnish her with many of the necessary traits of the day, so it did not matter if she did not like it.

To give or not give a girl piano lessons based on her interest in the instrument was a point of controversy in the 1800s. Some people, like the Beecher sisters, believed that forcing a girl to play the piano against her will was a waste of time, for "a young lady who does not sing well, and has no fondness for music, does nothing but waste time, money, and patience in learning to play on the piano." However, by the latter part of the century, the piano had become so ingrained in social custom that many parents did force their daughters to play. In an issue of Godey's Lady's Book from November 1860, editor Sarah Hale included a piece on the popularity of music. In it, Hale states, "music is now so much the necessity of social life, enters so largely into every one's idea of a finished education for a young lady... that it seems but reasonable to expect parents who have the means should educate into some sensibility the musical taste and judgement of their children who have not been endowed by nature in this respect." Learning to play a musical instrument does have numerous benefits for one's mental and emotion health, but, as Ruth A. Solie points out, many girls struggled with the lessons. Solie describes one girl, Fanny Lewald, who had two lessons a week and practiced every day for twenty-five years, but never found any enjoyment in the activity. Lewald's father forced her to have the lessons as he did not see music as something of talent, but as simply a "necessary part of her becoming a woman." Some girls became great pianists and composers, like Amy Beach, while others, like Fanny Leward, grew to hate the piano. The fact was that if one was a middle-class, American girl in the nineteenth century, the piano was almost inevitable. A daughter was most likely going to find herself perched on the piano bench whether she liked it or not.

Women playing musical instruments was not new in the nineteenth century. Perhaps, if one was skillful enough and passionate enough about music, she had a better chance of becoming a professional musician than her female ancestors, but that was not the norm. Most women, whether they were a wife, mother, or daughter, played piano because of social responsibility, not passion and not to become a professional outside the home. That is not to say that all women disliked the piano, for that is far from the truth, but there was much more at stake than a hobby. To be a good wife, mother, or daughter, to even be a true woman, one had to play the piano.

## Conclusion

For the nineteenth century middle class American, playing piano was about more than just music. The piano represented wealth, taste, position, and duty. Society gave the instrument, something originally meant for the sole purpose of art, a tremendous societal responsibility. The bulky piano sitting in the corner of the parlor encompassed everything society wanted from a family. It brought the expectations of the outside world into the home. For the husband and father the piano was a symbol of his hard work, for it showed that his income was such that he could afford it. For the wife and mother, the piano was the sign of a tasteful decorator, a doting companion, a caring, supportive mother, and a moral teacher. For the daughter, the piano represented her future feminine duty. She devoted hours of her time to the instrument every week, for if she could not play the piano she could become an outcast and may never live up to the standards of a nineteenth-century wife. Apart from the cause and effect the instrument experienced due to the manufacturing and commercial explosion of the 1800s, the piano's greatest achievement was domestic. Few other objects have infiltrated and transformed everyday life in the same way. Although the parlor piano is not as important today as it once was, the fact that it still lingers in so many homes shows that its significance will never disappear entirely.

# Bibliography

## Primary Sources

19th and 20th Century Steinway and Sons Advertisements. Retrieved from the Antique Piano Shop Online Museum. https://antiquepianoshop.com/online-museum/steinway-sons/.

Advertisements. The World of Music, vol 3, no. 14 (March 16, 1846).

Ambuhl, Edward and Austin Hart. "The Scientific Frog". Published by Horace Waters.

The Lester S. Levy Sheet Music Collection, box 53, item 052 (1860). Accessed at https://levysheetmusic.mse.jhu.edu/collection/053/052.

Beecher, Catherine and Harriet Beecher Stowe. The American Home. Bedford: Applewood Books, 1869.

Birdseye, George. "Home Music". Godey's Lady's Book (1883-1892), vol. 114 (Mar 1887): 274.

Bishop, J. Leander. A History of American Manufacturers from 1608-1860, vol. 3. Philadelphia: Edward Young and Co., 1868.

U.S Census Bureau. "Pianos and Piano Materials: Comparative Summary." Census Report, Volume 10, Manufacturers Part 4, Special Reports on Selected Industries, 1860 to 1900, table 4. Accessed January 28, 2020, https://www2.census.gov/library/publications/decennial/1900/volume-10/volume-10-p4.pdf.

Challoner, Robert. First Twenty Hours in Music. Cincinnati: Geo. D. Newhall and Co, 1883. Accessed at https://babel.hathitrust.org/.

Downing, Andrew J. The Architecture of Country Houses. New York: D. Appleton and Co., 1850.

Dunn, Finlay. "Annie Laurie". Published by Beck & Lawton. The Lester S. Levy Sheet Music Collection, box 118, item 007. Accessed at https://levysheetmusic.mse.jhu.edu/collection/118/007.

Ferguson, Anna. The Young Lady's Guide to Knowledge and Virtue. Boston: G.W. Cottrell, 1848.

Hale, Sarah Josepha. "Editor's Table: Music. The Effect of Fashionable Follies in the Nineteenth Century". Godey's Lady's Book and Magazine (1854-1882), vol. 61 (Nov. 1860): 461-464.

Hale, Sarah Josepha. Manners: Or Happy Homes and Good Society. Boston: J. E. Tilton and Co., 1868.

Illustrated Catalogue of Grand, Square, and Upright Pianos Manufactured by Joseph P. Hale, New York, 1881. Retrieved from the Antique Piano Shop Online Museum, https://antiquepianoshop.com/online-museum/hale-joseph-p/, 30.

Montgomery Ward and Co.: Catalogue and Buyers' Guide. New York: Dover Publications, 1895.

"The Mother". Godey's Lady's Book and Magazine (1854-1882), vol. 60 (June 1860): 529.

"The Piano Forte". The World of Music, vol. 1, no. 10 (June 8, 1840): 76.

"Piano Fortes". The American and Commercial Daily Advertiser, Dec. 1, 1820. Accessed at https://news.google.com/newspapers?id=6DpAAAIBAJ&sjid=ircMAAAAIBAJ&pg=5363%2C4138494.

"The Piano at Home." New York Times (1857-1922), Jan 04, 1880. Accessed from http://proxy-bc.researchport.umd.edu.

Sherwood, Mary Elizabeth Wilson. Home Amusements. New York: D. Appleton and Co., 1881.

Spofford, Harriet Prescott. Art Decoration Applied to Furniture. New York: Harper and Brothers Publishers, 1878.

## Secondary Sources


Ames, Kenneth L. Death in the Dining Room and Other Tales of Victorian Culture. Philadelphia: Temple University Press, 1995.

Braden, Donna R. "'The Family That Plays Together Stays Together': Family Pastimes and Indoor Amusements, 1890-1930". In American Home Life, 1880-1930. Edited by Jessica H. Foy and Thomas J. Schlereth. Knoxville: The University of Tennessee, 1992.

Bushman, Richard. The Refinement of America: Persons, Houses, Cities. New York: Knopf, 1992.

The Cambridge History of Nineteenth-Century Music. Edited by Jim Samson. Cambridge: Cambridge University Press, 2001.

Closson, Ernest. History of the Piano. London: Elek Books Ltd., 1947.

Ehrlich, Cyril. The Piano: A History. New York: Oxford University Press, 1976.

Grier, Katherine C. Culture and Comfort. Rochester: The Strong Museum, 1988.

Hamm, Charles E. Yesterdays. New York: W. W. Norton & Company, 1979.

Isacoff, Stuart. A Natural History of the Piano. New York: Vintage Books, 2011.

Kota, Julia Edlund. "Music Instruction in the Nineteenth Century: Views from 'Godey's Lady's Book'". Journal of Research in Music Education, vol. 38, no.4 (Winter, 1990): 245-257.

Loesser, Arthur. Men, Women, and Pianos. Mineola: Dover Publications, 1954.

McDannell, Colleen. "Parlor Piety: The Home as a Sacred Space in Protestant America". In American Home Life, 1880-1930. Edited by Jessica H. Foy and Thomas J. Schlereth. Knoxville: The University of Tennessee, 1992.

"Popular Songs of the Day". The Library of Congress Celebrates the Songs of America. Library of Congress. Accessed Oct. 21, 2019. Accessed at https://www.loc.gov/collections/songs-of-america/articles-and-essays/musical-styles/popular-songs-of-the-day/.

Solie, Ruth A. "Gender, Genre, and the Parlor Piano". The Wordsworth Circle, vol. 25, no. 1 (1994): 53-56.

Tawa, Nicholas E. Sweet Songs for Gentle Americans: The Parlor Song in America, 1790-1860. Bowling Green: Bowling Green University Popular Press, 1980.

Theriot, Nancy M. Mothers and Daughters in Nineteenth-Century America. Lexington: The University Press of Kentucky, 1996.

Toll, Robert. Blacking Up: The Minstrel Show in Nineteenth Century America. New York: Oxford University Press, 1974.

# “Old Town Road” and the Racial Politics of Country Music

L. Alexandra Rodriguez Arellanos

# L. Alexandra Rodriguez

**L. Alexandra Rodriguez Arellanos finished her second Bachelor's degree in American Studies in Spring 2020. She would like to thank Dr. Bhalla, Dr. Fouts, and Dr. Minner for their support, as well as the entire AMST department. She is currently a fellow at Paideia -The European Jewish Institute in Stockholm earning a Master's certificate in Jewish Studies. She is planning to apply to doctoral programs in Fall 2020 with a research focus on the intersection between popular media culture, emerging media, comedy, and the effects on marginalized groups.**

**She was selected for the AMST Outstanding Student Award and awarded the Esperanza Endowed Scholarship Fund. She was also the Vice-President of UMBC Hillel and was a contributing writer to The Retriever.**

"

This thesis was conceived over two semesters as part of two separate classes. In Dr. Fouts's class, I started the preliminary research as well as an overall outline for a large research thesis paper. For the final capstone class, AMST 490, I worked with Dr. Bhalla to expand and even change the direction of paper as I wrote and researched it. It was an intimate process, combining my research interests and creation of a professional thesis paper. I had heard from a friend that the song "Old Town Road" had been based on a TikTok cowboy trend and this piqued my interest. I found the Rolling Stone article that outlined the basic controversy over the classification of the song and knew this was an important topic to research. This incident overlapped with many issues we have dealt with in American Studies: marginalized groups, questions of who is an "American" and what is whiteness, and the racialized history of the US and its effects on all aspects of society. This paper was completed during the beginning of the Coronavirus outbreak and before the protests over racial equality, It demonstrates an ongoing issue while Americans confront the racialization of our society.

**-L. Alexandra Rodriguez** "

**Image 10.**
A single black cowboy hat in a collection of white cowboy paraphernalia.

## Abstract

In the spring of 2019, Lil Nas X's song "Old Town Road" became a national hit and the country-trap song was seemingly breaking boundaries by not only blending two separate genres but also debuting on multiple music charts simultaneously. But almost as quickly as it debuted the public and the country music establishment was asking if Lil Nas X and trap music, a subgenre of hip-hop, could ever be country. This paper explores the questions of what qualifies as country music, who makes the decisions as to what country music is, and where blackness fits into the country genre. The story of Lil Nas X and "Old Town Road" is what occurs when racial politics collides with entrenched whitewashing of the country music genre, even though the genre itself has black roots. "Old Town Road" is one incident in a larger historical thread found throughout country music and its complicated identity politics and anti-blackness. There is no simple answer as country music and southern identity became intricately intertwined with the concept of whiteness. This qualitative paper uses direct quotes and citations from a variety of sources ranging from African American studies, country music history, and interviews with music industry professionals. While this paper focuses on music, the main question is more relevant than when I wrote it before the George Floyd protests in the summer of 2020: why are African Americans excluded from the "mainstream" establishment and even more when they directly helped contribute to its creation?



*Keywords: racial politics, whitewashing, boundaries, Old Town Road (OTR), Lil Nas X, identity politics, anti-blackness, & white southern identity*

# Introduction

> "It's a simple matter of people responding to a clear case of hypocrisy and trying to keep a genre 'pure' that never really was. If Cowboy Troy, Big & Rich, Jason Aldean, Kid Rock and Uncle Kracker could be accepted by country audiences, then so should Lil Nas X."
>
> *- Dart Adams, musical journalist and historian*

In Spring 2019, Lil Nas X's song "Old Town Road" (OTR) became a national hit. The country-trap song was seemingly breaking boundaries by blending two separate genres and debuting on multiple charts simultaneously. It made the jump from social media into mainstream radio. But almost immediately after its debut on the *Billboard* charts, executives removed it from the "Hot Country" chart, with a vague statement that, while the song "incorporates references to country and cowboy imagery, it does not embrace enough elements of today's country music." Op-eds questioned whether Lil Nas X and trap music, a predominantly Black musical genre, could ever be country, a White, conservative genre. When country singer John Osborne was asked about OTR he said, "Go listen to Kris Kristofferson and then go listen to ['Old Town Road'] and if you tell me they have anything to do with each other, then I will quit. I'm out. I'm done with the genre" (Newman, 2019). Some critics argued that "Old Town Road" had to be country, as it not only had country themes, but now included the vocals of country star Billy Ray Cyrus. To some, Cyrus's endorsement gave both Lil Nas X and OTR country music legitimacy. "The addition of Billy Ray Cyrus on the remix helps tip it over to country, according to [country music duo] LoCash's Chris Lucas. 'It made it a lot more country to me, putting Billy in it,' he said" (Newman, 2019). Both the evolution of OTR in relationship to questions of what qualifies as country music, according to the country establishment, and where Blackness fits into the country genre is part of a larger historical thread found throughout country music and its complicated identity politics and anti-Blackness. The story of Lil Nas X and "Old Town Road" is what occurs when racial politics collide with entrenched whitewashing of the country music genre, complicating success for Black country artists in mainstream country music.

## Lil Nas X's "Old Town Road": A Timeline

In order to analyze the reaction by the country music establishment, it is important to establish the very short timeline of events from the creation of "Old Town Road to its record-breaking time on the *Billboard* charts. In early 2018, Lil Nas X was still Montero Lamar Hill, a 19-year-old living with his sister. He was born outside Atlanta and had recently dropped out of the University of Western Georgia. He had no job and was writing music while he tried to figure out his next move. He found the beat that would become "Old Town Road" on YouTube on Halloween night. The beat, titled 'Ninety,' was created by YoungKio, a 19-year-old Dutch beat producer who had taken the main banjo part of the beat from a Nine Inch Nails song. Hill paid $30 for the track and worked on this song, his 19th "...for weeks, like, during the time where my sister was ready for me to leave her house" (Spanos, 2019). Hill was inspired by his southern roots, growing up in a small town in Georgia, and the western themed video game *Red Dead Redemption 2*. Hill uploaded "Old Town Road" (OTR) to SoundCloud and iTunes on either December 2 or 3 under the name Lil Nas X and labeled the song as a country song. He began to promote it heavily on Twitter using memes and short videos. He went to Twitter and made multiple tweets asking friends and fans of the song to help him pass it along to Billy Ray Cyrus. The song got some traction through retweets but it did not explode in popularity until March 2019.

Between the time when the song was uploaded in December 2018 and grew in popularity in March 2019, the social media platform TikTok came to the U.S. from China, and the #yeehawchallenge began. TikTok began as a Chinese social media app that eventually gained popularity in the US in 2018. It became the fastest growing app in the U.S., downloaded 1.5 billion times as of December 2019 (Bond, 2019). TikTok allows people to create and share short videos with each other, and soon "TikTok challenges" became popular on the app (Carlisle, 2019) (Schwartz, 2020). In March 2019, a new movement also began on Instagram, coined the "Black Yeehaw Agenda" by its purported creator, Bri Maldandro, a Black woman from Texas. Malandro showcased Black bodies in cowboy aesthetic to challenge "the ubiquity of the white American cowboy myth [which] reflects a lot of deep-rooted ideas about heteronormativity and whiteness in the US. It also speaks to the historical erasure of the Black cowboy" said Maldandro. Users on TikTok took this trend from Instagram

and labeled it the #yeehawchallenge. This relabeling erased the Black origins of the "Black Yeehaw Agenda" and the original goal of showcasing Black bodies in country-western attire that has traditionally only been associated with White bodies. Calling it the #yeehawchallenge turned it into a silly costume and dance challenge that had TikTok users wear cowboy items, such as plaid shirts, cowboy hats, jeans, and boots and perform stereotypical "western" activities (like riding horses, lassoing objects, and performing caricature dances of a hoedown, such as kicking one's legs to the sides in an exaggerated fashion). The Black erasure with the #yeehawchallenge would foreshadow the struggle between OTR and the main country music establishment as to the place of Black bodies.

During the middle of the Black Yeehaw Agenda and the #yeehawchallenge surge, social media influencer @nicemichael found the song, OTR, and asked Lil Nas X if he could upload himself dancing to it on TikTok as part of the challenge. Lil Nas X allowed it, and the video went instantly viral on TikTok. Lil Nas X argues, "A lot of people like to say, you know, it was, like a kid accidentally got it. It's like no, this is no accident. Like I've been- I've been pushing this hard" (Coscarelli, 2019). However, it is hard to ignore how many things had to come together to create such a quick, viral sensation. This set of events does not mean that Lil Nas X is not internet or meme savvy. A *New Yorker* piece found that, before all the fame, Lil Nas X was not just a heavy Twitter user but was also active in tweetdecking. Tweetdecking is when "networks of popular accounts... coordinate retweeting and promoting each other, and rip off viral tweets from less prominent accounts. In other words, it is forced, gamed virality" (Feldman, 2019). But Lil Nas X also created OTR right before the Black Yeehaw Agenda. Though he could not have predicted the #yeehawchallenge in December, he seemed to be attuned to social media trends.

On March 16, 2019 OTR debuted simultaneously on *Billboard's* "Hot 100," "Hot R&B/Hip-hop," and "Hot Country" song charts. Also on this date, *Billboard* executives quietly removed the song from the "Hot Country" charts, where it had debuted at #19 (Hall). *Rolling Stone* magazine broke the story of the song's removal on March 26, and the magazine received a statement from *Billboard* on the March 28 which stated:

> "Upon further review, it was determined that 'Old Town Road' by Lil Nas X does not currently merit inclusion on *Billboard's* country charts. When determining genres, a few factors are examined but

> first and foremost is musical composition. While 'Old Town Road' incorporates references to country and cowboy imagery, it does not embrace enough elements of today's country music to chart in its current version."

Radio stations during this time had to download the song off YouTube or SoundCloud in order to play it, which meant that OTR got airtime "before labels, radio programmers and playlist curators can sort [streaming songs] into genre buckets. When the music industry enforces genre borders after the fact, it becomes part of a power struggle about who has the right to make what and, in this case, whether Black artists can fit in predominantly white genres" (Leight, 2019). During the same week that OTR was removed, the #3 song on the "Hot Country" chart was "Meant to Be" by Bebe Rexha ft. Florida Georgia Line (FGL), which featured "trap drums on that" according to Lil Nas X (Levy, 2019). In fact, when looking at the top 25 songs on the "Hot 100" chart for that week, six songs feature musical components that are rock, dance, or R&B based (*Billboard*). The most egregious example, besides "Meant to Be," is the R&B-sounding ballad, "Talk You Out of It" by FGL. An article in defense of the decision by *Billboard* to remove OTR from the "Hot Country" chart stated:

> [Silvio] Pietroluong,[*Billboard*'s senior VP for charts and data development, allows that country music has shifted recently to more 'beat-heavy tracks' (pointing to Sam Hunt and Thomas Rhett,), but notes that 'Meant to Be' was 'actively worked by the label to country radio and eventually hit No. 1 on the Country Airplay Chart.' That, along with FGL's long-established presence on the country charts, got 'Meant to Be' country classification" (Levy, 2019).

On the day of OTR's debut, March 16, country artist Billy Ray Cyrus received a call from his record label executive from Columbia Records, Ron Perry, who asked him to listen to the song. Cyrus loved the track and wanted to add his vocals to it (Coscarelli, 2019). Between March 16 and the beginning of April, in the midst of the removal controversy, Billy Ray Cyrus remixed the song with Lil Nas X and they released the new single on April 3. Two days later Cyrus asked on his Twitter why OTR was not

considered a country song, as he believed it had all the necessary elements. Despite being removed from the "Hot Country" charts, the song placed #53 on *Billboard*'s "Country Airplay" chart, which uses data from airplay by radio stations. The airplay data reflects, in part, song requests received from the public. On April 13, OTR made the #1 spot on the general "Hot 100" chart, which is a combination of data such as airplay, online sales, etc. The song stayed there for 19 weeks, the longest a song has held the #1 spot in the history of *Billboard* (Hall, 2019).

It seemed at this point like the song had officially crossed the country boundary, in part from the support from Billy Ray Cyrus. But Lil Nas X's contribution was still being minimized. On April 20 a poster congratulating Cyrus on achieving a #1 song on *Billboard* was placed in Nashville. It included only Cyrus' picture, and below the title of the song, in smaller font, was written "Lil Nas X and YoungKio." Cyrus protested the poster on his Instagram with an image of himself standing next to the poster holding a handmade sign saying he would not have gotten there without Lil Nas X or YoungKio. On June 6, a new sign was created to be displayed on Music Row, now with both Lil Nas X and Cyrus' pictures side by side.

## What Happened?

It is amazing to think that in 6 months this teenager from Georgia would change how the public thinks about country music, race, and the role of social media in music, as well as disrupting well-established institutions like *Billboard* and Nashville (a metonym for the entire, mostly Nashville-based country music industry). When it removed OTR from the country chart, the country music establishment faced immediate backlash and accusations of racism. These accusations of racism are not new and have plagued the country music industry since its beginning. "Nashville has been dominated by white artists since the birth of country music, even though that genre has strong roots in Black musical styles like blues" (Chow, 2019, "It Feels"). *Billboard* attempted to defend itself by stating that this categorization was not a racial issue but rather one of reputation within the country music industry. It was an affront to the country music establishment that Lil Nas X had not gone through the traditional gatekeeping and somehow jumped from the obscurity of the internet to reputable prominence without permission. "Shane Morris, founder of BMD Agency in Nashville, says part of the push back against Lil Nas X wasn't just related to race. It was also the country industry being afraid of how the rapper emerged; on social media,

without going through the Nashville gatekeepers. 'There isn't like a SoundCloud for independent country,' Morris says. 'The fans don't adopt music in the same way. They very much are given what they're supposed to like and then that's that'" (Martin and Omeokwe, 2019).

These arguments ignore the racialized aspects of the entire genre and the fact that White country artists have always been free to borrow elements from other genres. When established country artists make non-country sounding songs, they are still labeled country, as seen with the song "Meant to Be," which was on the country chart at the same time as OTR. Other examples include 2005's more egregious "Honky Tonk Badonkadonk" by Trace Adkins with its hip-hop beats, rapping, and racist Black stereotypes (#2 on the "Hot Country" charts) or Bubba Sparxxx (a self-proclaimed pioneer of 'Hick hop', or country rap) (Peisner, 2018), whose album *Pain Management* made it to #40 on the "Country Albums" chart. Sam Sanders, host of *It's Been a Minute* on NPR, made clear the point, "Lots of folks are saying... 'Hey, country, you allow white artists to get on these charts with songs that aren't quite country all the time'. There are artists like Sam Hunt who was clearly influenced by hip-hop, artists like Taylor Swift who made country songs that were more pop than country for years" (Martin and Omeokwe, 2019). There are racial double standards at play that have consistently been dismissed. OTR is not unique in dealing with racial double standards but it is unique because social media and the internet allowed it to bypass the gatekeepers and let listeners themselves decide what they considered country.

## The Birth of "White" Country Music

As far as a commercial musical genre, country is one of the oldest, starting around the 1920s. Ironically, in the context of the pushback against OTR's emergence from social media, its creation can be credited due to a new emerging technology: the radio. Even in the beginning, there was an established hierarchy as to who allowed what artists to perform as country. This began with radio station owners inviting specific folk singers to perform live on the air and moved on to the early record labels only recording specific acts they considered provincial and "authentic" enough.

After World War I, radio grew in popularity in the U.S., particularly in the South. In 1923 there were 510 radio stations with more planned (Lippman, 2007, p. 467), and 89 were in the South (Malone, 2018). Rural folk musicians saw this new medium as a way to gain more popularity and share their songs, and stations often

had live performances. As radio grew, the record industry wanted to tap into this "salable commodity" of fiddle-based music, in part to increase the sale of records that had decreased due to better radio technologies, especially in comparison to the phonograph (Malone, 2018). By this point hillbilly music had "assimilated African-American rhythms, blue notes [and] black fiddling styles… via white minstrel shows, the banjo… [e]ven steel guitar [which] originated by Hawaiian musicians in the late 1800s" (Lewis, 2001, p. 109).

In the 1920s the music industry was based entirely in the North and would either bring recording artists to New York or Chicago or send "remote teams to record southerners in their home locales" (Hughes, 2016, p. 16). These expeditions contradict later claims that commercial country music was born purely in the South. Early on, the record industry began to divide the records into "hillbilly music" or "race" records regardless of the accuracy (Lewis, 2001, p. 109). "[B]etween 1924 and 1932 Black and White artists collaborated at twenty-two racially integrated sessions that produced sixty-nine recorded masters" (Huber, 2013, p. 21). Early "race" records "encompassed blues, jazz, gospel numbers, and sermons marketed to African American consumers" while "[h]illbilly records, first recorded in 1922… so named in order to capture the music's supposedly white rural southern origins, [and] consisted chiefly of southern fiddle tunes, string-band numbers, old parlor ballads, and religious songs" and were marketed to White consumers in the rural South (Huber, 2013, pp. 22-23). Record companies would promote their hillbilly records by emphasizing the Anglo-Celtic origins and images of "good old" barn dances and "pastoral images" (Huber, 2013, pp. 24-27). This commercial push to distinguish country music as a White genre cemented the idea that it was a solely White creation. These labels would remain in place until after World War II, when they were replaced with "rhythm and blues" and "country and western".

In a cynical commercial move, record companies sometimes released African American artists under the hillbilly label, but not include any pictures or illustrations (Huber, 2013, pp. 27). Some Black singers, such as Henry Thomas, would write songs during this early period that would later be considered classic hillbilly hits such as "Arkansas," "Fox and the Hounds," and "Fishin' Blues" (Lewis, 2001, p. 110). "[N] early 180 recordings featuring African American artists appeared in hillbilly series or on records intended for sale on the hillbilly market" and, as scholar Patrick Huber (2013) states, this crossover demonstrates that early country music was "a culturally

constructed commercial music, an 'invented tradition'" (Lewis, 2001, p. 47) and a racial divide that record executives were counting on to double sales without creating new content.

## Early Country Music Pioneers and the African American Influence

Popular demand for country music grew in the early 20th century and performers began to look for fresh material. Many early performers would also become songwriters as well as writers but "had no direct experience with the tradition" (Malone, 2018). In order to give themselves an air of authenticity, they began to imitate previous hillbilly tunes. These songs heavily borrowed from African American folk songs, if not outright stole them. The first country stars would be no exception.

Jimmie Rodgers, who many consider the father of country music, recorded his first songs in 1927. Rodgers incorporated blues yodeling into his singing. Folklorists tried to tie it directly to White, Swiss Tyrolese yodeling, which had some success in the US in the 1840s due to the Tyrolese Rainer Family (Nunn, 2009, p. 631). Rodgers was raised in the rural Pine Springs community outside Meridian, Mississippi, also known as the "epicenter of yodeling blues" (Nunn, 2009, p. 629). In fact, yodeling was commonly found in recordings by African American singers from the area in the 1920s (Nunn, 2009, p. 631).

As early folklorists tried to separate any connection of country music to African American musical styles, even modern folklorists have attempted the same. David Evans stated in his 1972 work "Black Musicians remember Jimmie Rodgers," "[Black singer, Tommy] Johnson's refrain derives mainly from the Afro-American field holler tradition, while Rodgers' refrain displays an obvious debt to Swiss yodeling style. The melodic similarities between the two singers are probably purely coincidental" (Nunn, 2009, p. 629). This assertion is undercut by Rodgers' widow, who stated that he was influenced by the work songs of African Americans, and the fact that yodeling was brought to American audiences through Blackface minstrel shows (Nunn, 2009, p. 631). According to Rodgers' biographer, Nolan Porterfield, Rodgers even participated in a few interracial recordings and in once case "he heard an African American jazz band that he enjoyed, and he promptly recruited the musicians to accompany him on a recording at his Monday session" (Huber, 2013, p. 33). Most famously Rodgers collaborated with Louis Armstrong to record "Blue Yodel No. 9,"

part of a permanent exhibit at the Rock and Roll Hall of Fame as one of the "500 Songs That Shaped Rock & Roll" (Main Exhibit Hall).

Another early influential group is The Carter Family, who were also directly taught and inspired by Black musicians, and, in some cases, were given songs by Black artists. The Carter family started in Virginia in 1926 and was composed of A.P. "Doc" Carter, Sara Doughtery (his wife), and Maybelle Addington (his sister-in-law and wife's first cousin). While the Carters "did not use African-American textural features such as... glissando... and legato... they did, however, perform music that was influenced by African Americans" (Lightfoot, 2003, p. 180). It may not have been solely "influenced" but rather "taken" as George Lewis quotes John Arkins in his article, "A.P. Carter, who traveled through Virginia and Tennessee to collect folk tunes for the Carter Family to record, had a poor memory for melody and often had Lesley Riddle, a Black blues singer and guitar player, accompany him to help him remember" (Lewis, 2001, p. 110). Riddle may have also taught Mother Maybelle "her famous 'Carter Scratch' guitar playing technique, one that has become the model for generations of country pickers since" (Lewis, 2001, p. 110) and that was derived "from a minstrel style known as 'thumbing' or 'thumb-lead clawhammer'" (Lightfoot, 2003, p. 180). In their repertoire, which consisted mostly of folk songs, novelty tunes, parlor music, sacred tunes, and some blues, half of the songs came from "black religious expression...The Carter family clearly loved African-American sacred music and made it a strong component in their inventory of songs" (Lightfoot, 2003, p. 181).

Whenever Carter, Rogers, and others are talked about, the contributions African-American musicians made in helping create modern country music are almost never mentioned. In Malone's (2018) book there are only one-line attributions when talking about the history of Rodgers and the Carters; "... a line from [Rodgers] well-known 'Muleskinner Blues'... may very well have been inspired by the times when... he carried water to the black workers", and "One known Carter informant was Lesley Riddle... a black guitarist and singer who taught the family 'Cannonball Blues' and other songs and sometimes accompanied A.P. on collecting trips" (Malone, 2018). Even in such an expansive historical work, African Americans have been relegated to a line or two in the creation of an entire genre.

## White Southern Identity & Country Music

So how did country music become a deeply racialized genre, and one in particular that has been tied to a White, southern, working-class identity with country music? In the 1920s a new scholastic field developed, "Southern Folklore Studies," which argued for "the historical importance of the white southern middle and lower classes" (Manuel, 2008, p. 419) and placed the White male at the center. This body of literature is crucial in country music scholarship and helped establish the racial and social categories it would later be ascribed to. The advent of "Southern Folklore Studies" systematically downplayed and removed the influence of Black country artists, already marginalized by the simple fact of their race.

"One of the greatest collectors of American folksongs" was John Lomax (Hirsch, 1992, p. 183). Lomax collected "cowboy songs" and African American "ballads" as he called them (Hirsch, 1992, pp. 186, 190) and in doing so was trying to make the argument that the U.S. had a "rich national culture" that could "be built on an indigenous American folk culture" (Hirsch, 1992, p. 190).

Lomax was born in Mississippi and raised in Texas. He received his B.A. from the University of Texas at Austin and his M.A. in English from Harvard. Lomax received a fellowship to study cowboy songs and began to collect songs as early as 1915 from all the lower classes of society such as miners, sailors, cowboys, convicts, and Blacks. He was also a folklorist for the Roosevelt administration's Federal Writers Project from 1936-37. It was important to Lomax to collect these songs and ballads as, in his mind, they contributed to the future culture of the US. "According to Lomax, a major aspect of the nation's culture came from those groups that polite society dismissed" (Hirsch, 1992, p. 190). This is not to say that Lomax believed in the equality of such marginalized groups, particularly racial minorities.

Lomax may have been highly educated, but having been born and raised in the South, he had a "southern racial conservatism" that is "characterized by the belief that Blacks have a place in the South- a defined and subordinate place befitting an inferior race" (Hirsch, 1992, p. 185). His view was if everyone stays in their place, the new South can grow and be profitable with rising industrialization, as the South had to shift away from an agrarian society after the Civil War. Lomax though "never endorsed the racial radicalism that manifested... in aggressive and violent behavior towards Blacks" (Hirsch, 1992, p. 186). He and other contemporary Southern folklorists chose to study the African-American presence in the region "in order to create" an

"idealization of plantation society that justified slavery in the past and provided a rationale for the creation of the caste system that replaced it" (Hirsch, 1992, p. 184).

It was common among "turn-of-the-century New England intellectuals… [to turn] to the study of subjects such as medieval knights or Oriental religion in search for an alternative to the modern world" (Hirsch, 1992, p. 186). Lomax was trying to find a more primitive culture from which the U.S. could learn and grow much like Europeans were learning from Roman and Egyptian histories. This desire was part of a larger belief that, without a rich history, a society could not flourish and establish a distinct culture, which was an intense fear by American intellectuals. If they could find a primitive culture to set the foundation for American Southern culture, it would automatically create a division between the "primitive" and "modern," between uncivilized and civilized, between the unsophisticated and the modern White intellectuals of New England. Whatever "primitive culture" he found would be treated as an Other, one to learn from but also treat as a stepping stone to something better. Though Lomax understood that these primitive groups, and later in particular Blacks, contributed to a rich musical history, he did not see these peoples as equals to modern White creators.

Whenever Lomax talked about Black folk songs he always compared them to Western art, "[t]hus, an African-American convict reminds Lomax of 'blind Homer'" (Hirsch, 1992, p. 191). These comparisons served the purpose "that indigenous African-American folksong could only be regarded as art if it could be compared to true art-Western high culture" (Hirsch, 1992, p. 191). Often he would use terms such as unsophisticated, natural, "children of nature" and simple (Hirsch, 1992, p. 192). Lomax's work reflected larger Victorian attitudes of the time dividing the world into civilized and savage. Lomax approached Black folk songs in a patronizing way, characterizing their creation as primitive and Blacks as childlike. This view cemented the idea that Blacks, even when free, were inferior to Whites.

Ethnologists and anthropologists around the 1920s and 1930s added to this idea. W.J. Cash, in his 1941 work *The Mind of the South*, argues that the South is its own distinct region and fundamentally different from the rest of the country. Cash, along with Frank Owlsey's 1941 *Plain Folk of the Old South,* helped create the idea that rural, White, middle-class southerners were a "distinct social group within a larger nation-state" (Manuel, 2008, p. 420), but ignored the influence that Blacks played on this social group in the Appalachian area.

This new reinterpretation of Southern heritage had to separate its identity from the slaves and free Blacks, and White Southerners began to believe it was only Irish/Anglo-Saxon heritage that created a unique Southern culture (Nunn, 2009, p. 640). Southern intellectuals were trying to create "images of their world that gave them a sense of wholeness at the cost of rejecting or denying social change" (Hirsch, 1992, p. 184). Cash did acknowledge the influence Blacks and Whites had on each other but ignored Black agency (Manuel, 2008, p. 420) in asserting that Blacks only copied Whites, never had their own creations. Echoing this sentiment, George Pullen Jackson, while recording Appalachian folk songs in 1933, wrote in "White Spirituals in the Southern Uplands" that, even though there were similarities in Negro spirituals and the white spirituals, it was the Negroes that copied the songs rather than the reverse (Manuel, 2008, p. 422).

As this ethnography and scholarly work was being done, country music was being created and the myth of country music being a solely White creation was tied in. Newman Ivey White, an English professor, published *American Negro Folk-Songs* in 1928, a year after Jimmie Rodgers recorded his first single, and stated that, "African American religious song was derived from white sources, [and] that secular and popular music, too, was adapted by blacks from white antecedents, specifically minstrelsy and 'coon songs'" (Nunn, 2009, p. 634). This explanation is in direct contrast to White's own recognition that Whites were imitating Black musical styles; "he had collected not primarily from African American singers, but 'from students who had learned them from the Negroes'" (Nunn, 2009, p. 633).

This racial classification of country is still alive in modern scholarship. Even decades later, academics were still equating musical styles with racial characteristics. Alan Lomax (son of John Lomax) insisted in 1959 that White folk music was different from Black folk music in his article 'Folk Song Style' for *American Anthropologist* (Manuel, 2008, p. 424). "...white folk music emphasized individuality, the teaching of morality, and constrained melody and rhythm... in contrast, black folk music was communal, expressive, and sensual." He continues, "the body of the [African American] singer moves sinuously... [the singer's voice] introduc[es] bass grunts with no self-consciousness... sexual and aggressive content openly expressed... Romantic love absent" (Lomax, A, 1959, pp. 930-31). Lomax believed that musical traditions were "the qualitative end-product of a certain set of actions" and thus music was representative of the cultures that created it. In other words, Black music represented

uncivilized sexuality and animalistic primitiveness.

In *Country Music, U.S.A.*, published in 1968 (and revised in 1985 and 2002) and considered to be the definitive history of country music, author Bill C. Malone writes in the opening chapter, "Hillbilly music (a once universal designation for country music) evolved primarily out of the reservoir of folk songs, ballads, dances, and instrumental pieces brought to North America by Anglo-Celtic immigrants" (Malone, 2018, p. 1) with little reference to the deep connections of Black musical participation.

All these racialized ideas about music, "ordinary, rural folk," and race would play an important role as country music was being created. Though the record label executives created the country and race labels without input from these Southern Folklore Studies academics, their work legitimized, academically and socially, the racial separation that was already occurring on American society writ large. It also helped normalize dismissing contributions of Blacks to Southern society during the racial upheaval that the South was going through post-reconstruction.

## Black Country and Country Authenticity

Despite being erased from the mainstream history of country music, there have been famous Black country artists. Lil Nas X is part of a long musical heritage and a link in a line of other successful Black country artists. The most famous of these is Charley Pride. Charley Pride was not only a successful Black country artist, but he is listed as an important part of country music history in several publications and is in the Country Music Hall of Fame. But like Lil Nas X, the color of his skin was a barrier and potential problem. "My biggest problem was that promoters were afraid to bring me in," Pride said in an interview, "...RCA signed me, and all of the bigwigs, they knew I was colored, but unanimously, they decided that we are still going to sign him. They decided to put the record out and let it speak for itself" (D'Ambrosio, 2014). Though Pride seems to let the record executives off, it is telling that it would be Pride that would suffer physical or financial harm, so the record executives had little to lose in taking a gamble on Pride. This would not be the only time Pride would downplay how race and racism played a complicated part in his career.

When Charley Pride began his singing career in 1966 Pride heard a rumor that his picture was omitted on the record sent out to the radio stations because he was Black (D'Ambrosio, 2014). "At Pride's first show in Detroit, famed Nashville DJ Ralph

Emery introduced the singer, who was initially greeted with applause, then stunned silence when he took the stage. Emery recalls that Pride told the crowd, 'I realize that I've got that permanent tan, but my name's Charley Pride and I am from Mississippi, my daddy was a farmer down there. And I sing country music. I want to entertain you if you'll let me.' Once he started singing, the applause returned" (Betts).

Pride, though, did not want to address race in interviews, as seen in a 2006 interview with *The Guardian*, "Does he get fed up with questions about race? 'I understand why they get asked', [Pride said] 'But people are so hung up on skin. They're always asking "Why do you look like us and sound like them?" or "Why do you look them and sound like us?"'" (Hodgson, 2006). He also did not address the problematic fact that Willie Nelson used to call him "Supernigger" as a term of endearment, because, to Pride, what mattered was that Nelson helped him early on in his career and they were long-time friends (Bargmann, 2016). His silence on race is something that is lauded in Pride's entry in the Country Music Hall of Fame's website: "As with Jackie Robinson, who broke the color line in big-league baseball, he suffered whatever discrimination he was exposed to in silence, determined that talent was what counted." Purposeful or not, this ignoring of race and racists experiences by Pride tells everyone involved in the country music business, and Black artists, that to pretend the genre is color-blind and well-meaning is an important part of being successful.

Darius Rucker is another Black country artist who seems to have broken the color barrier, but he himself also downplayed racist incidents and race as a factor. Before he became a solo artist, he was the singer in Hootie and the Blowfish. Their debut album, "Cracked Rear View," included the song 'Drowning,' a protest song about South Carolina flying the confederate flag at its capitol. The band was performing at the University of South Carolina for an MTV Unplugged session and, while walking through the campus, Rucker "tapped his friend on the shoulder and pointed to an open window on an upper floor. In plain view hung a large confederate flag... 'You see that?' Rucker said. 'That's meant for me'" (Bargmann, 2016). But in the same article in which this story was told, the journalist constantly states that Pride and Rucker do not want to focus on race. "I've always tried to think of myself just as an American," Pride says. "That's what I am. I'm an American." "Rucker was not about to let racial identity politics get in the way [of his pivot into country music]." "[Rucker's core belief was that]...it would be better to take some things at face value, rather than freight them with political or racial implications" (Bargmann, 2016). Pride

and Rucker both are resistant to having either of their careers defined by race, which is understandable. But their dismissiveness of even broaching the question or discussing the complicated racial politics at play within country music does a greater disservice to racial equality within the genre. Even Rucker stated, "I'm waiting for another African-American to break through in [to] country and have a big thing," yet he refuses to discuss the possibility that he and Pride are exceptions and race plays a large part in that.

An important factor in Rucker's reluctance in discussing race is that he has embraced the White aspects of what some believe country is: intense patriotism that is almost jingoism, Black erasure in dress and speech patterns, dismissal of racial identity politics, and a politically conservative viewpoint. This shift toward conservative politics happened around 1968-69, but "historian Diane Pecknold observes that it wasn't so much that country music moved to the right but that the right moved toward country music... there was a real hunger in a lot of parts of America for representation, and country music did offer a landscape that was talking a lot about old-fashioned values" ("How Country Music", 2017). In 2016, Rucker closed his set on the opening night of the CMA Music Festival with his rendition of "God Bless the U.S.A.," pacing in front of a giant screen displaying the American flag, with Rucker occasionally bowing his head. As Bargmann (2016) witnessed, "At precisely orchestrated moments the house lights come up, revealing a sea of white faces... Rucker exhorts them to 'stand up' when singing the refrain: 'And I'll gladly stand up next to you and defend her still today...'". This lyric could be easily dismissed as a simple and easy song to entice a crowd to sing along, but in 2014 Rucker faced scrutiny online for singing "White Christmas" at the Rockefeller Center Christmas tree lighting ceremony. Only a few hours before he was scheduled to perform, a New York City grand jury had acquitted a White New York City police officer for the chokehold death of Eric Garner. Protestors had planned to interrupt the performance but were barricaded by police several blocks away. "Rucker actually laughs when he remembers the uproar that came [with that]... It was funny. I laughed at it.... 'White Christmas' has been around forever... It's just a song about snow!" (Bargmann, 2016). It is a purposeful feigned ignorance to not understand how having a Black singer sing "I'm dreaming of a White Christmas" after several public murders of Black people could be seen in a different context.

Rucker is not the only Black country artist to lean toward a feigned racial

ignorance and lean toward the socially conservative. Cowboy Troy is a Black, self-proclaimed "hick-hop" and "blackneck" artist that combines country with rap. He performed at the 2008 GOP convention and was an "out-spoken supporter of the McCain-Palin ticket in its run against Barack Obama" (Gussow, 2010). Cowboy Troy called himself a Christian conservative, which is "at odds with his progressive cultural politics" (Gussow, 2010). The reason to point to their conservative political views, which they are entitled to, is that this is in direct opposition to their push on the racial boundaries of country music. They state that they want to see more Black artists in the genre but are supporting political platforms that are not as progressive when it comes to racial issues. It is a performance of racial ignorance. Activist Black groups, like Black Lives Matter, tend to support civil rights, racial equality, and racial justice.

## Black vs White Performance

As described above, "Old Town Road" (OTR) came into country music with many factors against it, but the most egregious to the country music establishment was that it bypassed the record executives. Lil Nas X labeled the song country himself, and was he was a Black man combining rap and country. "[Twenty] years ago, [...] radio and labels worked together to make hits. Since artists needed those institutions to become popular, it was easy to dictate certain paths to success — a country hit came from a country label and earned support from country radio" (Leight, 2019). "There are few things that... country radio... dislikes more than a country phenomenon that originates from outside its own community" (Moss, 2019). The record executives and *Billboard* had no control over the song, and hence were not the gatekeepers, either commercially or racially.

The statement from *Billboard* that the song was excluded from the country charts due to its "musical composition," the trap beats and rapping, and that it did "not embrace enough elements of today's country music" is a hypocritical statement. There are examples of White country artists using rap, hip-hop, and even Black imagery in their songs and remaining on the *Billboard* chart. Such examples are "Meant to Be," as mentioned above, Florida Georgia Line, Bubba Sparxxx, and the more traditional country star, Trace Adkins, with his 2006 song 'Honky Tonk Badonkadonk.'

Trace Adkins is a solidified mainstream country artist, as directly quoted from his website with "11 million albums sold... GRAMMY nominations. CMT (Country Music Television) and ACM (Academy of Country Music) awards... [and]

nearly 200 million plays on YouTube". The song Badonkadonk "incorporates a variety of sounds including elements of techno… funk, and hip hop", "deploys the 'twang' that signifies country's whiteness" and "performed nods to hip hop music, language, and lifestyle" with the lyrics making "various pun and plays on hip hop tropes" (Morris, 2011, p. 467). The main difference is that, while both songs combined country, including that "twang", and hip-hop tropes and sound, Atkins's song received positive reviews with *Billboard* ironically stating, "the song 'cleverly connects country, hip-hop and techno'" (Morris, 2011, p. 467). Atkins was lauded for being innovative and "wagging his finger at tradition" (Morris, 2011, p. 467), while Lil Nas X's work was seen as a gimmick (Leight, 2019).

OTR resulted from Lil Nas X's personal interest in trap music, but Atkins is playing a Blackface minstrel show with the song and the song's music video. The scholar David Morris (2011) says that "[a] closer look at 'Badonkadonk' finds as much mockery as celebration of hip hop, as well as familiar, if subtly executed, racial caricatures of black people" (Morris, 2011, p. 468). The word Atkins borrowed, "Badonkadonk," was first introduced by "rappers Keith Murray, LL Cool J, and Ludacris" in the 2001 song 'Fatty Girl' (Gussow, 2010, p. 62). The music video takes place inside a strip club, like other rap videos around the same time, and "[a] t one point Adkins flashes a pair of four-finger rings, hip-hop style bling spelling out the words 'Honky' and 'Tonk' inch-high in, presumably, cubic zirconia across his knuckles" (Morris, 2011, p. 473). Lil Nas X references more country motifs in the song than "Badonkadonk" does.

And yet it was Lil Nas X who was told by *Billboard* that OTR did not have enough modern country music elements. A source at from country music digital distribution was quoted as saying, "[i]t doesn't take much to question whether something is really country or not...Trap drums [like the ones in 'Old Town Road'] are one of the things that make people want to say, 'It's something else.'" (Leight, 2019). Whenever a White artist uses hip-hop/rap they are standing on White side of the racial divide, while Black artists always come from the Black side, i.e., not country (Gussow, 2010, p. 63). It was ignored that Atkins was putting on a stereotypical Black performance but Lil Nas X was accused of putting on a fake country (White) performance. As seen with Pride and Rucker, ascribed racial performances are expected. Cowboy Troy (CT) is the Black predecessor to Lil Nas X in having a hip-hop country song, yet he himself still acts in stereotypically expected ways. CT's

Nashville producers, "Big Kenny" Alphin and John Rich (Big & Rich), released his debut album in an email that stated Cowboy Troy "is the world's only six-foot, five inch, 250 pound black cowboy rapper" (Gussow, 2010, p. 43). This statement plays on the stereotype of Black men as large, menacing, and virile. Big and Rich do not push CT's country music but rather sell him as a Black gimmick. "[They] never fail to invoke [his] height and race in their public statements", "their production group" is called Musik Mafia, similar to rap labels with the purposeful misspelling of music and allusions to the mafia and violence. Big and Rich are using CT to push the idea that they are pushing for racial unity while taking advantage of racist tropes. CT raps with a southern twang, wearing Black cowboy hats and jeans, and with "a dancing dwarf named Two-Foot Fred," reminiscent of Blackface minstrelsy. In fact, Big and Rich's label, Raybaw Records, "is an acronym for Red and yellow, black and white. It might be argued that what [they] are offering here… is a corporatized version of racial reconciliation" (Gussow, 2010, p. 53).

## Conclusion: Lil Nas X and OTR's Transgressions

Lil Nas X chose to not downplay his Blackness in every decision he made, in his choice of trap beats (a subgenre of hip-hop), in choosing the country genre for himself, and in embracing his connections to both Souths, the Black and the White. He has stated that his song is country-trap, "It's not one, it's not the other. It's both," and he had always wanted to maintain creative control. "I wanted to stay independent because I figured there was no way I was going to be able to have control to create the type of music I want. I was basically ignoring a lot of labels. I got on a call with [Columbia Records] and told him about why I didn't want to sign. He told me his vision for me—and he pretty much saw everything how I saw it, in a way. It was a surreal moment. I was allowed creative control, too" (Chow, 2019, "Lil Nas X Talks"). According to Nashville, Lil Nas X did everything wrong from the start. He bypassed their gatekeeping, chose to call himself a country artist, combined Black music unironically, refused any performative Whiteness, and managed to get an established country star to give him country credibility. He and the song did not break any barriers but rather placed in sharp relief the hypocrisy within the entire genre. *Los Angeles Times* journalist Marissa Mos summarized it succinctly:

**"Nashville is overdue to confront its complicated past with how it has capitalized on black traditions but not built up black superstars" (Moss, 2019).**

# Bibliography


Aday, Ronald H., and Benjamin S. Austin. "Images of Aging in the Lyrics of American Country Music." *Educational Gerontology*, vol. 26, no. 2, Mar. 2000, pp. 135–54.

Adkins, Trace. "About." *Traceadkins.com*, https://traceadkins.com/pages/about.

Bargmann, Joe. "Will Darius Rucker Break Country Music's Color Barrier Once and For All?" *Dallas Observer*, 5 July 2016, https://www.dallasobserver.com/music/will-darius-rucker-break-country-music-s-color-barrier-once-and-for-all-8445362.

Bernstein, Jonathan, and Jonathan Bernstein. "After Vegas Shooting, Country Music's NRA Ties Show Signs of Fraying." *Rolling Stone*, 5 Oct. 2017, https://www.rollingstone.com/music/music-country/after-vegas-shooting-country-musics-nra-ties-show-signs-of-fraying-126241/.

Betts, Stephen L."Charley Pride 'American Masters' Documentary: 10 Things We Learned." *Rolling Stone*, 21 Feb. 2019, https://www.rollingstone.com/music/music-country/charley-pride-documentary-pbs-10-things-we-learned-797147/.

Bond, Shannon. "As TikTok Grows In Popularity, It's Also Setting Off Alarms In Silicon Valley." *NPR.Org*, 10 Dec 2019, https://www.npr.org/2019/12/10/786835248/as-tiktok-grows-in-popularity-its-also-setting-off-alarms-in-silicon-valley.

Carlisle, Madeline. "Lil Nas X, The Woah, Will Smith: The Top TikToks of 2019." *Time,* 10 Dec 2019. https://time.com/5747121/tiktok-2019-best-videos-memes-dance-challenges/.

"Charley Pride - Country Music Hall of Fame." *Country Music Hall of Fame*, 2018, https://countrymusichalloffame.org/artist/charley-pride/.

Chow, Andrew. "Lil Nas X Talks "Old Town Road" and the Billboard Controversy." *Time,* 5 Apr 2019. https://time.com/5561466/lil-nas-x-old-town-road-billboard/.

Chow, Andrew. "'It Feels Like I'm Chosen to Do This.' Inside the Record-Breaking Rise of Lil Nas X." *Time,* 15 Aug 2019. https://time.com/5652803/lil-nas-x/.

Coscarelli, Joe. "'Old Town Road': See How Memes and Controversy Took Lil Nas X to No. 1." *The New York Times*, 10 May 2019. https://www.nytimes.com/2019/05/10/arts/music/old-town-road-lil-nas-x.html.

Cowboy Troy. "I Play Chicken With The Train." YouTube, uploaded by Cowboy Troy, 25 Jul 2009, https://www.youtube.com/watch?v=NUPK9z59yUc.

Craig, Clay, et al. "Name Dropping and Product Mentions: Branding in Popular Music Lyrics." *Journal of Promotion Management*, vol. 23, no. 2, Apr. 2017, pp. 258–76.

D'Ambrosio, Brian. "For Charley Pride, Red Ants Festival Will Be a Homecoming." *Last Best News*, 21 Jul 2014. http://lastbestnews.com/2014/07/for-charley-pride-white-sulphur-festival-will-be-a-homecoming/.

Darrisaw, Michelle. "7 Black Country Artists Who Paved the Way for the Viral Song 'Old Town Road.'" *Oprah Magazine*, 18 Apr. 2019, https://www.oprahmag.com/entertainment/a27182186/black-country-singers-lil-nas-x-old-town-road/.

"DeFord Bailey - Country Music Hall of Fame." *Country Music Hall of Fame*, 2020, https://countrymusichalloffame.org/artist/deford-bailey/.

Feldman, Brian. "Before 'Old Town Road,' Lil Nas X Ran a Now-Banned Meme Account." *Intelligencer*, 5 Apr. 2019. *nymag.com*, https://nymag.com/intelligencer/2019/04/lil-nas-x-was-a-popular-twitter-user-before-old-town-road.html.

Guidry, Nate. "Country Music's Blacklist." *Pittsburgh Post Gazette,* 18 Feb 2001. http://old.post-gazette.com/magazine/20010218country2.asp.

Gussow, Adam. "Playing Chicken With the Train: Cowboy Troy's Hick-Hop and the Transracial Country West." *Southern Cultures*, vol. 16, no. 4, Winter 2010, pp. 41–70.

Hall, Jason. "Lil Nas X Now Included on Updated 'Old Town Road' Music Row Congratulations Poster." *WZTV*, 7 June 2019. https://fox17.com/news/local/music-row-old-town-road-congratulations-poster-changed-to-include-lil-nas-x.

Hall, Kristin. "Billboard Removes Rapper Lil Nas X from Country Chart." *AP NEWS*, 29 Mar. 2019, https://apnews.com/6045fec139204644b616afb63622c2d9.

Hirsch, Jerome. (1992). Modernity, Nostalgia, and Southern Folklore Studies: The Case of John Lomax. The Journal of American Folklore, 105(416), 183-207.

Hobbs, Dawn R., and Gordon G. Gallup. "Songs as a Medium for Embedded Reproductive Messages." *Evolutionary Psychology*, vol. 9, no. 3, July 2011.

Hodgson, Martin. "The Hidden Faces of Country." *The Observer*, 15 July 2006. https://www.theguardian.com/music/2006/jul/16/popandrock3.

Hot Country Songs Chart. *Billboard*, 23 Mar 2019. https://www.billboard.com/charts/country-songs/2019-03-23.

"How Country Music Went Conservative." On the Media, *WNYC Studios*, 6 Oct 2017. https://www.wnycstudios.org/podcasts/otm/segments/how-country-music-went-conservative.

Huber, Patrick. (2013). Black Hillbillies: African-American Musicians on Old Time Records, 1924-1932. In Pecknold, Diane, editor. *Hidden in the Mix: The African American Presence in Country Music* (pp 19-81). Duke University Press, 2013.

Hughes, C. L. (2016). Country Soul: Making Music and Making Race in the American South (Illustrated edition). The University of North Carolina Press.

Ingram, David. "Blues and Country Music." *Nature, Culture & Literature*, vol. 7, Brill / Rodopi, 2010, pp. 69–95.

Jared, Scott. "Carolina's Libraries Fill Gaps in 'Country Music.'" *The Well*, 17 Oct. 2019, https://thewell.unc.edu/2019/10/17/carolinas-libraries-fill-gaps-in-country-music/.

Katz, M., and D. VanderHamm. "Preserving Heritage, Fostering Change: Accidental Archives of Country Music and Hip-Hop." *The Public Historian*, vol. 37, no. 4, Nov. 2015, pp. 32–46.

Kurzban, Robert. "Cheatin' Hearts & Loaded Guns: The High Fitness Stakes of Country Music Lyrics." *Review of General Psychology*, vol. 16, no. 2, June 2012, pp. 187–91.

Kyriakoudes, Louis M. "The Grand Ole Opry and the Urban South." *Southern Cultures*, vol. 10, no. 1, 2004, pp. 67–84.

Leah, Rachel. "Lil Nas X and 'Old Town Road' Expose the Myth of Nashville's Country-Purity Standards." *Salon*, 9 Apr. 2019. https://www.salon.com/2019/04/09/lil-nas-x-and-old-town-road-expose-the-myth-of-nashvilles-country-purity-standards/.

Leight, Elias. "How Lil Nas X's "Old Town Road" Got So Popular." *Rolling Stone*, 26 Mar 2019. https://www.rollingstone.com/music/music-features/lil-nas-x-old-town-road-810844/.

Levy, Joe. "Lil Nas X's 'Old Town Road': Inside Billboard's Charts Decision." *Billboard*, 19 Sept. 2019. http://www.billboard.com/articles/business/chart-beat/8530110/inside-the-old-town-road-charts-decision.

Lewis, George H. "The Color of Country: Black Influence and Experience in American Country Music." *Popular Music & Society*, vol. 25, no. 3/4, Fall/Winter 2001, p. 107.

Lightfoot, William E. "The Three Doc(k)s: White Blues in Appalachia." *Black Music Research Journal*, vol. 23, no. 1/2, University of Illinois Press, 2003, pp. 167–93.

Lil Nas X. "Old Town Road (Official Movie) Ft. Billy Ray Cyrus." YouTube, uploaded by Lil Nas X, 17 May 201,9 https://www.youtube.com/watch?v=w2Ov5jzm3j8.

Lippmann, Stephen. "The Institutional Context of Industry Consolidation: Radio Broadcasting in the United States, 1920-1934." *Social Forces*, vol. 86, no. 2, Oxford University Press / USA, Dec. 2007, pp. 467–95.

Lipsitz, George. "The Possessive Investment in Whiteness." *The Possessive Investment in Whiteness*, Temple University, 1998, pp. 1–46.

Livingston, Carolyn. "Naming Country Music: An Historian Looks at Meanings behind the Labels." *Philosophy of Music Education Review*, vol. 9, no. 2, 2001, pp. 19–29.

Lomax, Alan. "Folk Song Style." *American Anthropologist*, vol. 61, no. 6, [American Anthropological Association, Wiley], 1959, pp. 927–54.

Main Exhibit Hall. *Rock and Roll Hall of Fame,* 2021. Main Exhibit Hall | Rock & Roll Hall of Fame (rockhall.com)

Malandro, Bri. "'One in Four Cowboys Were Black'. The Yee Haw Agenda's Founder on the Politics of Cowboy Style." *The Guardian*, 21 Feb. 2020. https://www.theguardian.com/fashion/2020/feb/21/one-in-four-cowboys-were-black-the-yee-haw-agendas-founder-on-the-politics-of-cowboy-style.

Malone, Bill C., and Tracey E. W. Laird. *Country Music USA: 50th Anniversary Edition*. Anniversary edition, University of Texas Press, 2018.

Martin, R., Omeokwe, A. "Lil Nas X, Country Music's Unlikely Son, Sparks Conversation On Genre And Race." *KCUR 89.3 - NPR in Kansas City*, 24 May 2019. *www.kcur.org*, https://www.kcur.org/2019-05-23/lil-nas-x-country-musics-unlikely-son-sparks-conversation-on-genre-and-race.

Manuel, Jeffrey T. "The Sound of the Plain White Folk? Creating Country Music's 'Social Origins.'" *Popular Music & Society*, vol. 31, no. 4, Oct. 2008, p. 417.

Meacham, Jon, and Tim McGraw. "Whose Country?" *TIME Magazine*, vol. 194, no. 7, Aug. 2019, pp. 50–53.

Morris, David. "Hick-Hop Hooray? 'Honky Tonk Badonkadonk,' Musical Genre, and the Misrecognitions of Hybridity." *Critical Studies in Media Communication*, vol. 28, no. 5, Dec. 2011, pp. 466–88.

Moss, Marissa. "Lil Nas X's 'Old Town Road' Sounds like Country's Future. So Why Has Nashville Snubbed It?" *Los Angeles Times*, 1 May 2019. https://www.latimes.com/entertainment/music/la-et-ms-lil-nas-x-old-town-road-nashville-country-20190501-story.html.

Newman, Melinda. "Country or Not? Lil Nas X's "Old Town Road" Raises Big Questions About Genre in the Streaming Age." *Billboard*. 9 Apr 2019. https://www.billboard.com/articles/business/8506428/lil-nas-x-old-town-road-splits-country-music-industry-opinion-genre-streaming-age.

Nunn, Erich. "Country Music and the Souls of White Folk." *Criticism*, vol. 51, no. 4, Fall 2009, pp. 623–49.

O'Connor, Patrick Joseph. "Cowboy Blues: Early Black Music in the West." *Studies in Popular Culture*, vol. 16, no. 2, 1994, pp. 95–103.

Pecknold, Diane, editor. *Hidden in the Mix: The African American Presence in Country* Music. Duke University Press, 2013.

Peisner, David. "Inside Country Rap's Big Dreams and Contradictions." *Rolling Stone*, 24 Jan 2018. https://www.rollingstone.com/music/music-features/rhymes-from-the-backwoods-the-rise-of-country-rap-205828/.

Peterson, Nancy J., editor. Toni Morrison: Critical and Theoretical Approaches. Johns Hopkins UP, 1997.

Petrusich, Amanda. "Darius Rucker and the Perplexing Whiteness of Country Music." *The New Yorker*, 25 Oct 2017. https://www.newyorker.com/culture/cultural-comment/darius-rucker-and-the-perplexing-whiteness-of-country-music.

Reefer, B., Spanos, K. "How Lil Nas X and 'Old Town Road' Defy Categorization." *Smithsonian*, Dec 2019. https://www.smithsonianmag.com/arts-culture/lil-nas-x-old-town-road-american-ingenuity-180973492/.

Reese, Ashley. "The 'Yee Haw Agenda' According to Bri Malandro, Its Creator." *Jezebel*, 27 Mar 2019. https://jezebel.com/what-everyone-is-getting-wrong-about-the-yee-haw-agenda-1833558033.

Ryan, John, and Legare H. Calhoun III. "Gender or Genre? Emotion Models in Commercial Rap and Country Music." *Popular Music & Society*, vol. 20, no. 2, Summer 1996, p. 121.

Schwartz, Drew. "TikTok Challenges, Ranked by How Likely They Are to Maim or Kill You." *Vice*, 20 Feb. 2020. https://www.vice.com/en_us/article/m7q988/what-are-the-most-dangerous-tiktok-challenges-skullbreaker-cha-cha-slide-bright-eye.

Scott, Sidney. "18 Photos That Prove Black People Do Country Music." *Essence*, 5 Nov 2016. https://www.essence.com/entertainment/black-country-singers/.

Sisario, Ben. "Lil Nas X Added Billy Ray Cyrus to 'Old Town Road.' Is It Country Enough for Billboard Now?" *The New York Times*, 5 Apr. 2019. *NYTimes.com*, https://www.nytimes.com/2019/04/05/business/media/lil-nas-x-billy-ray-cyrus-billboard.html.

Smith, Lindi. "Here Are the Most Common Words Found in Modern Country Songs." *Wide Open Country*, 21 Nov. 2016, https://www.wideopencountry.com/common-words-in-country-songs/.

Smithsonian American Ingenuity Awards. *Ingenuity Awards - Youth - Lil Nas X*. https://www.smithsonianmag.com/videos/category/arts-culture/smithsonian-american-ingenuity-awards-2019-_2/?jwsource=cl.

Spanos, Brittany. "Giddy Up! Here's What You Need to Know About the Yeehaw Agenda." *Rolling Stone*, 8 Mar. 2019. https://www.rollingstone.com/music/music-features/welcome-to-the-yee-yee-club-bitch-805169/.

Stein, Daniel T. "'I Ain't Never Seen a Nigger': The Discourse of Denial in Lee Smith's The Devil's Dream." *European Journal of American Culture*, vol. 22, no. 2, Jan. 2003, pp. 139–57.

Taylor, Fredrick J. "Black Music and Musicians in the Nineteenth Century." *Western Journal of Black Studies*, vol. 29, no. 3, Fall 2005, pp. 615–21.

"The Black Country Artists Who Paved The Way For 'Old Town Road.'" 1A, WAMU, *NPR.Org*, .14 Aug 2019. https://www.npr.org/2019/08/14/751192417/the-black-country-artists-who-paved-the-way-for-old-town-road.

"The Collection Online /283,363 Items." *Country Music Hall of Fame.* https://digi.countrymusichalloffame.org/.

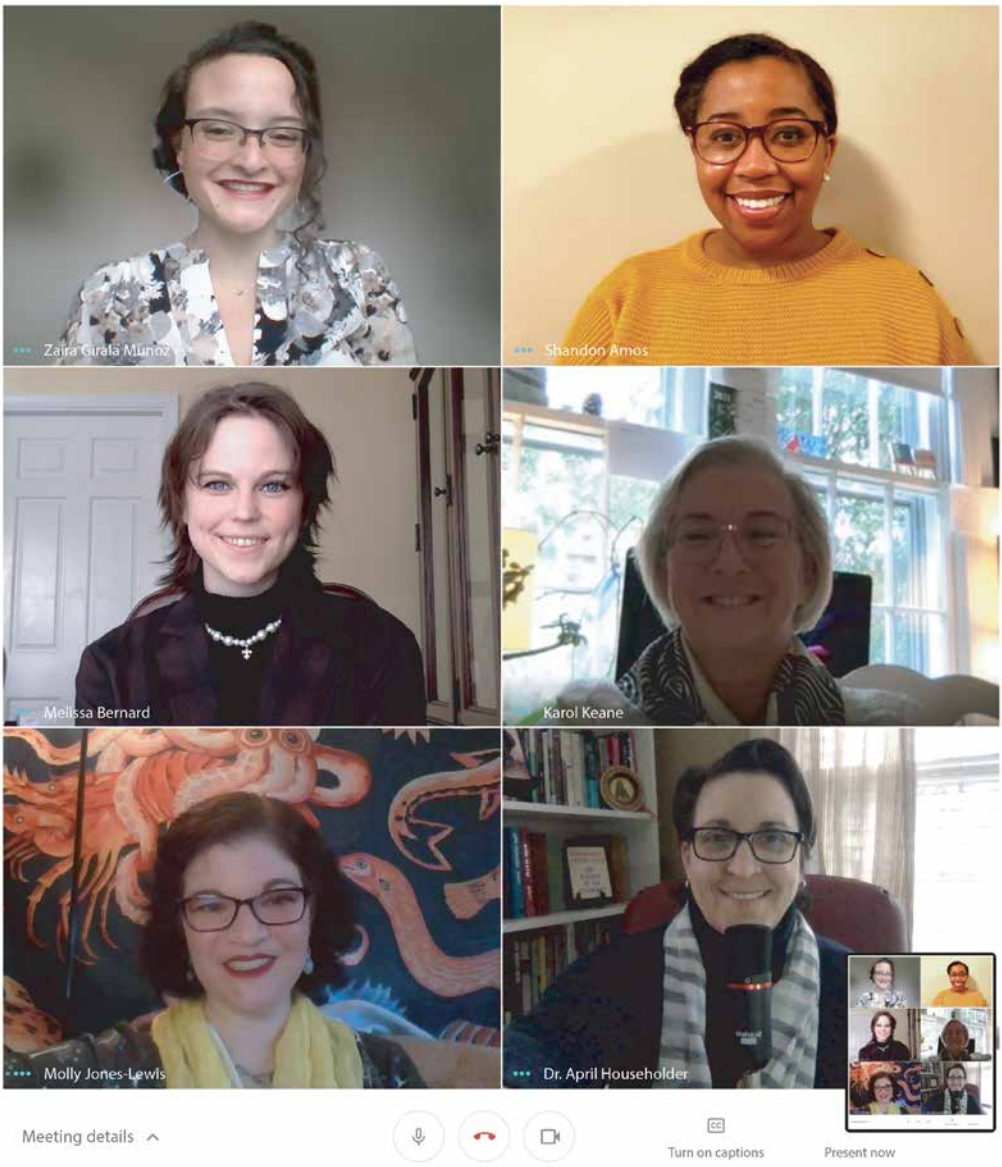
Thompson, D., and Hacquard, D. "Region, Race, Representation: Observations from Interviews with African American Musicians in Appalachia." *Journal of Appalachian Studies*, vol. 15, no. 1/2, 2009, p. 126.

Trust, Gary. "Hot 100 Songs: Longest-Leading No 1s." *Billboard*, 24 Mar. 2020. http://www.billboard.com/articles/business/chart-beat/6077132/hot-100-songs-longest-leading-no-1s.

Van Sickel, Robert W. "A World without Citizenship: On (the Absence of) Politics and Ideology in Country Music Lyrics, 1960–2000." *Popular Music & Society*, vol. 28, no. 3, July 2005, pp. 313–31.

Wald, Gayle. "'Have a Little Talk': Listening to the B-Side of History." *Popular Music*, vol. 24, no. 3, 2005, pp. 323–37.

# Editor & Designer Biographies



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# UMBC REVIEW

JOURNAL OF UNDERGRADUATE RESEARCH

Vol. 22

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