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Dear Reader,

The purpose of academic research ought to be the exposition of truth, the questioning of norms, and the development of new ways of engaging with the world. The DU Undergraduate Research Journal (DUURJ) seeks to promote these attributes by providing students an outlet to showcase their rigorous and thoughtful research. At a time when the freedoms of human thought and action are being curtailed around the world, this could not be more important. With that, I would like to welcome you to the Spring 2022 issue of DUURJ.

In this issue you will find articles investigating diverse topics ranging from DNA damage responses and transcatheter valve efficiency to presidential rhetoric and a study of Americans' awareness of conservation. You will also find two faculty interviews with preeminent DU scholars from the Department of Chemistry and Biochemistry and the Graduate School of Social Work. We round out this issue with an editorial piece examining the annual Undergraduate Research Showcase, the primary way DU students can orally present their research.

This issue could not have been completed without the tireless efforts and support of many people. To the section editors, I am eternally grateful for your insights and thorough reading which helped these articles be the best they could be. To the authors and artists, thank you for entrusting us with your amazing work – I am honored to present it in this way. This could not have been done without the help of our peer reviewers who are, as I said in the last issue, the backbone of academic research. Thank you to our advisor, Dr. Kate Tennis, who has given us the guidance and support to work independently and make DUURJ our own. I would be remiss without thanking Toni Panzera, who is the engine behind DUURJ and without whom this would not exist.

On a more personal note, I must express my gratitude to the DUURJ community for trusting me as Editor in Chief. At times it has been challenging, but I have been honored to support undergraduate research and empower students to share their excellent work. Next year the leadership board will look quite different, with current members assuming the roles of graduating seniors. To Griffin, Toni, Kari, and Anit, it has been a pleasure working with you this year. While each of us will be going our separate ways, I wish you the very best in wherever life takes you. To the new leadership, next year will not be without its challenges, but never lose sight of the purpose of DUURJ. You are worthy of this responsibility, and I have full faith you will make your DUURJ something special.

Sincerely,



Arlo Simmerman
Editor in Chief



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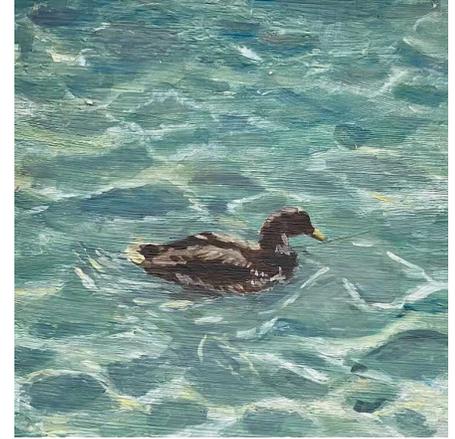
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The Effect of the Oncometabolite Fumarate in the Response to DNA Damage: An analysis of the role of fumarate in the response of cells A2780 to DNA damage induced by cisplatin

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Abstract

Previous research has been conducted on the effect of oncometabolites on DNA damage repair; however, these studies have traditionally focused on the response to damage caused by DNA double-strand breaks, whereas this study involves cisplatin-induced damage that creates DNA cross-links. This study reports on the effect of the oncometabolite fumarate on the response of A2780 cells to DNA damage produced by cisplatin. Three assays were used to complete this study: comet assay, cell cycle assay and apoptosis assay. The comet assay revealed that fumarate influenced the response of cells to DNA damage and, at a lower 1mM concentration, appeared to protect cells from further DNA damage. When looking at cell cycle progression, it was found that fumarate did not change the cell cycle nor modify the effect of cisplatin. The apoptosis assay showed that fumarate also did not induce apoptosis nor alter cisplatin-induced apoptosis. This investigation contributes to existing knowledge of the role of oncometabolites, specifically fumarate, on DNA damage repair responses.

Resumen

Se han realizado investigaciones previas sobre el efecto de los oncometabolitos en la reparación del daño del DNA; sin embargo, tradicionalmente estos estudios se centran en la respuesta al daño causado por las roturas de la doble cadena del DNA, mientras que este estudio implica el daño inducido por el cisplatino que crea enlaces cruzados en el DNA. Aquí se reporta el efecto del oncometabolito fumarato en la respuesta de las células A2780 al daño en el DNA producido por el cisplatino. Se utilizaron tres ensayos para completar este estudio: ensayo de cometa, ensayo de ciclo celular y ensayo de apoptosis. El ensayo de cometa reveló que el fumarato tiene un efecto en la respuesta de las células al daño en el DNA y, a una menor concentración, parece proteger a las células de un mayor daño en el DNA. Al observar la progresión de los ciclos celulares, se encontró que el fumarato tampoco cambia el ciclo celular ni modifica el efecto de cisplatino. El ensayo de apoptosis mostró que el fumarato tampoco induce apoptosis y no altera la apoptosis inducida por el cisplatino. Esta investigación se suma a la información conocida sobre el papel de los oncometabolitos, específicamente el fumarato, en las respuestas de reparación del daño del DNA.

1 INTRODUCTION

Cancer refers to a number of conditions characterized by abnormal and uncontrolled cell growth. This uncontrolled cell behavior is due to the accumulation of genetic and epigenetic alterations in the genome that target tumor survival and metastasis¹. Cancer is a very complex disease that can be caused by a variety of genetic or metabolic mutations. In recent years, there has been a shift in cancer research to better understand the links between cancer and altered cellular metabolism². Dysregulated metabolism is understood to be central to cancer cells' ability to survive, proliferate and metasta-

size. It appears that many cancer genes and mutations affect three major metabolic pathways: aerobic glycolysis, glutaminolysis, and one-carbon metabolism³. In place of normal ATP production, cells are forced to generate large quantities of nutrients necessary for the rapid cell growth and division of a cancer cell⁴. In terms of patient care, detection of simple metabolic changes in the body may be able to indicate early tumor and cancer development⁴. More specifically, bioinformatics analyses of gene expression data from cancer patients have associated deletion of mitochondrial genes with poor clinical outcomes⁵. When mutated, mitochondrial

genes encoding enzymes such as fumarate hydratase (FH) can lead to cancer development².

The role of hydratase in the Krebs cycle, or tricarboxylic acid (TCA) cycle, is the transformation of fumarate to malate. When fumarate hydratase is mutated and this transformation does not occur, there is a buildup of fumarate in the cell. The accumulation of metabolites like fumarate appears to play a causal role in the development of a wide variety of tumor types. Thus, fumarate is known as an oncometabolite and considered to be a potential biomarker of prognosis, treatment efficacy and early disease recurrence⁶. Oncometabolites, in short, are conventional metabolites that when abnormally accumulated in large amounts, exhibit prooncogenic functions⁷. Fumarate can competitively inhibit α -ketoglutarate (α -KG) dependent dioxygenase enzymes due to their similarities in structure as shown in Figure 1⁸. Dioxygenases are involved in the regulation of hypoxia conditions and epigenetic changes and, when inhibited, can alter gene expression and chromatin structure⁸. Oncometabolites can then modify the response to agents that induce DNA breaks, either by increasing or blocking the ability to repair these breaks. This study focuses on the impact of fumarate and the consequences of inhibition of these dioxygenase enzymes on the cell's response to DNA damage.

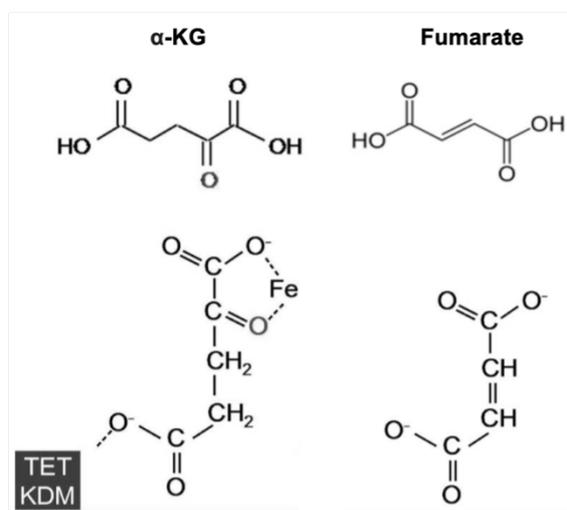


Figure 1. Similarity in α -KG and fumarate structure⁸

The introduction of cisplatin can be used to induce DNA damage and along with the induction of fumarate, to study the subsequent effect of fumarate on repair. Cisplatin is a platinum-based chemotherapeutic drug used to treat solid tumors such as those of ovarian, prostate, and lung cancer⁹. The drug primarily forms intra- and inter-strand cross-links within the DNA. The cross-link between two adjacent guanines is believed to be the critical lesion responsible for the cytotoxicity of cisplatin¹⁰.

The formation of cisplatin-DNA adducts interferes with DNA replication and transcription, altering the DNA structure. These alterations are then recognized by cellular proteins which alert damage repair systems⁹. The efficacy of cisplatin as a chemotherapeutic agent is therefore dependent on the cell's ability to detect and respond to DNA damage¹¹. The cell's response to repair the damage is not guaranteed, in which case the cell may undergo apoptosis. The signaling pathways that control apoptosis then also significantly impact a cell's responsiveness to cisplatin¹⁰.

In this study, cisplatin was introduced into the A2780 line of ovarian cancer cells to induce inter-strand crosslinks in the DNA. DNA damage repair systems under the influence of fumarate were called upon to repair the damaged DNA. The response of these repair systems was then measured using a series of three damage-detection assays: comet assay, cell cycle progression analysis, and apoptosis analysis.

The comet assay or single gel electrophoresis is a relatively simple and sensitive method for the detection of DNA damage and repair¹². This technique has several advantages, such as a relatively low cost, use of small cell samples, analysis at the single cell level, and efficiency⁹. The comet assay is a widespread and useful tool in genotoxicity testing in cells both *in vitro* and *in vivo*¹³. When the electric field is applied to lysed and stained cells suspended in a thin agarose gel during electrophoresis, negatively charged DNA is attracted to the positively charged anode. Undamaged DNA strands are too large to be moved, while smaller fragments are attracted from the core to the anode¹². The migration of DNA from the nucleus resembles the shape of a comet, hence the name of the assay (Figure 2). The amount of DNA damage is strongly correlated with the extent of DNA migration and can be analyzed using an electronic system such as the Komet 5.

Cell cycle and apoptosis assays are based on the principle of DNA replication and the amount of DNA in a cell at any given point in its life. In this study, cell cycle analysis was used to quantify cells in one of three phases: Gap 1 (G1), Synthesis (S), and Gap 2 (G2). The G1 phase consists only of cell growth during which only one chromosome is present in the cell. In the S phase, the cell has begun replication. In the G2 phase, replication is complete, and two chromosomes are present in the cell. Apoptotic cells, in comparison, have reduced DNA content, as they are on their way to cell death. By quantifying the DNA content of each cell, the phase in which the cell was arrested can be determined. Visualization of these phases is simplified by the use of a fluorescent dye and is performed by flow cytometry to detect varying levels of fluorescence. The fluorescence is bound by the cell stoichiometrically (in proportion to the level of DNA present in the cells) and these levels of fluorescence are a direct indicator of the cell's cycle¹⁴.

In apoptosis analysis, the percentages of apoptotic cells measured by flow cytometry is divided between early apoptosis and late apoptosis. This division is determined based on the levels of annexin V and propidium iodide (PI) that are able to enter each cell. A cell in early apoptosis is characterized by an increase in cell membrane permeability and translocation of phosphatidylserine residues from the inside of the cell membrane to the outside¹⁵. The presence of these phosphatidylserine residues outside the cell membrane is irreversible and indicates that the cell is engaged in apoptosis. Annexin V is a Ca²⁺-dependent phospholipid-binding protein that binds tightly to these residues and thus indicates the presence of cells in the early stages of apoptosis. For PI to stain the cell, it must be able to cross the cell membrane. Since the membrane of a living or early apoptotic cell is still intact, entry of PI is prohibited. In a late apoptotic or necrotic cell, a decrease in plasma membrane integrity has occurred, allowing PI entry and staining of the cell¹⁶. Knowledge of cell arrests, both through cell cycle and apoptosis analyses, give rise to a better understanding of DNA cross-link damage repair in the presence of the oncometabolite fumarate.

2 OBJECTIVE

The principal objective of this work was to determine the effect of the oncometabolite fumarate on the response of A2780 cells to DNA damage produced by cisplatin. While much is unknown about DNA damage response in the presence of oncometabolites, it was hypothesized that fumarate would influence DNA damage repair systems. This study was performed by analyzing genomic instability (comet assay), cell cycle progression, and the induction of apoptosis (flow cytometer). Six conditions of differing levels of fumarate and cisplatin were tested using these three methods.

3 METHODS

3.1 Cell Culture

The human ovarian cancer cell line A2780 is known for its use in toxicity testing and cancer genetic studies (Sigma-aldrich, 2021). This cell line is a model in cisplatin treatments. Cells were cultured in a medium composed of 89.8% RPMI medium, 10% FBS, and 0.2% Plasmocin®. All cells were cultured in an incubator at a temperature of 37°C.

3.2 Cell Treatment

For each assay, A2780 cells were plated in a six-well plate and received the following treatments: control, 1 mM fumarate, 5 mM fumarate, 20 µM cisplatin, 1 mM

fumarate + 20 µM cisplatin, 5 mM fumarate + 20 µM cisplatin. Cells were exposed to the treatment for three hours before performing the corresponding assay. After the three-hour treatment, excess medium was removed, and the cells were washed with cold PBS (phosphate buffered saline). The cells were then subjected to another brief incubation with the addition of trypsin to ensure their detachment from the plate. After centrifugation and removal of excess medium, cells were resuspended to reach the desired concentration.

3.3 Comet Assay

The first step in performing the comet assay was the preparation of the agarose layers. To ensure the sterility of the slides, they were immersed in ethanol for a minimum of 24 hours at a temperature of 20°C. The first of the two agarose layers were prepared the day before the experiment using 0.5% normal melting point agarose (NMPA). To dissolve the agarose in water, it was heated in a microwave and then kept in a hot water bath. On each slide, 150 µL of solution was spread with a sterile finger. The slides were placed in the oven at 37°C until cell collection.

On the day of the experiment, the second layer was prepared with 0.5% low melting point agarose (LMA). The agarose was heated in the microwave and placed in a bath to keep it warm. 30 µL of $1.5 \times 10^6 - 2 \times 10^6$ treated cells was mixed with 65 µL of agarose and placed on top of a slide already containing the first layer of solidified agarose. A cover slip was placed on each slide and the slides were stored in a refrigerator at 4°C in the dark for at least 20 minutes until the agarose solidified. Following the plating of cells, all steps of the assay were performed under red light to avoid further damage to the DNA.

Once the second layer had solidified and after removing the coverslips, the slides were immersed in 200 mL of a lysis solution and kept at 4°C for one hour. The lysis solution was composed of 89% lysis buffer (NaCl 2.5 M, Na₂EDTA 100 mM, Tris 10 mM, NaOH 0.25 M), 10% DMSO (dimethyl sulfoxide), and 1% Triton X-100. The pH of the solution was 10.

After lysis, the slides were placed in the electrophoresis cuvette and allowed to denature for 20 minutes. The slides were placed directly next to each other without any space between them. The electrophoresis buffer in which the pores were denatured was composed of Na₂EDTA 1 mM and NaOH 300 mM at a pH > 13. Electrophoresis was performed on ice at 4°C in the dark for 20 minutes at a voltage of 0.83 V/cm and a current intensity of 300mA.

To neutralize the pores, they were placed in a cuvette and washed 3 times for 5 minutes with a neutralization buffer consisting of 0.4 M Tris at pH 7.5. The cells were fixed and dehydrated in ethanol, and the slides were

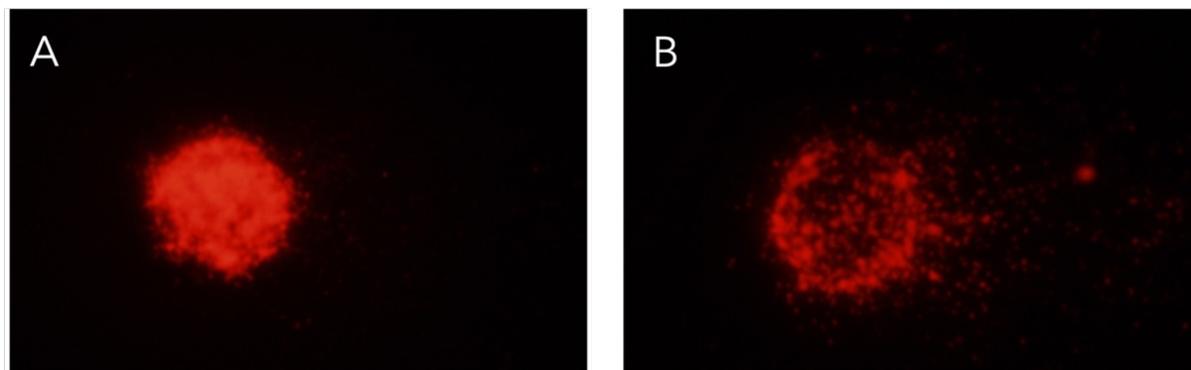


Figure 2. Image capture of two A2780 cells in a comet assay. (A) Control cells without treatment. (B) Cell showing increased DNA migration following treatment.

kept at room temperature in the dark overnight.

Each slide was coded for blinded analysis and the DNA nuclei from the lysed cells was stained with 40 μ L of ethidium bromide diluted in water. Nucleoids were visualized on the Olympus BX61 fluorescence microscope, equipped with an Olympus DP-70 digital color camera, belonging to the Photon Microscopy unit and Image Processing unit of the SCTs of the University of Oviedo. The cells were visualized with a 40x objective and a BP530-550 fluorescence filter. Images were taken of 50 individual cells per slide. For each treatment, two slides were prepared, resulting in a total of 100 images per condition. The nucleoid images obtained were analyzed with Komet 5 (Kinetic Imaging Limited, UK) to quantify DNA damage by the percentage of DNA in the tail. Three individual comet assays were performed in this study.

3.4 Cell Cycle Assay

For cell cycle analysis, $1.5 \times 10^6 - 2 \times 10^6$ cells were first fixed with 2mL cold 70% ethanol while the cells were constantly agitated by vortex. The cells were then left to rest for at least 24 hours in the freezer at -20°C . To remove the ethanol, the cells were centrifuged at 1,200 rpm for 5 minutes and washed with PBS. Then, to each sample, 100 μ L PBS, 100 μ L RNase, and 10 μ L propidium iodide (PI) were added and the samples incubated for 30 minutes. Each sample was placed in a 96 well plate and analyzed with the Cytoflex S cytometer (Beckman Coulter®). Three individual cell cycle assays were performed in this study.

3.5 Apoptosis Assay

To determine apoptosis levels and status (early or late), 1×10^3 cells were collected from each treatment. Each sample was centrifuged for 5 minutes at 1200 rpm and then 200 μ L of binding buffer, 5 μ L annexin V, and 1 μ L propidium iodide (PI) were added. The cells were

incubated in the dark at room temperature for 10 minutes. Each sample was then plated and analyzed with the Cytoflex S cytometer (Beckman Coulter®). Four individual apoptosis assays were performed in this study.

4 RESULTS

4.1 Comet Assay

A comet assay was used to study the effect of cisplatin and fumarate on DNA damage and the role of fumarate in DNA damage repair. The following results were obtained by scoring the percentage of DNA present in the comet “tail” using the Komet 5 program. Figure 2 represents the image captures of two cells to demonstrate quantifiable “tail” observed in a treated cell.

The results presented are from three independent experiments. Figure 3 shows the respective DNA damage for each condition, indicated by the percentage of DNA particles in the comet tail of each nucleoid.

As expected, the cisplatin condition caused a significant increase in DNA damage. The percentage of tail damage was 9.65% in the control and 13.77% after the addition of cisplatin. Untreated with cisplatin, fumarate had an effect and induced damage as well. The DNA damage present in the 1mM fumarate and 5mM fumarate conditions is nearly equal, showing that this increased damage is not concentration dependent. With the addition of cisplatin to fumarate, there is a significant decrease in damage in the 1mM fumarate condition (12.14%) relative to the cisplatin control (13.77%). The 5mM fumarate condition (13.76%) shows no significant change from the cisplatin condition.

4.2 Cycle Cell Progression

Analysis of cell cycle progression was used to determine the influence of fumarate and cisplatin on cell division. Treatment of cells with PI allowed detection of the DNA content within the cell, which was directly proportional

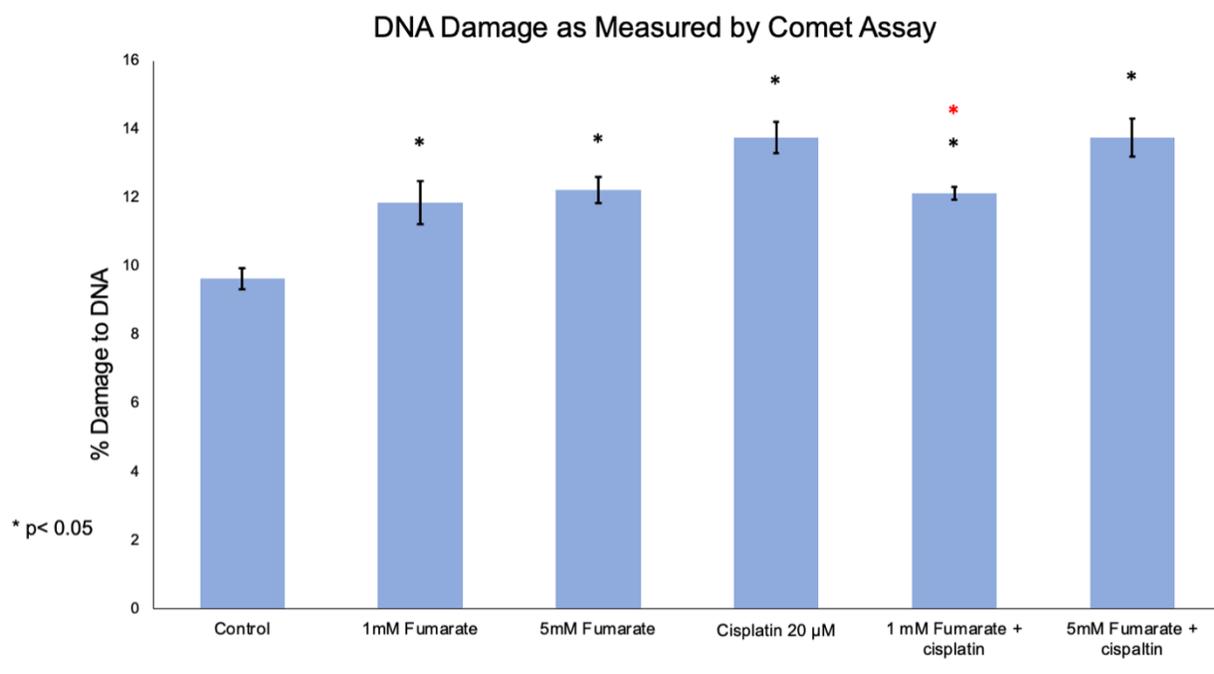


Figure 3. The effect of fumarate treatment on A2780 cells with cisplatin-induced DNA damage as analyzed by comet assay. All conditions are statistically significant compared to control. Compared to cisplatin, only the 1mM fumarate + cisplatin condition is statistically significant. * $p < 0.05$ comparing each concentration with control by paired t-test. * $p < 0.05$ comparing each concentration with 20 µM cisplatin by paired t-test.

to the stage at which the cell was arrested¹⁷. The flow cytometer was then able to quantify the number of cells within each phase according to the level of PI present. The results presented are from three independent experiments. Figure 4 shows the percentage of fumarate- and cisplatin-treated A2780 cells in each phase of the cell cycle obtained in the cytometry assays.

Relative to the control, the number of cells arrested in any phase of the cell cycle in the 1mM fumarate or 5mM fumarate condition is not significantly different. In all three conditions, most cells are arrested in G1 phase with few arrested in S and G2 phase. This is the expected result for normal cell division as the G1 phase is the longest phase involving cell growth. With the addition of cisplatin, there is a significant increase in the percentage of cells arrested in S phase and a significant decrease in cells arrested in G1 phase. This same trend is observed with the addition of both concentrations of fumarate to cisplatin. The addition of fumarate to cisplatin also produces no change from the cisplatin treatment.

4.3 Apoptosis Assay

Cells stained with annexin V were characterized as having undergone early apoptosis and those stained with IP as late apoptosis. Figure 5 shows the percentages of cells in early and late apoptosis after exposure to

cisplatin and two different concentrations of fumarate. The results presented are from four independent experiments.

With respect to the control, both fumarate conditions showed very similar levels of apoptosis, in both early and late. In these three conditions, 8.8% of cells experienced early apoptosis and 16.4% of cells experienced late apoptosis. With the addition of cisplatin to the control, there was an increase in apoptosis, but not to a statistically significant level. With the addition of both fumarate concentrations, there is no change from cisplatin treatment, only from control. The conditions with cisplatin show that on average, 20.1% of the cells experienced early apoptosis and on average 24.2% of the cells experienced late apoptosis. Regardless of concentration, the addition of fumarate caused no significant change.

5 DISCUSSION

5.1 Comet Assay

As shown in Figure 3, the addition of fumarate produced significantly more DNA damage compared to the control. However, this was not dependent on the dose of fumarate. If fumarate alone was causing damage to the cells, a higher fumarate concentration would be expected to yield higher levels of damage. Rather than indicating that fumarate induced DNA damage, the results more likely suggested that fumarate was blocking

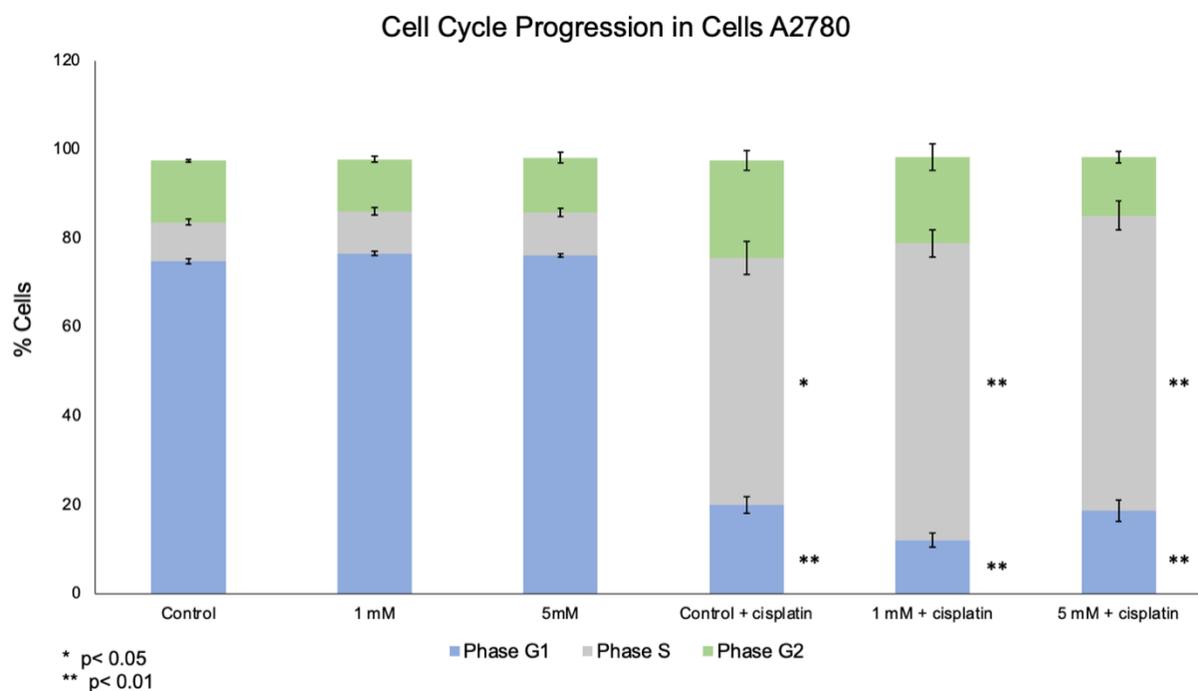


Figure 4. The effect of cisplatin and fumarate on cell cycle progression. The percentage of cells in cell cycle phases G1, S, G2 after fumarate and cisplatin treatments for three hours. G1 and S phases are statistically significant with respect to the control. * p < 0.05; ** p < 0.01 comparing each concentration with the control by paired t-test.

the repair of spontaneous damage. This phenomenon has been documented in other studies like that of Sulkowski et. al in 2020. Sulkowski observed that by disrupting local chromatin signaling, oncometabolites such as fumarate, succinate and 2HG, suppress DNA damage repair¹⁸. In his study, it also appeared that oncometabolites specifically suppress the homology-dependent repair (HDR) pathway and develop sensitivity to poly (ADP-ribose) polymerase (PARP) inhibitors; however, the mechanisms by which this does not occur are not yet clearly understood¹⁹.

When 1mM fumarate was added to the cisplatin-treated cells, there was a significant decrease in the amount of damage relative to the cisplatin control. This same effect, however, did not occur at the higher concentration of 5mM fumarate. This indicates that, at the lower concentration, fumarate had a protective effect against cisplatin. There are two theories as to how this occurred, but further studies are needed to verify this. It is possible that fumarate caused increased DNA methylation and thus prevented cisplatin from entering DNA and inducing further damage. Another theory is that cisplatin still damaged DNA, but fumarate, at a lower dose, was able to help repair the damage caused. Although the mechanisms of this phenomenon are still unclear, it appeared that 1mM fumarate did have a protective effect against cisplatin-induced damage. A study by Gueble & Bindra²⁰ revealed that the physiological

level of fumarate may play a role in the activation and regulation of certain DNA repair pathways. Under normal conditions, translocation of fumarate hydratase from the cytosol to the nucleus is crucial for activation of the DNA damage checkpoint²¹. Lack of FH and this translocation can then inhibit proper DNA damage repair²⁰.

5.2 Cycle Cell Progression

The addition of cisplatin was observed to increase the number of cells arrested in S phase, but the addition of fumarate did not change cell arrest trends compared to control or cisplatin. Traditionally, an increase in S phase cell arrest indicates high levels of toxicity caused by a block in DNA replication²². Several other studies have observed this phenomenon of cell arrest in the synthesis phase when treated with cisplatin. It has also been observed that as the dose of cisplatin increases, so does the number of apoptotic and necrotic cells²³. There are two explanations for this observed increase in S phase cell arrest under cisplatin treatments. The first plausible explanation is that detection of the damage caused by cisplatin caused the cell to arrest while awaiting repair. The second is that the damage caused by cisplatin (DNA cross-linking) blocked the DNA replication process itself. Under normal conditions, as observed in cells not treated with cisplatin, most cells are in G1 phase, as this

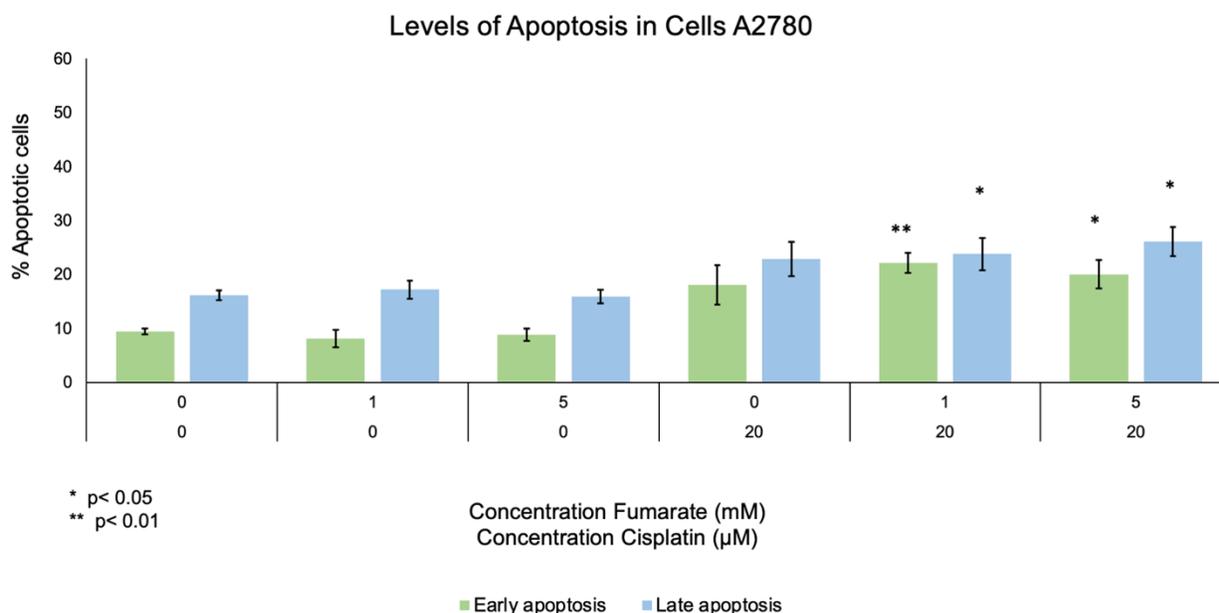


Figure 5. The effect of cisplatin and fumarate on apoptosis. The conditions of 1 mM fumarate + cisplatin and 5 mM fumarate + cisplatin are statistically significant in early and late apoptosis with respect to control. * p < 0.05; ** p < 0.01 comparing each concentration with control by paired t-test.

is the longest phase of the cell cycle as the cell collects adequate nutrients to be able to enter S phase²⁴.

5.3 Apoptosis Assay

A significant increase in apoptosis, both early and late, was observed in cisplatin-treated cells. This is a well-documented observation, and it has been shown that the induced apoptosis is both time and dose dependent. There is a positive correlation between the number of apoptotic cells and the treatment time and dose of cisplatin²³. However, due to the lack of change with the addition of fumarate to the control or cisplatin condition, fumarate was observed to have no effect on apoptosis. This aligns with expectations that oncometabolites, rather than directly affecting apoptotic sequences, affect chromatin structure and access to DNA repair systems. Therefore, it can be concluded that fumarate does not induce apoptosis either in early or late, or in the conditions with and without cisplatin.

6 CONCLUSION

From this study and each assay, three major conclusions were drawn. From the comet assay, it was found that fumarate influences the response of cells to DNA damage. At a concentration of 1mM, this effect appears to protect DNA from further damage. It was also concluded that fumarate does not change the cell cycle or modify the effect of cisplatin. Lastly, fumarate does not induce apoptosis and does not alter cisplatin-induced

apoptosis.

While there is still much research to be done, this study begins the process of understanding the effect of oncometabolites on DNA damage repair systems called upon by abnormal cross-links in the DNA. Metabolic reprogramming through chemotherapies that target metabolism has been an area of focus in recent years for cancer treatment²⁵. Oncometabolites can modify the response to agents that induce DNA breaks through their ability to increase or inhibit the ability to repair DNA damage. This study works to address the role of the oncometabolite fumarate in this process. An understanding of the role played by oncometabolites in DNA repair processes is of interest for several reasons. Knowledge of their influence on the response to different types of tumor treatments could provide useful information in the management of patients and their response to antitumor therapy. It is also thought that genes that encode Krebs cycle enzymes could be used as therapeutic targets to modulate a patient's response to therapy. Additionally, the effect of oncometabolites has only previously been studied in response to DNA damage induced by breaks, and this study offers a new insight into their role when DNA damage is induced by cross-links.

7 ACKNOWLEDGEMENTS

This investigation would not have been possible without the help and guidance of María Sierra and Enol Álvarez González. Many thanks to María for the continuous support and advice

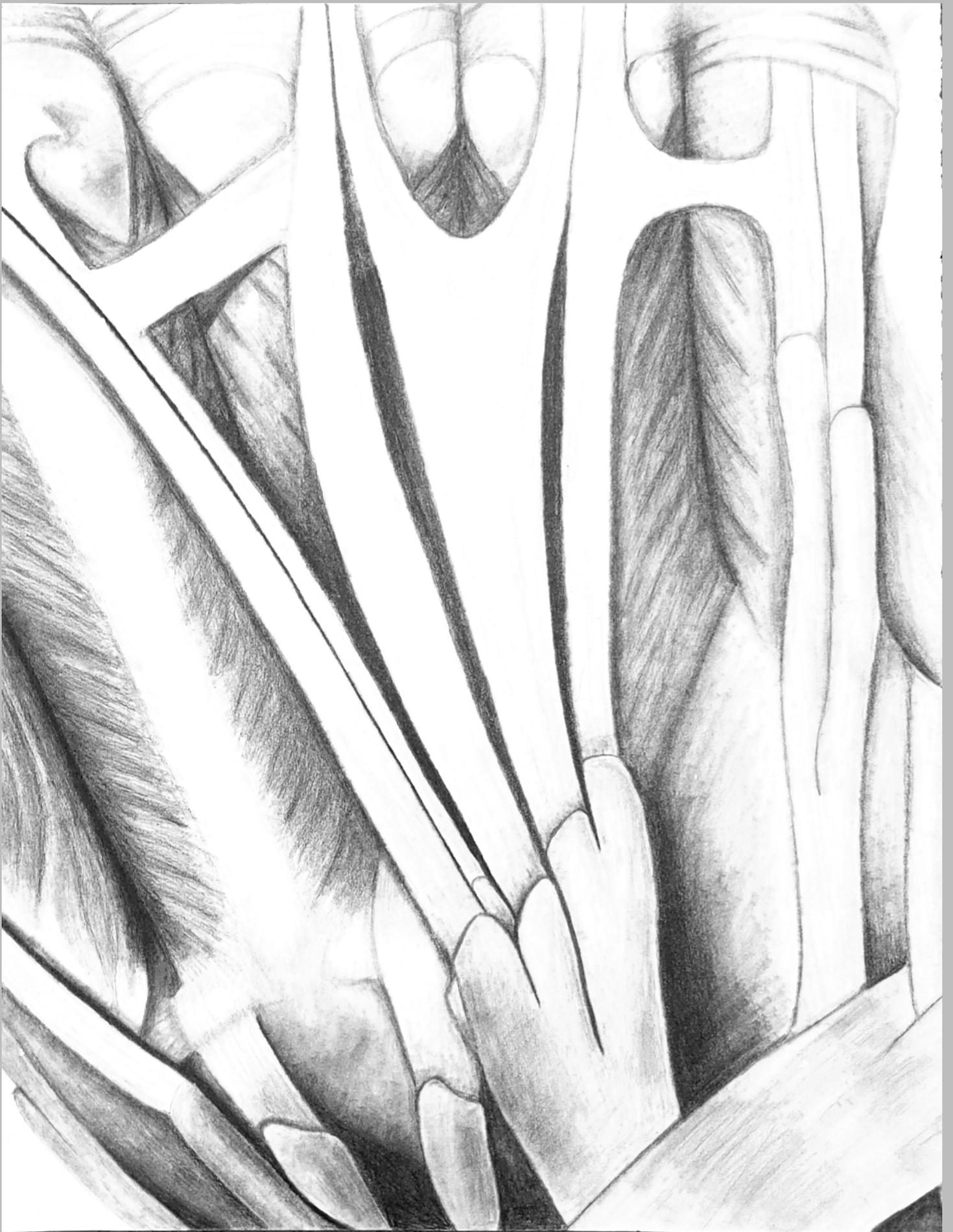
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8 EDITOR'S NOTES

This article was peer-reviewed.

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Tendons & Tissue by Amanda Kyle

Design Improvement of Transcatheter Aortic Valves for Aortic Stenosis Patients

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Abstract

Aortic valve disease is a common condition in patients above 60 years of age and is associated with significant morbidity and mortality. Aortic valve stenosis is characterized by the narrowing of the aortic valve, which can be quite debilitating. This disease is treated with transcatheter aortic valve replacement (TAVR), which is a rapidly expanding alternative to open-heart surgical aortic valve replacement (SAVR). Although TAVR is a less invasive than SAVR, long-term durability of the transcatheter aortic valves could be the Achilles heel of the procedure. Thus, the main objective of this research was to improve the design of transcatheter aortic valves using experimental testing and design analysis. After the design, building, and testing phases of four differing valves, it was seen that there are benefits to two specific designs. One design was a TAV based on a native aortic valve while the other was a TAV geometry that was optimized by finite element modeling. The native valve performed well during diastole based on its average regurgitation volume, while the optimized valve performed well during systole based on its average positive pressure difference and effective orifice area.

Keywords: Transcatheter aortic valve replacement, aortic valve, heart, experimental testing, 3D printing, laser cutting, stent, Dacron, leaflets, SolidWorks

1 INTRODUCTION

Aortic stenosis, which is caused by a calcific aortic valve disease, is currently the main cause for aortic valve replacement in developed countries¹. Aortic valve stenosis affects 2–7% of the population above 60 years of age and projections indicate AS prevalence will triple by 2050, due to the aging population^{1;2;3;4;5}. TAVR has emerged as a safe and effective alternative to SAVR for the treatment of patients with symptomatic severe aortic stenosis^{6;7;8;9}. In TAVR, a transcatheter aortic valve (TAV), made from biological tissue, is folded up on a catheter, passed through an artery into the heart, and expanded within the calcified native aortic valve (Figure 1)¹⁰. The native valve is the natural biological valve within a heart. TAVR is a non-invasive procedure, and the recovery time is substantially shorter than SAVR. However, durability is the Achilles heel of TAVs^{11;12;13;14;15}. Dvir and colleagues¹² estimated structural valve degeneration rate of TAVs to be approximately 50% at 8 years. The rate of structural valve degeneration in *surgical bioprosthetic valves* is known to be less than 15% at 10 years¹⁶. To be able to expand TAVR effectively to patients with a long-life expectancy,

long-term durability of a TAV should match with that of a surgical bio prosthesis (SAV).

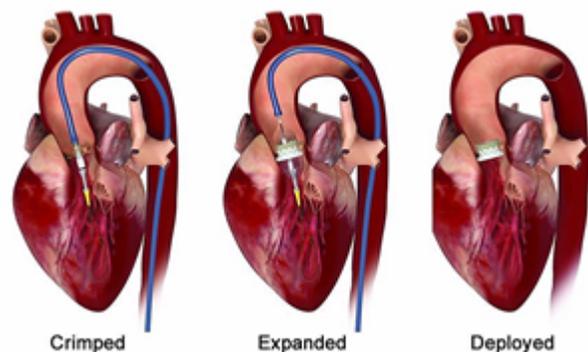


Figure 1. TAVR Procedure. A crimped valve is put in the aortic position using a catheter. Picture taken from Antelope Valley Hospital¹⁰.

Researchers have focused on the understanding of the structural mechanics of TAVs to improve longevity with SolidWorks modeling and simulations. The valves consist of three main components. Firstly, there are the leaflets, which make up the main part of the valve. Three of these mirrors each other in an arranged cylin-

drical fashion to allow blood flow to seamlessly pass through the valve. The leaflets are generally made of bovine, or porcine pericardial tissues^{14;15}. Next is the stent, which is a cylindrical frame with high radial strength to hold the valve in place. This provides a sturdy containment vessel for the leaflets. Generally, these stents are crafted with a tough but expandable material, such as cobalt chromium, stainless steel, and nitinol¹². Strong yet pliable material is required due to the harsh and ever moving cardiac environment. The final component is a piece (or two) of Dacron fabric, which is used as an anchor to attach the leaflets to the stent, and block areas which could cause leakage or regurgitation. All parts of a completed valve can be seen in the labeled image (Figure 2). It is widely accepted that high stress regions initiate calcification by damaging the structural integrity of fixed tissue¹⁷. These regions must be minimized through design.

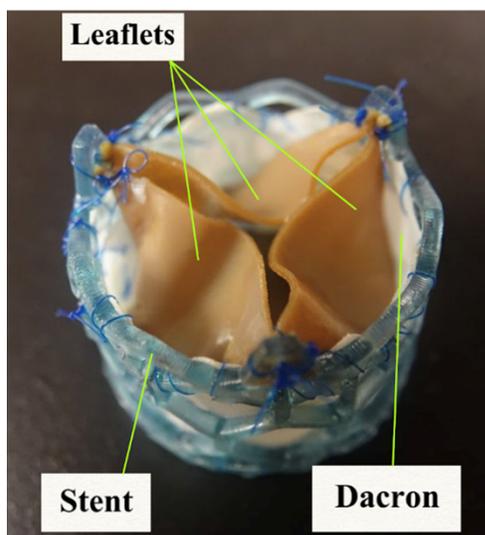


Figure 2. Labeled image of finished TAV including all three components: 1) Leaflets, 2) Stent, 3) Dacron. The TAV was built at the University of Denver by Samantha Shoun.

Valve designs require specific geometries and ratios to safely simulate real heart valves¹⁸. A successful design has been produced by Sapien 3¹⁹. In the past few years, a few computational frameworks have been developed to optimize TAV leaflet geometry and minimize peak stress on the leaflets²⁰. Researchers at the DU Cardiovascular Biomechanics Lab recently optimized TAV leaflet geometry using computational simulations²⁰. The optimized leaflet geometry was compared with a commercially available TAV (Edwards SAPIEN 3). A considerable reduction in the maximum in-plane principal stress was observed in the optimized leaflet geometry compared to Sapien 3 (Figure 3). The optimization results underline the opportunity to improve leaflet design in the next generation of TAVs to potentially increase long-term durability. A limitation associated

with these studies was that the effect of TAV leaflet geometry was not studied on the valve hemodynamics (blood flow motion). Moreover, it is not clear to what extent structural and hemodynamic performance of the optimized valve geometry are like that of a native aortic valve. TAVs typically have a vertical non-expanding post in contrast to a contoured shape of native valve.

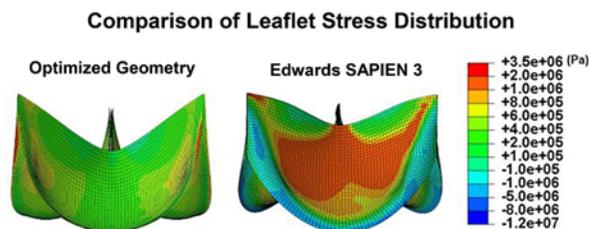


Figure 3. A considerable reduction in the peak in-plane maximum principal stress was observed in the optimized TAV geometry in comparison to the commercially available SAPIEN 3 valve²⁰

In this study, four transcatheter aortic valves will be designed, built, tested, and analyzed with the goal of creating durable and effective TAV designs for a TAVR procedure. Three optimized valves will be created, with designs based on geometry that has been optimized by finite element modeling. Ideal valves will have little to no regurgitation volume, a low PPD mean, a high effective orifice area, and small variance within all data sets. Changes in these data will tell the researchers which valve designs are preferable. Another additional valve will be created based upon the (average) native valve geometry and will serve as a control. All valves will have a 26 mm diameter to best simulate a TAV that would be used in a real life TAVR procedure. It is hypothesized that the final iteration of the optimized design will perform better than the first optimized iterations and the native design.

2 METHODS

2.1 Designing the Optimized and Native Transcatheter Aortic Valves

A statistically averaged geometry of a healthy aortic valve was created in SolidWorks based on reported values in the literature¹⁸ (Figure 4). This was a framework for the designs of the transcatheter aortic valves. As in several different experiments²¹, valve designs were created based upon ratios of general aortic valve geometries. These ratios are represented by certain valve lengths and angles (Figure 5). With set ratios of 1.2 for R_b/R_c and 1.4 for H/R_c , values for both the optimized and native designs were calculated. The optimized valves had a R_b of 13 mm, a decided height of 15.17 mm, and a commissure radius of 10.83 mm. In addition, the optimized model had a α of 23.58° and a θ

of 25.308° . These values differed from that of the native design in order to provide a better geometry based on finite element modeling for the man-made valve. The native valve measurements were 14.6 mm for height, 12.5 mm for R_b , 12.5 for R_c , 20° for α , and 34° for θ . The optimized valve had different radii for the commissure/base regions, while the native design required the same radii for both regions. The next step was to design the leaflets on SolidWorks. Two circles representing the base and commissure region were projected with a distance between them equal to the height of the perspective valves. The circles were cleaved into six even sections, each which would contain one half of a leaflet. A small space was added between the areas where each leaflet began and ended. This prevented overlap. Lines pertaining to the angles listed above were added as a blueprint for the leaflets. The spline function of SolidWorks was utilized to create the free edge and bottom boundary edge of each leaflet. Several points were carefully placed along blueprint lines to guide the spline. The area contained between the splines was filled then duplicated in a circular fashion to create three identical leaflets. Each one fell within the cleaved regions. Lastly the SolidWorks flatten function was able to flatten each leaflet into a 2D model that could be used as a template in the building portion of the experiment.



Figure 4. Statistically averaged geometry of a healthy aortic valve (top view).

With the leaflets completed, the Dacron and stent could be designed on SolidWorks as well. The stent is a crucial aspect of the valve, and it is generally designed to withstand the dynamic environment of a heart²¹. The prototypes in this experiment were 3D printed frames, since the focus was on the action of the leaflets and the basic geometry of the stents. The frame was not crimped, or balloon expanded. The stents were designed to be taller than the valves to fully encapsulate and protect the inner valve components¹⁹ and were designed to have a thickness of 1 mm. The additional height added to the stent was one third of the original leaflet height. The first design of the stents was inspired by the Sapien 3 valves¹⁹. The repeating geometric pattern of a TAV stent is utilized to secure the

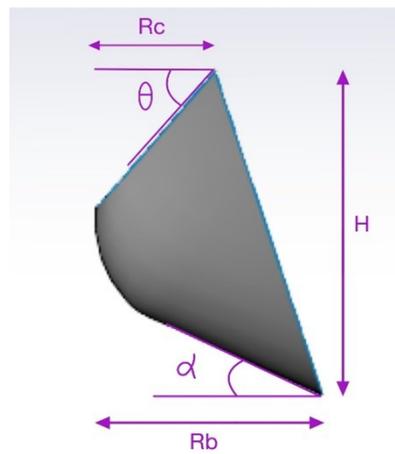


Figure 5. The ratios of valve properties are based upon differing geometries of both the leaflets and surrounding stent. The perspective shown is the side view of one leaflet. Defined valve parameters: R_b : radius at base; R_c : radius at commissures; θ : angle of free edge to the horizontal; H : leaflet height; α : angle from the base to the bottom valve edge

leaflets and assist with expansion and constriction of the valve during the TAVR procedure. The prototypes in this experiment still focused on a design that could be balloon expanded in future experiments using a different material. This was crafted on SolidWorks by first sketching a section of the geometric stent pattern then repeating for a total length that would equal the circumference of the valve. Next, the Dacron was fashioned to tightly fit into this stent. It was also inspired by the Sapien 3 valves¹⁹. The top portion of the Dacron fabric included the same geometric pattern as the top area of the stent. This allowed for the Dacron to align perfectly with the stent. The edges of the Dacron were created at an angle to later aid in the suturing and attachment of the components. As the experiment continued these same methods were used with altered designs to produce all the prototype valves. The outcome was several SolidWorks designs for each valve iteration (Table 1).

2.2 Building the Optimized and Native Transcatheter Aortic Valves

In the DU Cardiovascular Biomechanics Lab, three TAVs were constructed based on the optimized valve geometry²⁰, and one additional TAV was built based on a native design. Each valve was designed and created following the testing of the prior valve. This allowed for each iteration to improve upon the previous version. The building of these valves required two main pieces of hardware, including an Epilog Fusion M2 laser cutter²² and Formlabs Form 2 resin printer²³. The laser cutter resides in the DU Innovation Center while the 3D resin printer is in the mechanics shop at DU. To begin, the file for each flattened leaflet was

uploaded to the laser cutter from SolidWorks. Three identical leaflets were cut out of Edwards Lifesciences bovine pericardium. It was crucial to create a phosphate buffered normal saline solution²⁴ to store the leaflets in once they were removed from the main sheet of pericardium. This kept them moist and viable for testing. Proper cleaning techniques were in place to ensure the laser cutter would not be contaminated. The designs for the outer, and later inner Dacrons were cut from the laser cutter as well. This allowed for these small designs to be cut precisely. However, a small border equaling the diameter of the laser was added to each design as a tolerance to avoid cutting down the original size. The stent designs involved some trial and error in the building process. The stents were initially printed using a plastic filament; however, they were far too weak to survive soaking in the saline and testing. The filament broke down in the fluid. This was when the resin printer was utilized. A tough photopolymer resin was used to create the stents (Table 1). Each precise layer was added until the stent was fully printed, then the final product was washed in alcohol and water for safe handling. The stents were then placed under a UV light to harden.

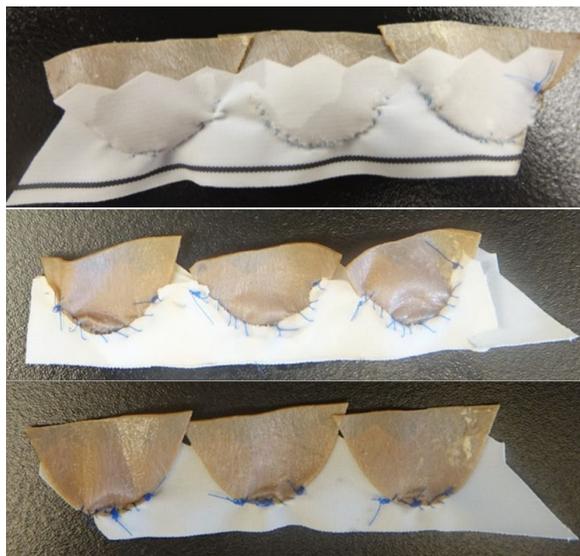


Figure 6. Running suture technique to secure the leaflets to the Dacron fabric.

With all necessary components, the valves were prepared for assembly. The first step of assembly was to suture the leaflets to the outer Dacron and later to the inner Dacron as well. A running suture was used in the last three valves (Figure 6). It was often helpful to place a few singular sutures along points to fasten the leaflets before the suturing. Once the leaflets were secured between the Dacron pieces, the edges were sewn together. Each Dacron piece was sewn separately. This produced a cylindrical Dacron/ leaflet sheet with the leaflets facing inward. Next, the Dacron was tightly sewn to the

stent. The stent was cut from its resin supports using a scalpel to prepare for sewing. Using a running suture method, the bottom part of the Dacron was secured to the posterior end of the stent. The middle and top sections were then attached. It was important to line up the geometry of the Dacron with that of the stent to ensure the height of the leaflets was correct. A Mitutoyo Digital caliper was used to ensure that the height was the same as the SolidWorks design. Once fully secured, the tips of the leaflets were sewn to the commissure posts with three stitches on each end. There were three posts per stent, each with an angle matching that of the TAVs free edge (θ). This completed the assembly of the valves. Each valve appeared similar with a few key improvements and modifications (Table 1). To prepare for testing, the valves were tightly wrapped in a white covering and placed in a ring to secure their place in the pulse duplicator.

2.3 Testing the Optimized and Native Transcatheter Aortic Valves

The final step was to test the valves in an in vitro pulse duplicator (Figure 7). A pulse duplicator system simulates a cardiovascular environment. It analyzes the valves under dynamic physiological loading conditions²⁴. The input parameters of the pulse duplicator complied with the international standard ISO 5840: 2015 recommendations for testing prosthetic heart valves²⁴. These standards included a heart rate of 70 beats/min, a cardiac output of 5 L/min, a mean atrial pressure of 10 mmHg, and a mean aortic pressure of 100 mmHg²⁴. As mentioned previously, the valves were prepared in a cylindrical disc and placed in the aorta section of the pulse duplicator (Figure 7). A solution of glycerin and saline was loaded in various chambers of the pulse duplicator to simulate the viscosity of blood. A solution of 37% glycerin and 63% saline proved to be the best substitute for the blood. The pulse duplicator had a flowmeter attachment to assist in measuring the systolic and diastolic cycles of the “blood” flow. The physiological flow condition of a heart was simulated through the manipulation of peripheral resistance and local compliance in the pulse duplicator system²⁴. Once the valve was placed in the artificial heart attachment, it was submerged into a tank of water then sealed off. The tank was pumped with more water to ensure the calculated pressure differences would be accurate. No air was left in the tank. After the flowmeter was calibrated, the duplicator recirculated the glycerin/saline solution through the device apparatus and artificial heart. Strain gage pressure transducers were used to measure the pressure on the aorta and left ventricle areas of the pulse duplicator apparatus²⁴. The pulse data was recorded on an in-lab personal computer, and was ready for later analysis.

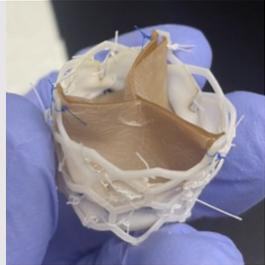
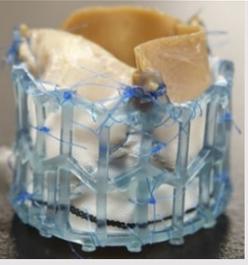
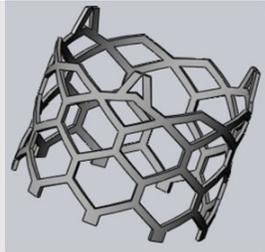
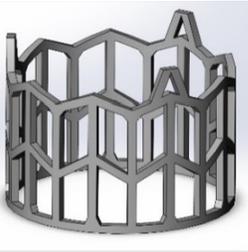
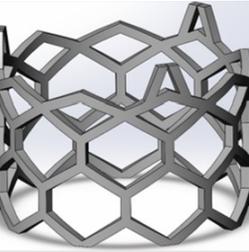
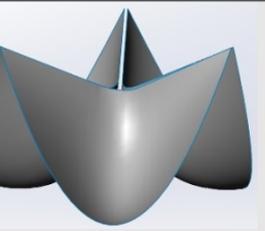
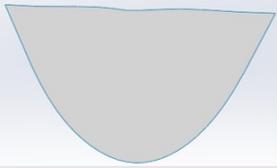
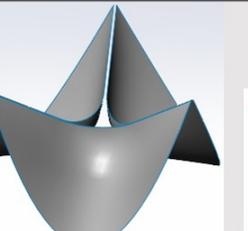
Optimized Valve #1	Optimized Valve #2	Optimized Valve #3	Native Valve
			
SolidWorks Designs			
			
Optimized Leaflets		Native Leaflets	
			

Table 1 Each valve iteration improved upon the next as seen in the final products and the SolidWorks designs. The optimized valves used the same leaflet design, while the leaflet design for the native valve was different. White stent = weaker plastic filament; Blue stent = stronger resin material.



Figure 7. Left – DU pulse duplicator system; Right – valve prepped for testing in a washer to be mounted in the pulse duplicator.

3 RESULTS

During the pulse duplicator tests, each complete systolic and diastolic cycle was represented by real time inputs for the aortic region of the prosthetic heart, the ventricular region, and the overall flow (Figure 8). These produced a continually changing output of graphs for each valve iteration (Figure 9). With these figures, there was also an output of thousands of supplementary data

points for the time during the test, flow levels, and pressures. These data were evaluated in excel to calculate a total regurgitation volume, effective orifice area, root mean square flow (RMS F. Flow) from the start of the forward flow to the end of the forward flow, and a mean positive pressure difference (PPD Mean)²⁵. All values were calculated from a PD-100 System User Guide provided by BDC Laboratories²⁵. These values were calculated for the first optimized valve, the sec-

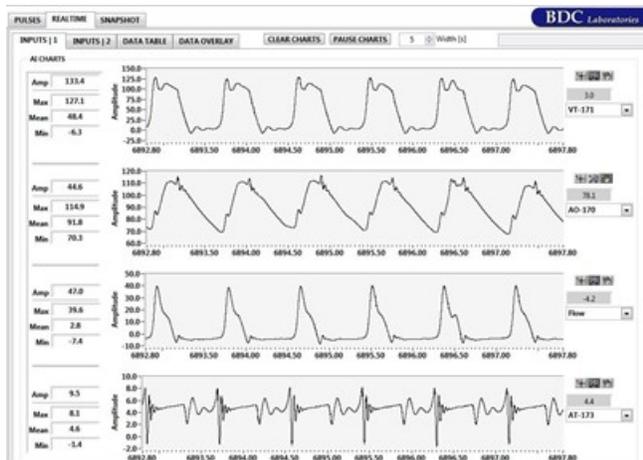


Figure 8. General real time graphs recorded during pulse duplicator tests. Represent regions of dynamic changes in prosthetic heart. The first curve represents the LV pressure, the second represents the aortic pressure, third shows the flow, and fourth demonstrates the left atrium pressure.

ond optimized valve, and the native valve (Table 2). The flow cycles were recorded incorrectly for the third optimized design, making the results void. However, the mean pressure gradient as well as the regurgitation volume for the third optimized design were approximated to be about the same as the values obtained for the second optimized valve.

4 DISCUSSION

This experiment proved to be successful. The first optimized valve was based upon prior research from the University of Denver and other various research institutions, as mentioned. The key differences from the first optimized valve to the second were the addition of an adjacent inner Dacron piece, a differing suture, and an improved stent. The inner Dacron piece allowed for a watertight seal around the inner portion of the valve that prevented leaking and regurgitation. The top portion of the inner Dacron piece was designed to outline the free edge of each leaflet, differing from the outer Dacron piece (Figure 10). Next, it was decided that a continuous running suture would be used to prevent holes in the prototypes as well (Figure 6). The first optimized valve had single sutures lining the areas of connection, however, several other experiments show that continuous sutures are preferred²⁶. Continuous sutures allow for tighter seals. Finally, the stent was modified to aid in the suturing process and better contain the valve. The evolution of the stent is demonstrated in the visual attached (Table 1).

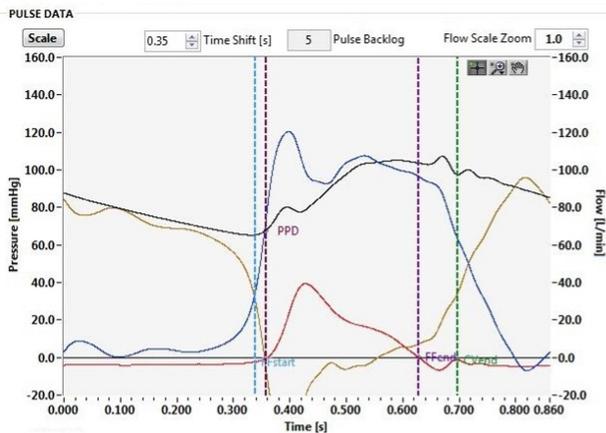
Several changes were made to the valve designs throughout the experimental process. The first two optimized valves had some issues staying in place as they were being tested, prompting the researchers to wrap

the native valve as well as the following two optimized valves in white covering before testing. From the second valve to the third, the sutures were placed closer together and in higher quantity to secure the components of the valve further. The continuous suture technique was still utilized. Furthermore, it was decided to lengthen the leaflets. This allowed for the original design of each leaflet to remain unchanged during the suturing process by providing a border for the sutures around each leaflet. While this aided the design of the third optimized valve, it hurt the fourth. The leaflets became too long and protruded out of the top of the stent (Table 1). The third optimized valve also had issues with the cycle recording during testing. There was a calibration error with the flowmeter, which compromised the data (Figure 9). The zero for the flow cycles was calibrated incorrectly. This led to the researchers not being able to differentiate between the cycles for the third optimized valve which made it impossible to calculate quantitative values for this valve. However, the PPD mean and regurgitation values for the third optimized valve can be estimated to be the same as these values for the second optimized valve.

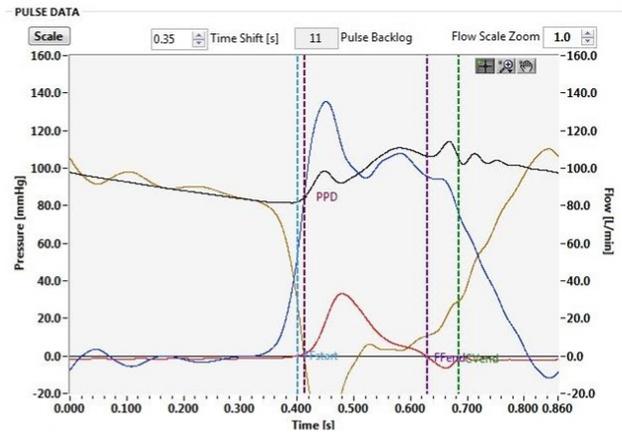
It was hypothesized that the final iteration of the optimized design would perform better than the first optimized iterations and the native design. The hypothesis was supported by the results of the second optimized valve but partially rejected by the results of the native valve. The native valve performed better than all tested valves during diastole, however the second iteration of the optimized valve performed better during systole. A systolic analysis is often more crucial than a diastolic analysis, the cycle patterns for each are seen in (Figure 11). As seen in Table 2 specific values for each valve were calculated on excel. To explain what is being seen in Table 2, the PPD mean pressure is the positive pressure difference between cycles. The RMS F. Flow represents the root mean square forward flow from forward flow start to forward flow end when the flow transitions from positive to negative. The effective orifice area is the minimal cross-sectional area of the flow²⁷. Finally, the total regurgitation volume is the volume of fluid that enters back through the valve after systole and during diastole. If this number is too high, it could cause serious health issues for a patient. As previously stated, an ideal valve would have little to no regurgitation volume, a low PPD mean, a high effective orifice area, and small variance in the data sets. The variance can be evaluated by looking at the standard deviation of each data set (Table 2). A lower standard deviation is preferable.

The valves can be compared in systole based on their pressure gradient as well as in diastole based on their regurgitation. The optimized geometry provides support for the hypothesis through the analysis of the systole conditions. The second optimized geometry had

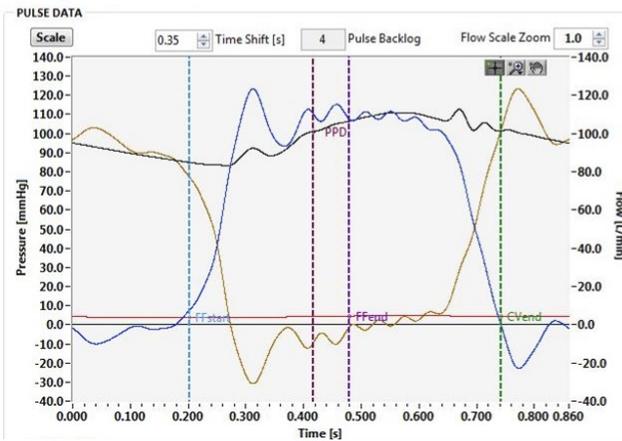
a) *Optimized Valve 1*



b) *Optimized Valve 2*



c) *Optimized Valve 3*



d) *Native Valve*

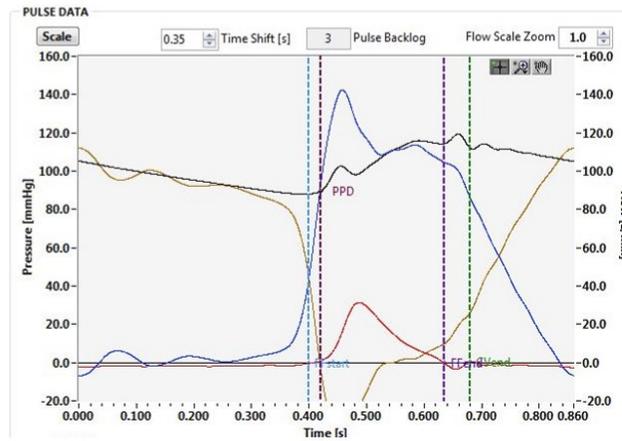


Figure 9. The graphs produced from the pulse duplicator test for each TAV are shown above. These represent various changes in pressure and flow over time during the testing cycles. Maroon represents the positive pressure difference (mmHg), purple represent the forward flow end (L/min), light blue is forward flow start (L/min), green is closing volume end (L/min), dark blue is inflow pressure (mmHg), black is outflow pressure (mmHg), red is flow (L/min), and yellow is pressure difference (mmHg).

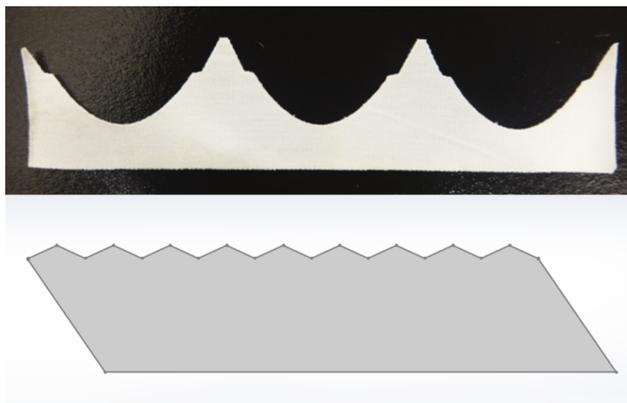


Figure 10. The inner (top) and outer (bottom) Dacron designs are different due to their location in the valve. The outer Dacron is sandwiched between the stent and outer side of the leaflets and matches the stent geometry. The inner Dacron lies within the inner side of the leaflets and matches the leaflet geometry

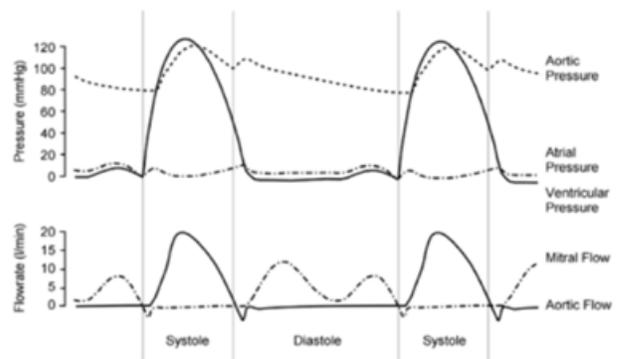


Figure 11. Shown here is a Wiggers Diagram²⁸. This represents the various events that occur during a cardiac cycle. These include systole and diastole.

a lower PPD mean than both the native valve and the first optimized valve (Table 2). Furthermore, the second

	PPD Mean (mmHg)	RMS F. Flow (mL/s)	Effective Orifice Area (cm ²)	Total Regurgitation Volume (mL)
Optimized Valve #1	17.378 (SD = 0.853)	359.41 (SD = -5.78)	1.7560 (SD = 0.0513)	-41.164 (SD = 1.49)
Optimized Valve #2	14.585 (SD = 0.962)	290.77 (SD = 3.20)	1.5516 (SD = 0.046)	-20.212 (SD = 2.13)
Native Valve	16.550 (SD = 0.518)	277.74 (SD = 2.56)	1.3898 (SD = 0.023)	-18.345 (SD = -1.79)

Table 2 Calculated data for each TAV. The average value over an average of 10 cycles is shown for each valve. Underneath this average is a standard deviation for the data collected over the ten cycles. The included valves are the first two optimized valves and the native valve. While the third optimized valve was unable to produce quality data for all calculations, the PPD mean and regurgitation values of the second optimized valve are approximated to be the same for the third optimized valve. The flow of the pulse duplicator was set at a cardiac output of 5 L/min.

optimized valve had a higher effective orifice area than the native valve (Table 2). This shows that the second optimized valve performed better during the systolic period of the cycles. However, the native valve can reject the hypothesis through the analysis of the diastole conditions. The native valve had the lowest total regurgitation volume during the diastole period (Table 2). Lower regurgitation values are preferential for a patient's health. The second optimized TAV however still has a lower regurgitation value than the first optimized TAV, showing that the design for the optimized TAV's improved in diastole as well as systole

Both the optimized valve and native valve used similar methods for their Dacron's, stents, and leaflets, but had core differences in their design such as values for H , R_b , R_c , α , and θ . The native valve had a shorter height, a matching R_b and R_c , a lower value for α , and a higher value for θ . It was hypothesized that the best optimized design would behave better than the native design because it was designed to account for various changes such as the material from a natural aortic valve to a manufactured TAV. While this was supported during systole, the native valve was superior during diastole. All the valves performed moderately well, even though some were better than others. They all had low standard deviation values per cycle for PPD mean, RMS F. Flow, effective orifice area, and regurgitation volume. This shows that they were able to continually perform under the harsh conditions of the pulse duplicator, without deforming shape or losing quality. During this experiment it was seen that a diamond geometry is preferential to a quadrilateral geometry for the stents. Finally, an inner Dacron, running sutures, and tough resin material are crucial for a high valve performance as well.

5 FURTHER DIRECTIONS

Future projects will continue to focus on altering designs of TAVs to be just as, if not more, durable than

SAVs. This experiment had some issues that can be improved upon in the future. A main problem from this experiment was the regurgitation through the valve during diastole. This occurred through gaps between the leaflets as well as between the leaflets and frame/Dacron component. In future experiments, this can be minimized by increasing the number of stitches, using blood instead of the glycerin/saline solution, and redesigning the stent. In addition, the third optimized valve failed. This can be rectified with an improved calibration method for the pulse duplicator. Furthermore, this experiment used a rigid stent as opposed to a collapsible stent, due to limited time and the desire to focus primarily on leaflet function and basic stent geometry. A similar study in the future could focus on a collapsible alloy stents, as most TAV studies do. The results of this study and other data available in the literature underline the opportunity to improve leaflet design in the next generation of TAVs to increase long-term durability of transcatheter heart valves.

6 ACKNOWLEDGEMENTS

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7 EDITOR'S NOTES

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Regent's Park by Aaron Butwinick

Factors Influencing Conservation Knowledge: A Survey of Residents in the United States

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Abstract

Basic principles have been established for visitors of national and state parks, but some visitors may be more aware of conservation practices than others. To understand visitor awareness, this study investigated three factors that influence the general public's understanding of the Leave No Trace (LNT) conservation ethic: natural areas visitation, state of residence, and media consumption. Each of the factors showed statistically significant impacts on awareness of LNT, supporting our hypotheses that this knowledge will increase with a higher frequency of park visits and media consumption, and that region of residence will also impact LNT knowledge.

Keywords: Leave No Trace, National Parks, State Parks, Media, Environment, Conservation, Natural Areas

1 INTRODUCTION

In the United States, millions of people visit natural spaces for the activities and scenery they provide. Visitor presence physically alters such spaces and can severely affect the longevity of the ecosystems and natural resources located there. In 2019, National Parks received over 327.5 million visitors¹. Furthermore, in 2018, over 807 million people visited state parks across the country². To sustain these visitation rates and ensure the health of these parks, there must be a minimal impact left by each individual visitor. Conservation principles have been in place at national and state parks, but visitor understanding of these principles may vary. To understand visitor awareness, this study investigates three factors that influence the general public's understanding of the Leave No Trace conservation ethic: natural areas visitation, state of residence, and media consumption.

The Leave No Trace (LNT) initiative emphasizes minimizing human impact on wildlife and ecosystems through a variety of practices to ensure both visitor enjoyment and ecosystem preservation. They engage the public through use of conservation principles such as "travel and camp on durable surfaces," "dispose of waste properly," "minimize campfire impacts," and "leave what you find"³. LNT was built upon work by the U.S. Forest Service, National Park Service, and the Bureau of Land Management and released in 1999. Its principles seek to minimize the impact of visitors on

natural spaces and call for people to be informed and critical of their use of national parks⁴. As visitors are not monitored in these large open areas, conservation practices rely on voluntary participation from those recreating within the space.

There are numerous studies which analyze the effectiveness of these principles and public attitudes toward them. Most of the studies conducted on LNT perceptions are on backcountry visitors instead of the more common and large group of day-users⁵. Research on awareness of LNT among backcountry visitors has shown variability in knowledge of these practices⁶. From previous research of overnight backcountry users, 44% of variation in LNT behaviors can be predicted, but the predictors vary greatly depending on the park, age, years of backcountry camping experience, and the size of group travelled in⁷. For the more common day visitor, little is known of their awareness of conservation practices like LNT.

Beyond park signage, we also expect that awareness of LNT should be influenced by public media. Utilizing media avenues for public conservation awareness may present a strategy to convince visitors to comply with conservation suggestions^{6,7}. Investigations into the patterns of viewing television with conservation topics found that nature documentary consumption is predicted by environmental concern and influences positive environmental behaviors⁸. However, studies like Holbert et al. focus on TV consumption and do not

encompass other forms of media, such as daily news, social media, and advertisements.

Conservation is gaining traction in many communities. It can be argued that this topic was made popular in the mainstream media by Steve Irwin, who promoted wildlife education and preservation throughout his career. A study done in 2010 showed that his career had a major effect on increasing the public's knowledge of wildlife and conservation practices⁹. Such wildlife education programs and nature documentaries can be accessed nationally via television, but little is known on the variability of conservation awareness by state. Differences in conservation awareness may depend on the prominence of environmental education in each state. Ruskey et al. analyzed components of state-level environmental education to determine the extent of success in each state¹⁰. The next step is to determine the success of these environmental education programs by gauging conservation knowledge in the general public. There is a gap in research as to the effect of state residency on conservation awareness. Environmental education efforts may play a role, and it is unclear if an additional variables affecting conservation knowledge is accessibility to parks based on number per state.

Despite the depth of research in these separate areas, there is no research specifically on the different factors which influence LNT awareness amongst the general public. This survey seeks to investigate variables which affect resident knowledge of LNT in the United States. Specifically, this survey analyzes three factors and their relationship with self-assessed knowledge of LNT practices: use and frequency of visit to state and national parks, consumption of environmental news in regular media, and current state of residence. We predict awareness will increase as the frequency of park visits per year and consumption of environmental media increases. Finally, we predict residents in different regions of the U.S. will have different levels of awareness and that the number of parks in each region will positively affect awareness scores.

2 METHODS

To collect data on knowledge of the LNT initiative, we created a five-question survey using Qualtrics. The questions were designed to compare state of residence, use and time spent in state and national parks, and appearance of conservation topics in regularly consumed media to a self-assessment of awareness of conservation practices. Self-awareness of LNT was determined by the survey respondents on an integer scale of 1–10 with 10 being the most aware and subject to interpretation by the individual. All questions were designed as multiple choice with no option for free response except for Question 4, seen in Appendix A.

Participants for the survey were recruited over social

media. The survey was shared by all three researchers on Facebook, by one on Snapchat, and by one on Instagram. The recruitment post can be found in Appendix B. Abridged versions were used for Snapchat and Instagram. All versions of the recruitment post stated the age requirement of 18 years or older, the length of the survey at five minutes, the role of the survey as a school assignment for a conservation biology course, and the voluntary and anonymous nature of participation.

The survey was available for two weeks and then closed to further public response. States were converted to United States regions using the U.S. Census Bureau guidelines to ensure an adequate sample size to test the impact of geography¹¹. We analyzed frequency of park visits and frequency of conservation media topics as predictors for self-reported awareness scores as the dependent variable. To do this, responses to the survey were coded from ordinal categories into numeric values. A multiple linear regression was performed to analyze how frequency of park visits and consumption of conservation media affected self-reported LNT awareness. To test the differences between region of residence for self-reported LNT knowledge, an ANOVA was performed. Finally, a linear regression was done to investigate the relationship between frequency of park visits and the number of state and national parks in the region of residence.

3 RESULTS

Our survey received a total of 292 responses. Using a multiple linear regression, we found that both frequency of media and frequency of park visits each significantly explained self-reported awareness of LNT (Table 1; $awareness = 5.80 + (0.57 * \text{frequency of media}) + (0.37 * \text{frequency of visits})$). Additionally, 12.9% of variability in awareness of LNT was explained by the two variables frequency of visiting parks and the amount of conservation media consumed.

Term	Value
R^2 adjusted	0.129
p of media	0.0001
p of visits	0.0018
Whole model prob > F	0.001

Table 1 Multiple Linear Regression Results of Consumption of Environmental Media and Frequency of Park Visits to LNT Awareness. A statistical term and their values for the multiple linear regression of frequency of visits and frequency of media consumption compared to the self-reported awareness scores.

Awareness of LNT also significantly differed by region; with the Midwest scoring lowest and the West scoring highest (Figure 1); $F = 6.58$, $DF = 3$, 277 $p <$

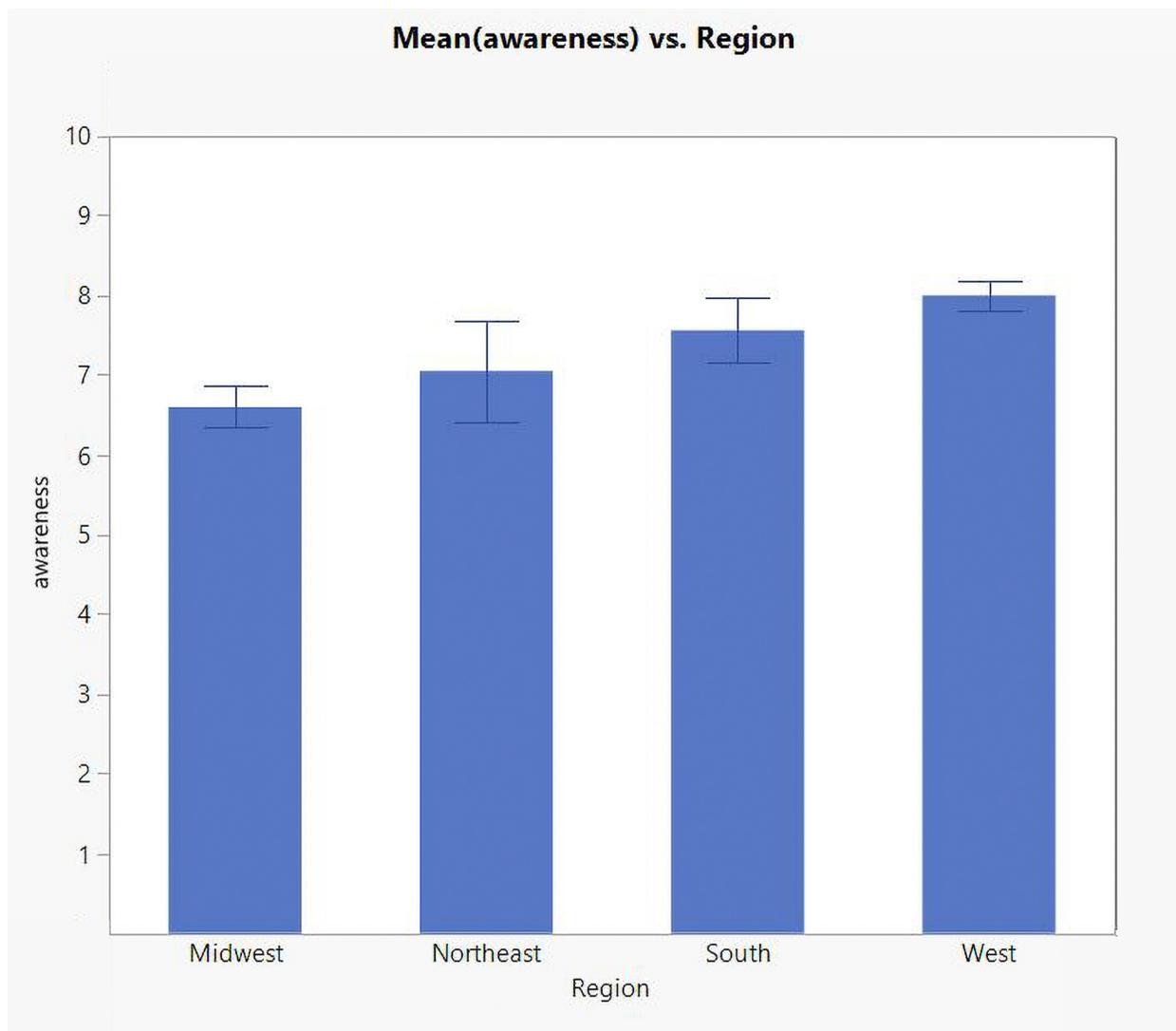


Figure 1. Mean Awareness Score and Current Region of Residence. Respondents provided their state of residence, and these states were arranged into regions in accordance with the US Census Bureau Regions of the US. The respondents reported their awareness of LNT conservation practices on a scale of 1–10 and values are subject to respondent bias.

0.001)

Additionally, the number of state and national parks within the respondent’s region did not significantly explain the frequency of park visits ($p = 0.253$).

4 DISCUSSION

Each factor tested showed statistically significant impacts on awareness of LNT, supporting our hypotheses that this knowledge will increase with higher frequency of park visits and media consumption, and that region of residence will also impact LNT knowledge. Our results differ from the previous finding by Holbert et al. in 2003 in which they found that regular media consumption had no trend linked to positive environmental behaviors and only people who sought out environmental media had knowledge of conservation practices⁸. The

hypothesis that conservation media consumption impacts LNT knowledge had the strongest relationship, suggesting that those whose social media feeds or news sources prioritize conservation will have greater awareness of how to actively participate in behaviors which support conservation. Aside from media consumption and frequency of visiting parks, the current region of residence also influenced overall awareness. We theorized that the number of state and national parks in each region would influence the awareness of respondents from that region. Our data, however, did not support this hypothesis. Further investigation is needed to determine what causes differences in conservation awareness by region, but it may be due in part to variance in public education¹⁰. There are likely additional variables that explain differences in awareness by region. Given that the strongest relationship was between

awareness and conservation media consumption, there could be differences in social media feeds based on region or other cultural impacts that would explain why the awareness of LNT in the West is much higher than in the Midwest.

In this study all the values were self-reported allowing for irregularity in awareness levels. Since a majority of the respondents, although anonymous, consisted of people from our social media and who we know personally, there may have been some social desirability bias. Additionally, because all scores were self-reported, different people with the same actual knowledge of LNT Principles may have self-reported different scores. Because this survey was shared within the researchers' social media circles, it also limited our chance to reach out to multiple people from each state. Finally, it could be likely that people who do not know or do not care about conservation would not take the survey, skewing the average awareness. Overall, we had a large number of responses, but in future research it would be helpful to reach out to a more diverse group and provide more detailed definitions of national and state parks.

Another limitation in our findings is the format of the response options for Questions 2 and 4 (Appendix A). The possible responses for both questions were based on frequency of use, however, there was discontinuity in the response scales. For example, in Question 2 regarding frequency of park visitation, options went from 1–2 times a year to 5–6 times a year with no option for survey respondents that visit 3–4 times a year. This was an error in the survey creation, and respondents were at will to arbitrarily choose the option they found most fitting. We cannot assume all respondents who had 3 park visits rounded down, nor that respondents with 4 park visits rounded up, though this may have been true for some of the survey takers. There is also a gap between 6 visits a year to 12 visits a year. A similar issue is found in Question 4 where the frequency scale of media consumption has gaps and user response will reflect those errors.

Despite these limitations, we found a strong relationship between frequency of park visitation and media consumption on conservation knowledge in the general public. These findings suggest that if the public can be encouraged to visit these natural spaces and consume media on conservation, then more people will know about these important practices which could have a dramatic effect on natural spaces in recovery. Since region of residence has influence on conservation awareness, federal organizations like the National Parks Service can analyze individual state or regional efforts where awareness is high and replicate those techniques in states and regions with lower awareness values. It is also important to recognize that this form of conservation campaigning should also be advertised to different demographics who would not normally consume or

search out this information in ways which are easy to understand.

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6 EDITOR'S NOTES

This article was peer-reviewed.

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APPENDICES

A Appendix A

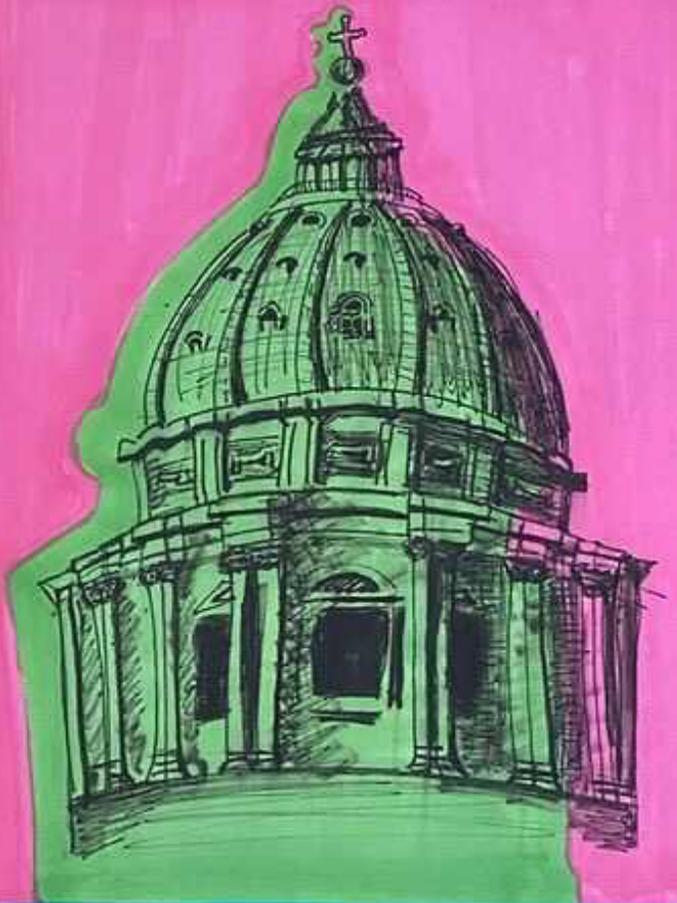
List of Survey Questions:

1. What state do you live in now?
2. Many people spend time outside in their daily lives by going on walks or spending time in city parks. How frequently do you typically visit national and/or state parks?
3. When you go to these spaces what do you do? Check all that apply. (hiking, climbing, camping, skiing, etc.)
4. How often do you hear about conservation in the media you consume (daily news, social media, TV and streaming services, advertisements)?
5. On a scale of 1-10, how aware would you say you are of "Leave No Trace" and other conservation efforts?

B Appendix B

Recruitment Post:

Hello! If you are 18 years of age or older, please consider taking our survey surrounding conservation practices. The survey is 5 questions and will take under 5 minutes. Your participation is entirely voluntary, all data is anonymous and will not be saved for future use. Our analyzed findings will be submitted for publication with the University of Denver Undergraduate Research Journal. The survey is linked below.



From Pop to Pastoral: St.Peter's Basilica by Katherine Miromonti

A Thematic Analysis of How a Rhetor and a Demagogue Framed Their Presidencies

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Abstract

This essay uses thematic analysis through the lens of framing theory to dissect how former U.S. President Barack Obama and former U.S. President Donald Trump created contrasting but successful frameworks of America to win their campaigns. The paper operates on the grounds that Obama is a rhetor and Trump is a demagogue. Frames consummate a multitude of themes that are created with rhetorical tools – namely figurative language. The storylines that are created by politicians can play an instrumental role in developing the constituent’s basis of reality. This study aims to unpack how a rhetor and a demagogue can use the same rhetorical tools to forge a successful framework for their audiences. The paper starts by establishing a basis of rhetoric, political rhetoric, and demagoguery. After creating that foundation, it leads into a thematic analysis of Obama’s 2013 Inaugural Address and Trump’s 2017 Inaugural Address, through themes of community, religion, and the future of America. The results reveal that the strength of their address’s relied on the framework used. Both presidents used the same themes to create differing realities of America, regardless of the morality of the speaker. This study provides further inquiry into Communication Studies research on how rhetors and demagogues use linguistics to persuade their audiences.

Keywords: Political rhetoric, demagoguery, rhetor, framing, figurative language

1 INTRODUCTION

Figurative language as a rhetorical tool in political speech is well acknowledged for its ability to evoke intense emotion and push the audience towards the rhetor’s belief¹. This study aims to fill the gap in Communication Studies research when considering how persuasive appeals of language can be used by a rhetor and demagogue to successfully frame vastly different narratives within the political landscape. The differentiating factors between the orator’s are revealed by their intent and moral character. The objectives of this paper are to better understand how a rhetor and demagogue use the same tools to shape contrasting realities for their audiences to win the presidency, so the public can become more adept at noticing a demagogue before they rise to power. Communication Studies scholars can then help to restructure the dialogue around political speech and the public’s consumption of it. This study will dissect political speech within modern politics, uncovering

Obama and Trump’s starkly different frameworks.

2 LITERATURE REVIEW

Rhetoric and ethics are closely aligned, and it is beneficial to first garner insight into that relationship with the use of previous works. James A. Herrick’s essay “Rhetoric, ethics, and virtue” explores how one might ground an ethics of rhetoric in virtues by practicing rhetoric itself². His research acknowledged that rhetoric has a long tradition of being linked to virtue or human character. Someone’s rhetoric may be seen as “a reflection of the person’s character².” Herrick pulled from Aristotle’s perception that part of a rhetors duty is to help his readers “to become good².” Most importantly, it is argued that advocacy is a good inherent to rhetoric, which is critical in maintaining democratic institutions². The author establishes a premise for how rhetoric should be viewed in conjunction with ethics. This is essential to note because, within this definition, a rhetor must deploy a strong moral character²; however, there is more to be considered when dealing with the persuasive appeals of ill-intended agents.

¹As noted by researchers in the article “Figurative Framing: Shaping Public Discourse Through Metaphor, Hyperbole, and Irony”¹. Their work unpacks the influence of persuasive appeals on the public.

After establishing a basis of the ethical domain of rhetoric, it is necessary to conceptualize political rhetoric in today's environment to see where it is prevalent and where bad actors can enter the scene. The article "Twisting Tongues and Twisting Arms: The Power of Political Rhetoric," Krebs and Jackson argued that "rhetoric is certainly a weapon of the weak, but those holding the reins of power can and must deploy it as well³" explaining that how the rhetor uses rhetoric is just as important. The researchers expounded "ideas influence how actors interpret evidence and sift through information³." The concept of ideas works in conversation with the premise of rhetoric's persuasive appeals; to push an audience towards an idea, the orator must rely on pathos and the ambiguity of a belief which is arguably just as malleable as an idea.

Stéphanie Bonnefille outlined the use of emotional appeals to provoke an audience behind an idea in "A cognitive rhetoric approach to two political speeches." Bonnefille shed light on the stark distinction between former U.S. President Obama and former French President Sarkozy's communication styles at the 2009 U.N. Climate Change Summit. She identified possibilities for figurative language to strengthen the rhetorical dimension of political speech. The analysis shows that Sarkozy emphasized literal language and Obama embraced figurative language. Obama took to storytelling and resorted "to a combination of two narratives, the apocalyptic vs. the rescue tale⁴." Such deployments of descriptive language prove to have a powerful performance and bring further interest to the influence of figurative language as a rhetorical tool to persuade audiences. My research will take it a step further to analyze recurring patterns within political speech that are used to frame the perception of the rhetor in the public's mind.

Although figurative language is an incredibly powerful rhetorical tool, in the wrong hands it can strengthen a demagogue. Demagogues are political leaders that rise to power in democratic institutions by pulling on the vulnerabilities of the public to polarize society and advance their personal goals². Language becomes a weapon yielded to contain its audience. As Jennifer Mercieca explained in "Dangerous Demagogues and Weaponized Communication," "weaponized communication tactics treat communication as pure instrumentality, using rhetorical tactics and people as machines⁵." The use of "machine" inherently defies a rhetor's behaviors. A defining characteristic of a rhetor is their good intent and moral character that can put the hearer into a desired frame of mind³. Influencing the audience through elaborate emotional appeals can become

weaponized when the intent is to oppress the audience. It is crucial to note that the tools used in demagogic and rhetorical speech remain static—the differentiating characteristic of a demagogue is when these tools are weaponized to "overwhelm audiences⁴" for their own gain.

While it may be controversial that the distinction between a demagogue and rhetor appears thin, the malleability in rhetoric within democracy must be unpacked. In "Athens, the Unjust Student of Rhetoric: A Dramatic Historical Interpretation of Plato's 'Gorgias'," Michael Svoboda investigated how Tucidides, Isocrates, and Polycrates challenged both the legitimacy of political power as well as the rhetoric with which democratic Athenians rationalized their former tyranny (from the Peloponnesian War). Greek philosopher, Socrates wondered how a student could use what he has learned about political discourse for their own benefit, by breaking or bending the laws. Such an insight led Socrates to limit rhetoric to "persuasion that creates belief rather than knowledge⁶." It leaves more to be investigated into how language can be weaponized for to create beliefs in a people and break through the veil of democracy, producing a demagogue. Demagogues are woven into the fabric of democracy. As Svoboda explained "when one uses terms like 'rhetoric' and 'freedom' and 'democracy,' one ought to do more than encomiumize them⁶." This blind appraisal can glorify democratic institutions and leave the public vulnerable to a demagogue.

How a charismatic leader in democracy uses the terms outlined in Svoboda's article is a point of prevalence. Eric Patterson analyzed Obama's use of rhetoric in the article "Obama and Sustainable Democracy Promotion." Obama is a skilled orator, being perceived as composed and inspirational. He heavily emphasized the "new beginning" theme and had the public intrigued. Throughout his speeches, "[Obama] has said a great deal about democracy⁶" maintaining a commitment to "sustainable democracy" to express American values and promote good. His time in the presidency aimed at making comrades out of countries through a progressive lens⁶. More is to be explored when uncovering the rhetorical tools that contributed to his enduring vision of a "new beginning."

Conversely, there has been research into the demagoguery of Trump and how one may rise to power and play on the vulnerabilities of a disheartened public. Paul Elliott Johnson's study "The Art of Masculine Victimhood: Donald Trump's Demagoguery" argues that Trump frames society in ways to make his audience "approach the unfamiliar as danger rather than opportunity" by using figurative language⁷. Moreover, Trump pulls on negative emotions and garners the power to do as he pleases under the shade of democracy. He em-

²This definition of a demagogue was paraphrased from Ryan Skinnell's research paper "Using Democracy Against Itself: Demagogic Rhetoric as an Attack on Democratic Institutions."

³This definition is derived from Aristotle's book *The Art of Rhetoric*.

bodies the intentions of a demagogue⁴. His words and actions will also be unpacked in closer analysis to see how he used language to create a narrative opposing Obama's.

The seven pieces above serve as a foundation for further inquiry into the relationship between rhetoric, rhetors, demagogues and political speech. Pulling from this literature allows for a deeper analysis of these subjects.

3 THEORETICAL FRAMEWORK

3.1 Frame Theory

Frame theory was coined by Erving Goffman in *Frame Analysis: An Essay on the Organization of Experience* to explain how individual's perceptions of the same events (or social occasions) may vary greatly depending on that person's grounded perspectives⁸. He set out to develop "some of the basic frameworks of understanding available in our society for making sense out of events and to analyze the special vulnerabilities to which these frames of reference are subject⁸." Through this theory it can be explained how an individual's perception of what is happening differs from what occurred. For example, what is occurring could be described as "a joke, or a dream, or an accident, or a mistake ... and so on⁸." This is particularly true when embracing the concept that reality is constructed.

Goffman called the primary framework and frame(s) within it, the "schemata of interpretation⁸." This frame allows individuals to make something that would be rendered meaningless, meaningful. Underneath this framework lies the belief that ordinary language and writing practices can allow people to express what they want to express. Given the political context of this paper, it is advantageous to focus on the social framework, which is found within the primary one. Goffman examined this structure to understand the aim, will and controlling effort of a live agency, an intelligence, and human beings⁸. When the speaker uses such a frame, it facilitates "guided doings" that motivates the individual to reach a shared point of view by creating standards based on the tactfulness, elegance, safety, economy, efficiency, and honesty of the speech⁸.

Researchers Dennis Chong and James N. Druckman expanded this idea in their article "Framing Theory," focusing on its impact on public opinion. They went on to name framing effects—when minor changes in the presentation of an issue can produce a substantial change

in opinion⁹. In conjunction with this, they brought in the phrase "frame of thought" making note that the individual's mindset and priorities influence their perception. This was connected to modern day when they referenced frames in communication, specifically targeting the political sphere, noting how "politicians attempt to mobilize votes behind their policies by encouraging them [potential voters] to think about those policies along particular lines⁹." One more crucial insight into framing theory is the strength of the frame. Strong frames are not necessarily morally righteous nor are they the most intellectual. Rather, they become powerful when they emerge as the best rationale against a competing position on an issue⁹. Frames can be strategic and structured based off the intended audience.

Framing has been used by researchers to study communication in the political sphere. Notably, in the article "Understanding and evaluating Trump's foreign policy: A three-frame analysis¹⁰," the authors unpacked Trump's foreign policy record by evaluating his objectives and methods through 'Stable Genius,' 'Art of the Deal' and 'Make America great again.' This was used to provide insight into how the administration framed the president's skills and goals. Similarly, Amy Lynn Fletcher used frame analysis in her piece "Clearing the air: The contribution of frame analysis to understanding climate policy in the United States." Framing was the preferred method to establish a better understanding of the discursive strategies used when discussing climate change, specifically during the Bush Presidency. She analyzed it through the lens of climate change as an economic opportunity, climate change as a security threat and scientific skepticism. This helped her grasp how and why frames can enter public discourse and the impact on public perception¹¹.

Therefore, using and having a working understanding of frame theory is essential for this paper. Framing is prevalent throughout society—but particularly so within political contexts. When viewing political figureheads, they may be able to use frameworks to control the public by evoking intended emotions within individuals to drive them towards a belief⁹. To delve into the dichotomy of two vastly different president's, it is paramount to view their success through framing theory. This research will view former U.S. President Barack Obama as a rhetor, using figurative language to create a vision of "new beginnings" and former U.S. President Donald Trump as a demagogue, using rhetorical tools to build upon "making America great again." Such contrasting methods still yielded the same results: a successful campaign. It is necessary to study how a strong framework does not always mean a moral one⁹, because as Communication Studies scholars, steps can be taken to combat the creation of oppressive frames. Frame theory will provide the greatest insight into how both speakers were able to shape their constituents'

⁴This relates to a prominent perception of a demagogue, by Patricia Roberts-Miller in her book *Demagoguery and Democracy*, viewing it as "A polarizing discourse that promises stability, certainty, and escape from the responsibilities of rhetoric through framing public policy in terms of the degree to which and means by which (not whether) the out-group should be punished/scapagoated for the current problems of the in-group" (p. 16).

thoughts in such a meaningful manner that they became mobilized to vote for them.

4 METHODOLOGY

4.1 Thematic Analysis

In conjunction with frame theory, a thematic analysis will be conducted. This methodology is best used to identify reoccurring patterns, ideas, or topics within a text. It helps investigate similarities, differences, problems, and issues that can be relevant to communication¹². It applies to various bodies of text and produces deep insight into the interactions and messages being conveyed from the data, while simultaneously exposing the communications field to areas of further inquiry by providing a fuller depiction of the medium being observed. Such a method does not have quantifiable measurements, therefore, leaving it up to the researcher to decide on how to structure the analysis and dictate what constitutes a theme. However, a theme generally encompasses "a common line of understanding occurring within the data¹²." It may be explicit or implicit within the text. Themes can also overlap or have no relation to one another. The guidelines include deciding whether to search for themes inductively or deductively, developing a systematic approach to derive the themes, repeatedly going back and forth between the text and the preliminary patterns, locating additional and/or similar thematic pieces in the next material to be reviewed, and finally discovering how this analysis contributes to the field of communication¹².

Two speeches will be analyzed. Obama's 2013 Inaugural Address and Trump's 2017 Inaugural Address were chosen because it was one of the first times either president addressed the public following their successful campaign frameworks. Thematic analysis is optimal because it can break down the underlying patterns that contribute to a speaker's frame. A deductive approach will be used and first categorize the text within each speech under themes of community, religion, and the future of America. This will require continuously searching for consistencies within the speaker's verbiage. Recurring rhetorical devices that reinforce the categories and shape of their frames will specifically be sought out. Then, the three themes will be analyzed together to conceptualize the narrative that constructed the overall framework forged by both presidents.

5 ANALYSIS

In the analysis, figurative language was discovered that fell underneath one of three themes: community, religion, and the future of America. Figurative language may be in the form of metaphors, similes, hyperboles, personification, allusions, alliteration and so on. The

keywords and phrases derived were not mutually exclusive. Thus, to align with a theme, the selected text had to correlate (directly or indirectly) to it. This was done by rereading each speech and pulling key fragments of descriptive text pertaining to the individual themes. In isolation, Obama's speech was deconstructed to understand how he used the outlined themes to frame America's current position and its path forward. An analysis of Trump's address follows, using the same procedures above.

5.1 Obama's Inaugural Address

5.1.1 *Community: We Must Move Together*

Obama crafted the concept of "togetherness" that enveloped his version of community. Obama promoted collaboration, rather than an "us versus them" mentality. Instead, he created a relationship between individuals and the collective in stating "that preserving our individual freedoms ultimately requires collective action." This message is consistently conveyed through continual usage of "one nation and one people," and the repetition of "we, the people." By using those keywords, it sends a message that Americans must see one another as comrades, not enemies when beginning a new presidency.

Obama reinforced this camaraderie with his metaphors, portraying Americans as fighting "society's ills" (referencing poverty, sexism, racism, homophobia, and others) which he goes on to iterate that they cannot be cured from government alone. The metaphor of illness implies that America is sick and to become healthy the people must work together to find a remedy. The usage of sickness is intertwined in the speech. He focuses on Americans needs to care for the vulnerable and protect others from life's misfortunes. Obama conceptualized it as "our obligations as Americans are not just to ourselves, but to all prosperity." Thus, the placement of the keyword "obligation" implies that it is societies duty to collectively ensure the well-being of others. It is essential to note that togetherness is embodied outside of America too. He emphasized the need to resolve differences with other countries peacefully. Relations with other nations were not conceptualized as threats, instead they were spun as opportunities for engagement. Through this, Obama reified how Americans should communicate with one another and how, as a nation, individuals should interact with one another.

5.1.2 *Religion: God and Greatness*

Throughout the entire speech there are underlying ties to religion. Although America established the separation of church and state in 1879⁵, God is repeatedly mentioned in political speeches—this text is no excep-

⁵U.S. Constitution Amendment I

tion. Historically, politicians use God in speeches to persuade Americans by appealing to their foundation of religion that many grew up with⁶. Obama similarly used religion to appeal to his audience in mentioning that, “while freedom is a gift from God, it must be secured by His people here on Earth.” Using the metaphor of a gift from God to conceive of freedom implies that freedom was not earned, but rather, as Americans, there is a duty to preserve it since the people are fortunate to have it. This narrative simultaneously empowers but disempowers the public. It reinforces the theme of community by framing Americans’ commitment to do good and advance the country behind a deeper motive – a dedication to one’s God(s).

Obama reinforces this in saying that, “that is how we will preserve our planet, commanded to our care by God. That’s what will lend meaning to the creed our fathers once declared.” The reoccurring metaphor of sickness and health appear in the usage of “preserve” and “care.” He eloquently created a duty for Americans to continue forward, in accordance with a deeper calling from God. The usage of a spiritual being can be immensely powerful in motivating people towards action⁷ – notably so with the continued word choice of “creed”, oftentimes defined as a body of beliefs that can drive people towards action⁸. It is critical to acknowledge that a generic God was also used to be inclusive of all religions. That is, once again, another tool used to unite rather than divide the public.

5.1.3 *The Future of America: A New Beginning*

Woven throughout the address, Obama tactfully positioned America as being on the precipice of further greatness. He strategically brought to light the new beginning in his introduction by tracing back to America’s past. He reaffirmed the foundation of the U.S. by referencing the Declaration of Independence and the age-old adage of “life, liberty, and the pursuit of happiness” (U.S. 1776). He continued to mention historical events by juxtaposing it with the advancements made to combat oppressive norms. Specifically noting how American’s were guided through “Seneca Falls [the first women’s rights convention], Selma [1960s voting rights movement for people of color] and Stonewall [riots by members of the gay community in response to a police raid at Stonewall Inn].” Such examples expose a progressive outlook from Obama by signifying

⁶This statement is supported by Bethany L. Albertson’s research paper on “Religious Appeals and Implicit Attitudes¹³,” exploring how politicians use religious appeals to influence behaviors and attitudes of their audience.

⁷Researcher, Korie L. Edwards essay “Presidential Address: Religion and Power – A Return to the Roots of Social Scientific Scholarship¹⁴,” addressed how instrumental religion can be in shaping the social world.

⁸A commonly used definition of *creed*, pulled from Merriam-Webster.

an awareness of the progress made through the will of the people (i.e., the social movements listed previously) and the potential of America to continue upward.

An integral aspect of the new beginning theme is the optimism that the people have the power to achieve new heights, as outlined by this excerpt:

“This generation of Americans has been tested by crises that steeled our resolve and proved our resilience. A decade of war is now ending. An economic recovery has begun. America’s possibilities are limitless, for we possess all the qualities that this world without boundaries demands: youth and drive; diversity and openness; an endless capacity for risk and a gift for reinvention. My fellow Americans, we are made for this moment, and we will seize it—so long as we seize it together.”

This text intentionally places Americans at the center of the discourse and empowers them to see themselves in a heroic way through the usage of “seize.” It provides one aspect of the frame which encourages listeners to view one another as agents of change. Obama expounds upon this through the key words and phrases “resilience,” “limitless,” “without boundaries,” and “reinvention.” The concept of these boundless capabilities is a hyperbole enveloped within contexts of communal power. Obama reinforces this by emphasizing the citizens power to determine the countries future. The speech elegantly sets a stern call to action, telling Americans to carve a new beginning.

5.2 Trump’s Inaugural Address

5.2.1 *Community: It Is Us Versus Them*

Trump had an actively divisive approach to his speech, in which a win/loss mindset was emboldened. Trump implies a weak and losing America, stating, “America will start winning again, winning like never before” reinforcing the concept that American’s have been robbed of their own greatness. Trump built upon this when he conveyed that it is the citizens time to “become rulers of this nation again.” Usage of the word “ruler” creates a power imbalance between the U.S. and other nations, facilitating an in and out group. It was reinforced with phrases like, “it’s going to be only America first. America first.” Such repetition drives the importance of Americans to focus on themselves and build an iron-gated community. Trump continued to promote this by encouraging citizens to buy and hire American.

He also ousted other nations in a bold statement assuring constituents that, “we will reinforce old alliances and form new ones, and unite the civilized world against radical Islamic terrorism, which we will eradicate completely from the face of this Earth.” This

sentence implies that Islamic populations are uncivilized, and it creates a connection in the listeners mind to associate Islam with terrorism. This grouping can reinforce oppressive stereotypes of Muslims and promote hostile environments in the states; such stereotypes, when paired with the dramatic and aggressive imagery created in the use of the word 'eradicate,' sets a dangerous precedent in a listener's mind to generalize and marginalize an entire population, should they agree with Trump. It is no longer only about making America great again; it is about uniting on a front to discriminate against those that are not American.

This theme saturated the speech when Trump mentioned protecting "our borders from the ravages of other countries" and how America has "made other countries rich while the wealth, strength and confidence of our country has dissipated over the horizon." By appearing to be bluntly honest in exposing America's supposed decline, he tactfully leads the individual to conclude that borders and protectionism will bring back the wealth, strength, and confidence that Trump claims had been stolen. An essential aspect of the us versus them mentality is that American's must be ready to fight. Not only did Trump reiterate that protectionism will lead to prosperity and strength, but he also told the public, "There should be no fear. We are protected, and we will always be protected." The concept of shielding oneself from dangerous outsiders sets a precedent that Americans must join to arrive at the "hour of action" to ensure that the country remains protected rather than fearful.

5.2.2 Religion: God Will Protect

A less substantial, but just as prevalent theme is the usage of religion. Trump implemented this to continue his "us versus them" theme by telling American's that they'll be "protected by God." Coinciding with this protectionism, is a call to unify citizens against outsiders. Referencing the Bible, it was stated that, "[it] tells us, how good and pleasant it is when God's people live together in unity." It is an intriguing line, as it follows the sentence, "when you open your heart to patriotism, there is no room for prejudice." This metaphor is in direct conflict with the former statement. Patriotism can certainly act as a divisive tool and actively lead to prejudice against other countries⁹. It is also contradictory that Trump emphasizes living "together in unity" as God's people but simultaneously strives to bar America from the rest of the world. The theme of religion was predominantly used by Trump to unite American's but divide them on the world stage.

⁹Andrew Vincent completed research that supports this statement. He unpacked the connection between patriotism, politics and human rights in his paper, "Patriotism and Human Rights: An Argument for Unpatriotic Patriotism"¹⁵.

5.2.3 The Future of America: Make America Great Again

Within the text, Trump outlined misfortunes in America to create the vision that, at the time of the speech, the country was doing poorly. By positioning the U.S. in a negative light, it has the effect of placing Trump as the one to guide the public through the darkness. To establish such a standing, he first elaborated on the inequalities plaguing the states.

"Mothers and children trapped in poverty in our inner cities, rusted out factories, scattered like tombstones across the landscape of our nation, an education system flush with cash, but which leaves our young and beautiful students deprived of all knowledge, and the crime, and the gangs, and the drugs that have stolen too many lives and robbed our country of so much unrealized potential."

The use of metaphors can entice an audience to listen. Pulling on the appeals of family values, Trump specifically referenced mothers and children when speaking of wealth inequality and the struggles of surviving. This can resonate deeply with lower class families on the precipice of poverty. "Trapped" implies that at the time of the speech there was no direct way to escape those hardships within the current government.

The simile that equates closed factories to tombstones conveniently alludes to the death of American manufacturing and its reverberations across the country. This use of language can strongly align with individuals that are against the outsourcing of labor¹⁰. Thus, it sets implications that Americans were robbed of opportunities to a more fruitful life. The keywords "deprived," "stolen," and "robbed" set a precedent that it must be taken back. It creates a dystopian vision of America as a skeleton of its once great stature and sets a tone that Trump is the one with the clarity to clean through the rubble and rebuild.

6 DISCUSSION

After conducting a thorough analysis of Obama and Trump's deployment of figurative language in shaping the themes of community, religion, and the future of America, the frames they built can be compared. It is fascinating to discover that through the same themes, both president's shaped immensely different narratives for the American public to follow. When viewing the analysis with the overarching theory of framing, it is observed that the themes play an instrumental role in

¹⁰There is further research on the impact of the outsourcing of labor, by the National Customs Brokers & Forwarders Association of America, Inc. They dissect the pros and cons of outsourcing, as well as the way that politicians frame outsourcing in a negative framework.

shaping one's framework¹¹.

Obama embodied a rhetor because he created themes of community, religion, and the future of America on the premise of promoting togetherness, aligning citizens with their Gods, and crafting a new beginning for the country that advocates for democracy and progressive movements. As noted previously in the research, an instrumental characteristic of a rhetor is their good intent¹². Trump harnesses demagogic traits through his creation of an us versus them mentality, crafting God as a protector and striving to "make America great again." Demagogues strive to unite their constituents by curating an in versus out group¹³. Much of Trump's Inaugural Address capitalized on the problems within America and delivered it to the audience as a weapon rather than a tool.

It is critical to draw back towards a key aspect of framing—that reality is shaped based off the perceived events and storylines being presented⁸. What is more influential is the strength of the frame. A strong frame does not mean that it is a moral one⁹. It is not outlandish to claim that although Obama created a morally strong framework to win the presidency, it was just as feasible for Trump to use the same tools to craft a powerful narrative that neglects the morality at question by creating a different truth for his audience. The morality of the speaker was less relevant in creating an influential framework for the listeners.

However, there were limitations within this study that need to be addressed. It operated under the assumption that Obama is a rhetor and Trump is a demagogue. Although there are academic resources supporting both claims, it would be advantageous in a future study to add rhetorical analysis as a second method to better incorporate and understand the rhetorical and demagogic traits depicted from the individual presidents. This could lead to a deeper study unveiling the rising of a demagogue in society and provide clearer action steps to mitigate the emergence of one. It also opens space to explore the impact of the framing on the audience. This research predominantly focused on the creation of contrasting but successful frameworks by two presidents, but it did not delve into the public's consumption of it. It could be insightful to conduct a study comparing Trump and Obama's core constituents, and how the president's frameworks created their realities.

This study encourages scholars to continue analyzing the power of rhetoric and framing in the political

environment. As frameworks forge lived realities, they become tools for those in power to shape their ideal narrative. By continuously scrutinizing the words of politicians, researchers can hope to raise greater public awareness on the ability of their words to provoke people to act and believe in a certain way. This has monumental implications for the future of society. Rather than being a gullible listener, people can become empowered to actively engage in and criticize a politician's storyline.

7 CONCLUDING THOUGHTS

By using thematic analysis through framing theory, the research was able to address the goal of exploring how a rhetor and demagogue can use the same figurative language to shape contrasting realities for their listeners, so demagogues can more easily be noticed before they rise to power. Analyzing the nuances of Obama's 2013 and Trump's 2017 Inaugural Address, it became apparent that both create themes of community, religion, and the future of America. Although the themes matched, the narratives contrasted. The strength of their frameworks proved to be the most influential factor. Trump, by embodying demagogic traits, created a divisive framework of America, and built a perceived reality of in and out groups. Obama, having characteristics of a rhetor, shaped a framework of America focused on togetherness and a new beginning. The research was useful in uncovering those insights, however more research needs to be done relating the frameworks to the public's consumption and more papers written analyzing both Trump's demagogic traits and Obama's rhetorical qualities in relation to their respective framework.

8 EDITOR'S NOTES

This article was peer-reviewed.

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¹¹As outlined in Erving Goffman's book, previously mentioned, *Frame Analysis: An Essay on the Organization of Experience*⁸.

¹²Aristotle's book *The Art of Rhetoric*, defined key characteristics of a rhetor.

¹³This concept still relates back to Patricia Roberts-Miller's description of a demagoguery, noting how, "Through framing public policy in terms of the degree to which and means by which (not whether) the out-group should be punished/scapegoated for the current problems of the in-group" (p. 16).

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A Study of Transparency by Mya Vander Pol



Cello by Katherine Miromonti



Come With by Mya Vander Pol

DU's Annual Research Showcase Celebrates Undergraduate Original Scholarship and Creative Endeavors

Anit Tyagi¹, on behalf of the Editorial Board

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1 OVERVIEW

The University of Denver hosts an annual research poster symposium in spring quarter for undergraduate students seeking to present their scholarly findings and creative works. One of the core tenets of the University is a commitment to improving human welfare through original research and DU undergraduate students have ample opportunity to help address socially relevant problems and complex issues facing populations throughout their time at DU. The posters and creative works presented at the symposium often represent the culmination of months of hard work for many students as they aim to show off the important impact of their research on society. Here the Editorial Board discusses the importance of the annual DU Undergraduate Showcase: Research, Scholarship, and Creative Works symposium and its implications for undergraduate students and the community.

2 WHAT IS THE SHOWCASE?

The annual showcase features students from across all academic fields and disciplines, as they assemble together to present their individual research or creative work to the DU community in the form of a poster or a three-minute oral presentation. The Undergraduate Research Center (URC), which hosts the annual event, helps facilitate opportunities for students to develop their research skills and intellectual inquiry by helping undergraduates find faculty mentors and providing grant support for their research projects. Daniel Linseman, Ph.D., Professor in the Department of Biological Sciences and Faculty Director of the URC stated, "The DU Research and Scholarship Showcase is a great opportunity for students to display and present their research and creative works to the DU community." Students who receive funding from the URC or need to fulfill thesis requirements are often required to present as Linseman notes that "undergraduate students who have received support from the Undergraduate Research Center in the form of either Partners in Scholarship (PINS) or Summer Research Grant funding are

expected to present their work in either oral or poster format. Other undergraduate students who have produced research or creative work towards their honors thesis or thesis for distinction in their major are also invited to present."

There is a large academic diversity of student backgrounds at the annual showcase. As Grace Warner, Program Coordinator of the URC, mentioned, "We get all students from all across the campus that choose to participate in the Showcase. That's what makes it such an interesting and exciting event! We have students from the Undergraduate Research Center, the Center for Community Engagement to advance Scholarship and Learning, the University Honors Program, the Pioneer Leadership Program (PLP), Living and Learning Communities, and various departments that engage with the event." While the number of students presenting has dropped off in recent years due to the COVID-19 pandemic, this year the 2022 event will be back in-person and is estimated to have approximately seventy participants, including students who will either be presenting research posters or providing a three-minute presentation. Overall, Linseman noted that the "annual showcase is an opportunity for undergraduate students to present their research and creative works to their peers and faculty at DU. It provides them with a learning experience of interacting with others, explaining their projects, and answering questions regarding their research."

Katherine Tennis, Ph.D., Director of the Center for Undergraduate Scholarship and Honors and Faculty Director of the Honors Program, lauded the importance of the event stating, "the DU Undergraduate Showcase of Research, Scholarship, and Creative Activity is an opportunity for students to showcase their projects and to learn about the research presentation process – including making academic posters and talking about their work in a professional setting. It is also an opportunity for students who are interested in getting involved in this work in the future to come and see what is possible and talk to their peers about the process."



Figure 1. University of Denver undergraduate students inside The Cable Center presenting their research projects at the annual showcase, May 2019

3 HOW STUDENTS CAN GET SUPPORT AS THEY PREPARE FOR THE ANNUAL SHOWCASE

Students are expected to learn a new set of public communication prowess as they prepare for the showcase. Linseman stated that “students will acquire the skills needed to create posters or PowerPoint presentations to present their work. They will also develop skills in communicating their research projects to an audience and fielding questions pertaining to their work.” DU’s Writing Center, located in Anderson Academic Commons, holds workshops and provides resources to help undergraduate students prepare their research abstracts, create an effective and visually appealing poster, and give concise academic presentations aimed at a lay audience. When asked what skills the Writing Center is hoping to teach students as they prepare for the annual showcase, Brad Benz, Ph.D., Teaching Professor in the University Writing Program and the primary faculty member administering these workshops, mentioned, “In the poster workshop, we focus on the rhetoric and design of good research posters. Since posters are a visual medium, we discuss reducing the amount of text on a poster, and we emphasize the importance of using strong images, visuals, tables, and figures in posters. We also have stu-

dents work on providing a very concise oral summary of their research - to be able to summarize it in one or two sentences to the people who stop and look at their posters.” The Writing Center often plays an important part in every step of the research experience at DU as Benz noted that the Writing Center helps students at “every stage of the research process, from conceptualizing their ideas to creating research questions to drafting PINS grants to getting ideas down in rough drafts to refining and revising final writing projects.” Students interested in receiving help in writing project proposals, or in preparing for academic presentations, should contact the Writing Center at wrc@du.edu.

4 THE STUDENT EXPERIENCE

Students often appreciate the opportunity the showcase provides them in presenting their work to the DU community. Andres Pulido, a senior majoring in Finance and International Studies, along with a team of students and faculty, conducted a two-year DU Grand Challenges-supported project analyzing and strengthening local policy and collaboration on homelessness in the Colorado cities of Englewood, Littleton, and Sheridan. Their goal was to provide an understanding of community attitudes and service provider resource re-

ferral practices, hopefully giving policymakers and service providers a deep analysis of factors affecting homelessness in those three cities. In reflecting on presenting at the showcase, Pulido came to the realization that to “drive community improvement and knowledge on complex topics, one must be able to explain it at both technical and nontechnical levels, spark intrigue in it, and speak to its implications. What helped in our case is that our project was intimately connected to the community through relationships and understanding present needs. This allowed, for instance, our ‘Covid-19 Best Practices Policy Report across the U.S.’ to inform rapid response efforts, and for our face mask drive to distribute thousands of face masks to those unhoused.” Pulido and his co-presenter, Avery Becklenberg, prepared to present a keynote presentation at the showcase by having “great discussions” with their faculty mentor, Linda Olson, Ph.D., PLP Director and Teaching Professor in Leadership Studies, those at the URC, including then-Director Tennis, and their team as a whole. “Through practice and careful thought,” Pulido noted that they “synthesized [their] project into a precise and story-driven presentation that illustrated the value of the project on a community and personal level.”

Rosie Contino, a senior majoring in Economics and International Studies, has spent years engaging in research focused on the sustainability of slum upgrading projects in the developing world, specifically the case of the Kenya Slum Upgrading Program (KENSUP). To prepare for the showcase, Contino “condensed” her research paper into a poster board, practiced presenting her research, and created handouts for those who were interested in further exploration of the topic. Reflecting on the skills she developed in preparation for presenting, Contino said, “Presenting at the research showcase over the years provided me with important experience in public speaking, synthesizing complex topics for a general audience, and an opportunity to share what I am passionate about with the DU community.”

5 IMPLICATIONS OF THE SHOWCASE

The annual showcase has become a staple of the research journey for many DU students and is an important event for the DU research community. “The Research Showcase is important for getting the message of URC funding availability out to the students and faculty,” Linseman noted, “It also creates a sense of community and highlights the amazing research and creativity of our students and their faculty partners.” Students echo the sentiments. For Pulido, the showcase was a “rewarding experience as a researcher” to reflect on his team’s hard work and connect with others in the DU community. “It truly gave us an outlet to express our appreciation to many at DU and our partners, for believing in five first-years, with a crazy

community-informed idea and a fire to create sustainable initiatives.” Contino found the event momentous in her research journey as it gave her the “chance to share my passions and work with the DU community.” In addition, “receiving constructive feedback from experienced DU faculty” and “getting to see what my peers have been researching was valuable.” Tennis stressed the significance of the showcase as “an opportunity to celebrate the hard work and achievements of our undergraduate researchers who contribute so much to the intellectual life and vitality of our campus. We invite all faculty, staff, students, and community partners to join us in celebrating this their exciting work and accomplishments.” Overall, to the DU community, Pulido noted that the research showcase is “a remarkable celebration of curiosity, tenacity, and impact, from collaboration and across all fields.”

6 CONCLUSION

The pinnacle of many undergraduate students’ research experiences at DU is the annual symposium, often providing an important opportunity to develop academic communication skills and meaningfully engage with other members of the research community. It is, for many students, the final stage of the scientific process that their research mentors have guided them through. Mary Clark, J.D., Provost Executive Vice Chancellor of the University of Denver, noted that “as an institution, our goal for research and scholarship is to solve the challenging problems of our time while allowing our students to gain valuable experience.” Clark stated that the high-quality research projects presented at the showcase are a testament to the powerful, “dynamic faculty-student partnerships” present on campus that seek to “make discoveries that have the potential to change the world.”

Throughout this article, we have highlighted the crucial importance and value of the annual DU Undergraduate Showcase: Research, Scholarship, and Creative Works symposium held for the DU research community. We encourage students to work with their faculty mentors to craft a poster or oral presentation, take advantage of all the University resources available to them, and engage with the academic community through this significant event.



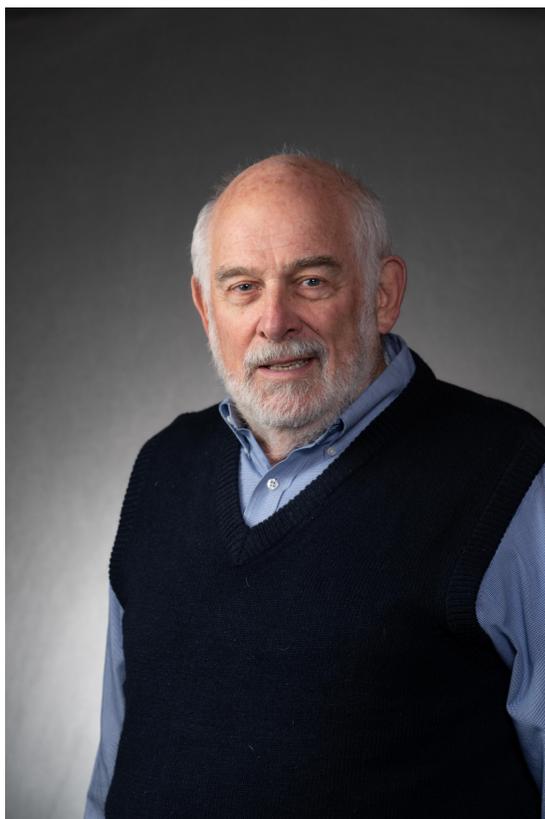
Help by Merit Willey

Dr. Lawrence J. Berliner

Department of Chemistry and Biochemistry

Anit Tyagi¹, on behalf of the Editorial Board

¹DUURJ Editor at Large, University of Denver



1 TELL US ABOUT YOURSELF, SUCH AS WHERE YOU WENT TO SCHOOL, HOW YOU BECAME INTERESTED IN YOUR MAJOR RESEARCH AREAS, AND HOW YOU FOUND YOUR WAY TO DU?

I attended UCLA and Stanford respectively, with a post-doctoral year at Oxford University studying molecular biophysics. My training was centered heavily around an instrumental technique called electron spin resonance (ESR) or electron paramagnetic resonance (EPR), which shows up in much, but not all, of my research. I learned very early that one technique does not suffice to prove something unequivocally.

How did I find my way to DU? I must have had a leaning towards Colorado. I interviewed at both CU medical

school and CSU for my first job; then later in my career again at CU biochemistry in the medical school when I decided that I would leave the Ohio State University to pursue a department chair position. After several opportunities in the interim, when I could obtain full retirement from OSU in 2001 I again interviewed for chair positions and DU was the best choice of what was open to me at the time. Moving from a large research powerhouse to a medium sized primarily undergraduate institution was a learning experience. The chair position at DU turned out be more like a department manager which was somewhat disappointing but nonetheless challenging given the constraints. I never regretted moving my Ohio family to Denver, however, as we wouldn't now have the wonderful new grandchildren who live nearby, great friends from the DU faculty and phenomenal culture that the environment has to offer.

2 WHY DID YOU BECOME A SCIENTIST? WHAT DREW YOU TO THIS FIELD? WHAT MAKES YOU GET UP IN THE MORNING?

I always wanted to become a chemistry major from when I was eight years old with an interest in magic tricks, and, at the time you could get a real chemistry set with "dangerous chemicals!" My interest went from making fireworks to scaring kids trick-or-treating during Halloween. Fortunately, safety glasses saved me from potentially severe injuries during one of my chemistry set experiments. What should drive one to wake up in the morning is the fun of 'playing' with a scientific apparatus in the lab while hopefully occasionally stumbling across some new unique observations that might result in an actual discovery.

3 WHAT ARE YOUR TEACHING INTERESTS? WHAT IS YOUR "TEACHING PHILOSOPHY"?

I enjoy teaching lots of subjects in both the scientific and interdisciplinary arena. At the graduate level, this has been advanced biochemistry and areas that cut across my research. At the undergraduate level, I taught fresh-

man chemistry for more than 30 years as well as some intermediate and advanced undergraduate topics. But I found the greatest rewards in small seminar courses where we critically discussed topics, such as bioethics and ethics in research. My teaching philosophy is to both challenge students and not overload them with facts that they can't totally digest. I really prefer the seminar course model, but this doesn't really work in large classes; from my perspective, there is no difference between 50 students and infinity! I would still try to have some interchange with students in my large courses, either by walking around the classroom while they are working on a challenging assignment, and leaving time at the end of the class for individual questions. I don't think that one way lecturing without feedback is going to be effective learning for many students. The best medium is office hours, with one-on-one free tutoring if the students have the time to meet.

4 WHAT SPARKED YOUR INTEREST IN THE FIELD THAT YOU WORK IN?

It's different for everyone. And I think that being open minded and learning new approaches and techniques are the key to creativity. I always tried to shift and expand my research at least every 10 years. Many of the students working with me also influenced my research directions as well.

5 HOW DO YOUR INTERESTS IN WHAT YOU TEACH IN THE CLASSROOM CORRELATE TO THE RESEARCH YOU DO?

I'd say very directly. However, teaching assignments in university departments are sometimes based on aspects other than the expertise or interests of the faculty member and can be subjective, sometimes even punitive, to the detriment of the students as well.

6 HOW HAS THE PROCESS, OR THE PROFESSION OF RESEARCH, CHANGED OVER THE PAST FEW DECADES IN YOUR FIELD?

Having spent over 50 years in academia at two academic institutions as well as several sabbatical years around the world, I have a unique perspective. The 'product' that an academic scientist is 'expected' to provide is publications, research dollars, from which the institution gets about 50% 'overhead', service to the institution, profession, and community, and -we almost forgot- teaching at principally undergrad as well as graduate and postdoctoral level. Unfortunately, many institutions don't have the time or expertise to evaluate the quality of scholarship, such as publications, and focus almost entirely on quantity and numbers of dollars,

which they also glean from undergraduate teaching. I sometimes think that a research faculty member is like a used car salesperson or contractor: the management is only interested in the quantity not the quality of units sold and the dollar income number. Obviously my scenario sounds pretty glum, yet I would be the first person to tell you that the academic world is one of the best jobs one could have; just be aware of the politics and expectations. I also want to emphasize one of the prerequisites, which is a sabbatical year every seven years. While some people categorize these as a "congressman's junket abroad," in every case I entered and brought back a new area that enhanced my research.

7 DESCRIBE YOUR RESEARCH IN LAYMAN'S TERMS:

Enzymes and proteins are principal 'machines' in living organisms. Understanding their structure and how they work, or their mechanism, is critical to understanding disease and genetic disorders everywhere from heart disease to cancer to dementia. We have studied several of these over the years as well as developing potentially important diagnostic methods as well.

8 WHAT WOULD YOU CHANGE TO IMPROVE HOW WORK IN YOUR FIELD IS DONE? IN OTHER WORDS, WHAT LEGISLATION MIGHT YOU PASS OR WHAT POLICIES WOULD YOU CHANGE AND WHY?

I've been both on grant committees as well as advising government granting agencies including lobbying Congress for supporting scientific research and education. I think that the federal agency granting trends have focused too much on 'productivity' or quantity rather than innovative "pie in the sky" ideas that might result in greater impact to society than numbers of journal articles. This is certainly the course that venture capitalists or very successful companies take: fund ten projects at modest budgets and claim success if more than one is successful. But a new faculty member can't get tenure without grants and publications, meaning that 'safe science' might be the better choice. Fortunately, we still get some innovative impactful results. Unfortunately, some faculty carry on the same safe science into their later years without any risk-taking or forays into more challenging, unknown areas.

9 CAN YOU SHARE A TURNING POINT OR DEFINING MOMENT IN YOUR WORK AS A SCIENTIST?

I've been fortunate, almost totally due to serendipity, to have stumbled across some interesting research areas that ended up with some significant impact that I never

expected. Suffice it to say that if a scientist produced several hundred publications and only one or possibly two impacted the field and society, that wouldn't be very rewarding from my perspective. Yet having just a few publications with a major impact is all that one might expect. The potential turning point for me was encountering one or two scientists who we shared our results with, go and publish the same experiments in advance of our carefully repeated work. That was devastating and I momentarily lost my interest in the profession; but we continued on. Amazingly the unethical scientists' results were wrong in the end!

10 DESCRIBE YOUR CAREER TRAJECTORY AND ANY ZIGZAGS YOU ENCOUNTERED.

Actually, my first project was in solid state physics using this technique where we built a special instrument to do experiments under high hydrostatic pressure, but for several reasons I became less interested in this area and asked my supervisor for another project. As we learn in life things don't go in a straight line, rather a crooked one that sometimes even circles backwards before proceeding ahead. And, due to serendipity, assuming that you are willing to follow an assumedly uncharted path, some amazing opportunities can arise. Thus, my interests shifted to studies of protein structure and conformation as well as enzyme mechanism.

11 TELL ME WHAT YOU LIKE TO DO WHEN YOU AREN'T WORKING ON RESEARCH.

Travel, gardening, theatre and opera, and especially most recently playing with my grandchildren.

12 VIEWS ON CURRENT PUBLIC POLICY ISSUES IN SCIENCE (CHEMISTRY, MEDICINE, ETHICS)?

I think that I covered most of these earlier. However, the ethical issues have become more relevant in the current millennium and I've experienced that up front as an Editor-in-Chief of two international Journals. The old saying "publish or perish" appears to now be both figurative and literal. There are institutions that give large financial incentives for publications in prestigious high impact international journals with amounts that can exceed one's annual salary. This is particularly prevalent in China but also other countries. In fact there's a few in the USA that provide nominal rewards. The worst thing is plagiarism and falsified data in publications. We try to filter these early with plagiarism software but duplication of results or fabricated articles can only be detected by expert peer review. Obviously some 'leak' through the process and some escape eventual discovery and retraction but the problem seems

to remain and increase rather than the opposite. This would involve aggressive action by governments, scientific societies and research institutions and the amount of enforcement varies widely. If we don't persevere then more scientists will start to waiver in order to improve their situations.

13 WAS THERE EVER AN OUTCOME IN YOUR RESEARCH THAT WAS UNEXPECTED, OR DID YOU EVER ENCOUNTER A SURPRISING SETBACK? HOW DID YOU REACT AND ADAPT?

Mostly the former fortunately. One has to be astute enough to know when to drop a project that's not going to be fruitful.

14 IF YOU COULD GO BACK IN TIME AND GIVE ADVICE TO YOURSELF BEFORE YOU BEGAN YOUR CAREER WHAT WOULD IT BE?

I dare to say "you learn along the way; otherwise, it's not going to be fun or interesting."

15 WHAT IS THE MOST FRUSTRATING, AND MOST REWARDING ACTIVITY, RESPECTIVELY, IN YOUR DAY-TO-DAY WORK?

Administrative responsibilities and endless meetings with no clear direction. Trying to convince students that research and advanced learning is not a game but real life. Supervising and watching students succeed at their work and become more expert at their projects or work than me.

16 WHAT DO YOU THINK IS THE NEXT BIG DISCOVERY OR PROBLEM SOLVED IN YOUR FIELD?

The Alzheimer's like disorder. What I'd like to see finally tackled is a solution to the devastating symptoms of diabetes. Albeit complex, it's been around a long time and there's even an NIH institute dedicated to the disease.



Birthday Wishes by Amanda Kyle

Dr. Jennifer Greenfield

Graduate School of Social Work

Anit Tyagi¹, on behalf of the Editorial Board

¹DUURJ Editor at Large, University of Denver



1 TELL US ABOUT YOURSELF, SUCH AS WHERE YOU WENT TO SCHOOL, HOW YOU BECAME INTERESTED IN YOUR MAJOR RESEARCH AREAS, AND HOW YOU FOUND YOUR WAY TO DU.

I have a Bachelor's degree in English from Albright College, a small liberal arts college in Pennsylvania. After finishing that degree, I worked in communications for a variety of nonprofit organizations, and on the side, I frequently volunteered for political campaigns and groups engaged in advocacy on social issues. Eventually, I found myself working for a nonprofit that provided tutoring and mentoring for children living in shelters in Washington, D.C. That work led me to the field of social work. I decided to pursue social work education, first receiving an MSW from Saint Louis

University, then going on for a Ph.D. at Washington University in St. Louis. Though I grew up on the East Coast of the U.S., I had always wanted to move west, and I was eager to find a job that would allow me to do community-engaged policy work as a scholar and faculty member. The job offer from DU felt like a dream come true.

2 WHAT ARE YOUR TEACHING INTERESTS? WHAT IS YOUR "TEACHING PHILOSOPHY"?

I teach about the policymaking process and how social workers and researchers can influence the laws and regulations that are passed and implemented at the local, state, national, and tribal levels. I very much believe in walking the walk, not just talking the talk, so I remain active in policy analysis and advocacy as well. I bring my real-world experiences to the classroom and invite my students to join me in my work in the community. I believe that each student brings their own unique expertise into the classroom, and so my classroom is a place where we pool our knowledge and our questions, and we actively engage with current events and current debates as we practice the skills students need to achieve their goals, which usually center around changing the world in one way or another!

3 WHAT SPARKED YOUR INTEREST IN THE FIELD THAT YOU WORK IN? WHAT DREW YOU TO SOCIAL WORK?

Before entering graduate school, I thought that social work was narrowly focused on individual-level concerns such as mental health, child welfare, and so on. It was a friend who first encouraged me to learn more about the field, because the work I was doing with volunteers and children in the shelters in D.C. was closely aligned with social work, but I was doing the work without the training I needed to be effective. As I learned more about social work, I realized that social work was concerned not just with the troubles of individuals, but also with the social and political contexts that shaped those troubles, the "upstream" causes of

the social problems I cared about. One of my internships in my Master's program sent me to the same community organizing training program where Barack Obama was trained as a community organizer, and a few months later I was giving oral testimony at the Missouri state legislature and organizing press conferences in support of Medicaid expansion. It was thrilling to see how evidence-based policy analysis could be paired with the impactful testimony of people with lived experience to influence lawmakers on important issues like health care access. And I love being able to link the individual-level concerns with the broader social and political processes. It means that every day, the job looks a little different!

4 DESCRIBE YOUR CURRENT RESEARCH IN LAYMAN'S TERMS. IN OTHER WORDS, DESCRIBE THE VERY BASICS OF THE FIELDS YOU STUDY AND TEACH AND THEIR COMMON APPLICATIONS.

My research began with a focus on how health insecurity and financial insecurity are linked. At the individual level, financial stress can lead to health concerns, but poor health often leads to decreased income and wealth. At the societal level, these dynamics are evident in the health disparities we witness between those who earn the least in our society and those who earn the most. Higher earners tend to have better health, better access to health care, and increased wealth accumulation over time. I was interested in studying the bidirectional relationship between health and wealth, and the ways in which social policies can influence this relationship. Does improving access to health care increase income and wealth? Does stabilizing employment through mechanisms like paid family and medical leave also help to improve health and increase wealth over time? These questions have led me to research a variety of policy topics, including paid family and medical leave, minimum wage laws, paid sick leave, TANF programs, and so on. I have become something of a policy generalist over time, in part because of opportunities to partner with state legislators and state agencies to answer policy questions they brought to me, and in part because policy wins, such as passing Colorado's minimum wage ballot initiative in 2016 and the paid family and medical leave initiative in 2020, have led to new sets of questions. I love being able to tailor my research to the pressing questions of the day. It makes the work feel relevant and always interesting!

5 WHAT WOULD YOU CHANGE TO IMPROVE HOW WORK IN YOUR FIELD IS DONE? IN OTHER WORDS, WHAT LEGISLATION MIGHT YOU PASS OR WHAT POLICIES WOULD YOU CHANGE AND WHY?

I still believe that expanding access to health care is a vital concern, and although the Affordable Care Act has expanded access significantly, cost of insurance and cost of actual care remain barriers to too many people. In addition, our health care system is still built to exclude, as is evidenced, for instance, in the egregiously poor health care access and outcomes among Black Americans and LGBTQ+ folk. There is still a lot of work to be done to ensure that every person in this country has access to quality, affordable, accessible health care as a basic standard of existence. And, of course, it is difficult to mention health care without also mentioning housing and food as other basic human needs that are currently out of reach for too many people.

6 CAN YOU SHARE A TURNING POINT OR DEFINING MOMENT IN YOUR WORK AS A RESEARCHER?

One pivotal moment in my career was the birth of my twin boys in 2013. Like many twins are, my kids were born preterm, and they spent their first month of life in a neonatal intensive care unit (NICU) in Denver. I had just finished a dissertation that looked at the impact of caregiving on the income and wealth of caregivers for older adults, but realized quickly that having hospitalized infants was just as likely to interrupt a person's income and career as caregiving for an aging parent. The experience also drove home how important paid family leave was in making sure I could stay employed and keep a roof over my head while my kids were in the hospital. Suddenly, the experiences of new parents and aging caregivers were linked in a new way in my mind, and I decided to expand my research beyond the previous focus on "aging issues." The next year, I launched a study of the experiences of mothers of hospitalized infants in Colorado. With support from Public Good and PROF grants from DU, that study ended up gathering longitudinal data from over 200 mothers and my research team, which includes M.D.s, a nurse scientist, and several social work Ph.D. students and alumni, has published eight peer-reviewed articles from the study, with more on the way.

7 TELL ME WHAT YOU LIKE TO DO WHEN YOU AREN'T WORKING ON RESEARCH.

I love being outside, so finding new places to hike in Colorado is one of my passions when I'm not working. I also love photography; my hikes are often slowed down

by frequent stops to take pictures, and I hope to improve my astrophotography skills in the near future. My twins love to have me join them in Minecraft and Roblox, so when we're not outside, you'll find me in those virtual worlds after school sometimes. And I also continue to do volunteer work in the community, including as a peer-support person for new parents in the NICU.

8 IF YOU COULD GO BACK IN TIME AND GIVE ADVICE TO YOURSELF BEFORE YOU BEGAN YOUR CAREER, WHAT WOULD IT BE?

I would tell myself to talk to my professors when I was struggling. I had hard times at various points in my educational career, especially as a sophomore in college, and in my second semester of my Master's program, and I was too embarrassed to tell my professors what was going on. Now that I'm on the other side of that, I realize how much most professors really want to help, and I wish I had been more willing and able to talk to mine back then. I work really hard as a professor to share about my own less-than-stellar moments as a student so that my students will realize how common those experiences are. I genuinely want students to succeed, and I know life can throw a lot of hurdles at us when we least expect them. Offering care and understanding is now one of my most urgent goals as a professor.

9 WHAT IS THE MOST FRUSTRATING, AND MOST REWARDING ACTIVITY, RESPECTIVELY, IN YOUR DAY-TO-DAY WORK?

One of the most challenging aspects of faculty life for me is the differing time horizons for the various tasks on my to-do list. I may think I have a good idea of what my week looks like, but one email, or ten, can change all that in a flash because a journal editor may give a short deadline for article revisions, a student may have an urgent need to talk with me, or something like COVID-19 or a natural disaster may prompt an unexpected need for new policy development. There have been countless times when I had to drop everything to draft an email or an op-ed in order to respond to a pressing issue, which ends up putting more long-term, but equally important, tasks on the back burner. It can be very hard to find balance between responding to the urgent stuff while also making sure that the more mundane stuff continues to move forward, which is why I'm perennially behind on answering emails!

By far the most rewarding part of my job is working with students and seeing their careers take off. Right now, most of my work is with Ph.D. students, and it is both thrilling and humbling to see them grow and excel

as scholars and instructors. It sounds like a cliché, but I genuinely learn so much from my students through reading their work, doing my own research to help answer their questions, and listening to their concerns about our world and our profession. I hope I never lose my willingness to learn from them, because I know I've become a better person and a better scholar through my engagement with the students at both GSSW and the Scrivner Institute for Public Policy at Korbel. One thing that I'd say to current students is this: please stay in touch! Most professors love to hear how our former students are doing!

10 WHAT DO YOU THINK IS THE NEXT BIG DISCOVERY OR PROBLEM SOLVED IN YOUR FIELD?

There are so many ways in which social work is engaged in society's most urgent issues that it is hard to choose just one area to focus on. With that said, I've been particularly inspired by the work of my colleague, Dr. Lisa Reyes Mason, which is at the intersection of climate change and social justice. I recently had the opportunity to join her research team in a policy analysis project that will be published soon in the *Journal of Policy Practice and Research*, and I would love to do more work focused on how to enact urgently needed policies to address climate change, and especially how to center the needs and voices of marginalized and environmentally vulnerable communities in that work. Although the many policy issues I've focused on feel urgent, I have to say that failing to mitigate the climate crisis puts a shadow on all the other good we're trying to do in our city, state, country, and world. I think we need all hands, and all disciplines, on the task when it comes to addressing climate change right now.



Picnic on the Amazon by Merit Willey

DU Undergraduate Showcase: Research, Scholarship, and Creative Works

Abstracts

Impacts of Ambient Air Pollution on Birth Weight Percentile and Gestational Age at Birth

Emma Aggeler¹, Elysia Davis²

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Research into early developmental periods has found that birth outcomes such as birth weight percentile and gestational age at birth are predictive of child development (Gutbrod et al., 2000). However, the research relating these birth outcomes with environmental factors such as maternal exposure to air pollutants remains relatively unexplored. Therefore, the current study examines whether exposure to air pollutants during pregnancy has an impact on birth weight percentile (BWP) and gestational age (GA) at birth. From a population of 272 mothers and children in the Denver area, no significant associations were found between child metrics and three types of pollutants (PM10, PM2.5, and O3), indicating that birth outcomes are not influenced by prenatal environmental exposures.

Point of Use Technologies to Increase Access to Clean Water in Rural Communities

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Access to clean water is an issue that many communities around the world struggle with. While large-scale efforts such as piping infrastructure have been successful, these are less effective at reaching small, rural communities. To supplement these efforts, point of use (POU) methods for water treatment can be implemented. These include boiling, chemical treatment, filters, and several additional technologies. These have all shown effectiveness in a lab setting, but their implementation in the real world, specifically in rural communities, has not been nearly as effective. In this paper, several different POU methods are evaluated for their effectiveness on a small-scale, including associated costs with each. A locally specific education campaign for the proper use of these technologies would empower individuals to treat their own water and be responsible for their own health in a way that has never been seen before.

Predicting Socioemotional Development Across the First Year of Life: Early Infant fNIRS and BITSEA

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Previous functional neuroimaging research on infant auditory vocal discrimination has found that infants demonstrate preferential activation to their mother's voice (Imafuku et al., 2014) and emotional tone vs. neutral tone (Cheng et al., 2012). Though it is understood that the ability to discriminate between individuals and emotional expressions is necessary to predict others' actions and guide behavior within a social interaction (Frith, 2009), little is known about the predictive value of neural response to these cues on socioemotional outcomes. The current study ($N = 21$; 8 M, 13 F) examined the predictive value of functional near infrared spectroscopy (fNIRS)-measured prefrontal cortical (PFC) neural response to mother's and stranger's voices at happy and angry tones in early infancy ($M_{age} = .98$ months) on parent-reported infant socioemotional behavior (BITSEA; Briggs-Gowan et al., 2004) at one year ($M_{age} = 13.14$ months). Following data collection, a repeated measures GLM identified 4 PFC fNIRS channels as being significantly active in response to the voice task. Bivariate correlations were run across all stimulus conditions on the 4 PFC fNIRS channels with all BITSEA scores. Neural activation in response to mother's happy voice or stranger's angry voice in 3 of the 4 PFC fNIRS channels was significantly associated with BITSEA socioemotional outcome scores including autism spectrum disorder risk scores. These results suggest that neural mother-stranger and emotional voice discrimination in the first months of life may be predictive of parent-rated socioemotional outcomes. More specifically, this neural sensitivity in early infancy may serve as a brain-based biomarker of risk for later socioemotional problems or disorders within the first year of life.

The Studio of the Latino Lover

Justin Bravo¹, Mia Mulvey²

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A review of art history often gives the impression that only white men have been creating good, impactful paintings and artwork in the last 200 years. This has the effect of excluding diverse voices, experiences and narratives in the arts and beyond into the collective history. The goal of my project is to extend a tumultuous, nuanced aspect of the Latino/Latinx experience in the practice of painting and artmaking. My approach to this will be a juxtaposition of making work that is in conversation with renown artworks, nested into silhouettes that represent racist tropes and stereotypes. This representation helps to illustrate that a diverse population does contribute and is in dialog with realms of art that have historically excluded the marginalized, disadvantaged and people of color. The implication of this project is an essential conversation directly connected to the need for diversity.

Geometry of Object Storage and Recognition in Human Memory

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Objects in the environment have a large variety of appearances due to 3D to 2D mapping, occlusion, self-occlusion and the relative position and orientation between the object and the observer. How does the brain store and recognize objects? There are three main ways we investigated: Structural Descriptions, Perspective Views, and Canonical Orientation. Using the mental rotation paradigm, to investigate how objects are stored and recognized in human memory. The mental rotation paradigm consists of a linear relationship between rotation angle of an object and a subject's reaction time to analyze the object. We investigate if there exists canonical storage in the human brain and if so, what is its relation to figural symmetry and elongation axis. We tested if the reaction time profile can be expressed as a linear combination of these two variables. In these preliminary data, the model appears to capture data relatively well with the possible exception of the 90-degree orientation angles. Preliminary data supports the canonical orientation hypothesis with symmetry playing an important role in determining the canonical orientation.

Social and Affective Impacts of the COVID-19 Pandemic on University Students

Megan Burnham¹, Kateri McRae²

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The COVID-19 pandemic has resulted in an unprecedented set of disruptions to university students' learning modalities, mental health, and social interactions. Students have had to pivot to online learning and navigate unexpected social isolation, leading to the development of different ways to connect with social groups as well as different personal pursuits. Despite downward trends in restrictions and growing progress with vaccinations, the pandemic still threatens and has impacts on students' lives daily, such as required testing, mask wearing, and isolation for individuals testing positive for COVID-19. We conducted a study to examine self-reported coping strategies, social interaction, social emotion regulation, and mental health symptoms in university students. We collected data at two time points so that we could compare these variables between spring of 2020 and summer of 2021. Additionally, this is the first line of research to measure university students' levels of social reappraisal support. We tested whether frequency of communication with core social contacts was significantly related to the social reappraisal support students received from those contacts, and if the support was related to mental health symptoms. We then gathered online survey responses from more than 150 university students across North America. Participants were asked to complete various psychometric measures, along with two custom questionnaires: the Pandemic Coping Questionnaire and the Social Network and Reappraisal Questionnaire. In both the current study and the previous study, we observed that students were experiencing less social interaction overall relative to before the pandemic; nevertheless, higher frequency in communication with core social contacts predicted greater social reappraisal support from those contacts. Additionally, we found that perceived stress was significantly lower in the summer of 2021 than the spring of 2020. Finally, participants who reported higher social reappraisal support from core social contacts also reported significantly less perceived stress. These results reaffirm that social contacts are important influences on reappraisal, which may then impact mental health.

Influence of Hypoxia Acclimation and Evolutionary History on the Muscle Structure of *Peromyscus* Mice

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At high-altitude (>2500 meters above sea level), small mammals are confronted with the challenge of sustaining aerobic processes, such as shivering thermogenesis, in the face of reduced oxygen availability and low temperatures. To overcome these demands, oxygen and metabolic fuel must be supplied to skeletal muscles. This supply requires a sufficient density of muscle capillaries and a high proportion of aerobic muscle fibers (those that use O₂). I tested the hypothesis that different species of mice of the genus *Peromyscus* – which have independently colonized high altitude – have evolved an increase in muscle capillary density and a higher proportion of aerobic fibers relative to closely related low-altitude species. I executed this study by measuring capillarity and muscle fiber types of gastrocnemius skeletal muscle (hereafter, gastroc) samples collected from a previous experiment, where each species of *Peromyscus* was exposed to stimulated elevations spanning normoxia to hypoxia (1000 m, 3500 m, and 4500 m above sea level) for six weeks. Histological sections of gastroc were taken, stained for capillaries and muscle fibers, and imaged on a light microscope. I have quantified images for oxidative fibers, leaving the analysis of capillary density remaining. Results from this analysis indicate an increase in density of oxidative fibers in the gastroc of species that are native to high elevation, relative to those living at low altitude. This suggests that the supply of oxygen and metabolic energy required to maintain aerobic processes is a ubiquitous adaptation of small mammals at high altitude, contributing to their success in profoundly hypoxic conditions.

Using Neural Networks to Extend Experimental Trajectories in Genetic Circuits

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There are many processes in nature which exhibit noisy time series data and for which data collection is difficult. Examples in biology include protein expression in genetic circuits, cell shape, and molecular simulation dynamics. In all these examples, there are practical limitations to data collection including cost and technological or computational difficulties. We present a procedure to extend time series data with machine learning. A gated recurrent unit (GRU) neural network is trained on a simple gene network as a proof of concept. The GRU network then extends a protein trajectory from the gene network. The principle of maximum caliber (MaxCal) is used to assess whether the GRU network has accurately and faithfully extended this protein expression trajectory. Our results indicate that the machine learning model can accurately extend a time trajectory of protein number. This procedure for data extension, combined with the quality control provided by MaxCal, can be extrapolated to more challenging gene circuits and other biological problems where extension of stochastic time series data would be useful.

The Case of Kenya: Evaluating Kenya Slum Upgrading Program from a Sustainable Urbanization Framework

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Global urbanization is occurring at an unprecedented rate. The brunt of this urban growth is occurring in the developing world, where cities pose a substantial threat to sustainability. Sustainable urbanization has emerged as an approach to this challenge which balances environmental, social, and economic concerns throughout the urbanization process. Slums pose a threat to sustainable urbanization in the developing world as they result in stalled economic growth, environmental degradation, and increased social inequality. Given the increasing popularity of slum-upgrading interventions, it is critical that such programs be aligned with the core tenets of sustainable urbanization. Unfortunately, there is a lack of existing holistic and replicable tools to evaluate slum-upgrading programs for sustainable urbanization. The ASPIRE Toolkit is a holistic assessment tool designed to evaluate the sustainability of infrastructure projects in developing contexts. The present study employs the ASPIRE Toolkit to evaluate the Kenya Slum Upgrading Program (KENSUP) for urban sustainability. The ASPIRE evaluation conducted in this thesis revealed that KENSUP performs strongly with regards to essential services, social infrastructure, and environmental management; however, the program performs below the standard for inadequate community participation, inequitable distribution of benefits, insufficient government capacities, and economic disturbances. Overall, the ASPIRE toolkit was found to be an effective tool for the assessment of slum upgrading programs and it is recommended that the tool be employed in future research.

State-Sponsored Cultural Production's Influence On Nationalist Politics In France

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Due to how their unique markets are impacted by governmental action, the French have claims to cultural products in a way that creates tangible manifestations of national identity. Using the central product regulated by the *Appellation d'Origine Contrôlée* (AOC), wine, I will see how a particular cultural market can contribute to the rise of nationalistic voting in France. Initially, I will understand the issue through reconciling the academic literature around cultural economics, politics, and nationalism with the rich history of wine and culture in France. From this, I will begin my research by tracking the history and recent successes of the *Rassemblement National* (RN), France's most codified right-wing political party. Then, to operationalize this question, I will use local elections in comparative wine regions to see how much cultural markets are both explicitly referenced and implicitly played upon in campaign rhetoric. This will be done by evaluating newspaper articles from local elections since the formation of the RN. If the RN's increased claims to French culture translate to the voters through the media, the rise in RN success could be tied to the cultural nationalizing of the products that French regions pride themselves on. While the literature may expect a direct casual effect between state-led national identity through tangible cultural products and election results, the research does not show a direct effect of cultural claims as the reason for RN success. Yet, France still provides a particularly interesting case study of direct governmental influence in their recognized cultural economies that can still inform the discourse around cultural nationalism in the twentieth century.

Characterization and Comparison of Calcium Oscillations Between Oligodendrocytes and Other Mammalian Cells

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Mucopolipidosis Type IV (MLIV) is an autosomal recessive lysosomal storage disorder of the nervous system characterized by severe motor impairment, delayed cognitive development, ophthalmological abnormalities, and a lack of myelin in the brain. It results from mutations that render the ion channel TRPML1 non-functional. TRPML1 is permeable to calcium, zinc, iron, and several other ions. Calcium is a vital ion in the propagation of electrical signals in the nervous system. Oligodendrocytes are the cell type in the central nervous system that produce myelin. As MLIV is a hypomyelinating disorder, studying calcium ion dynamics in oligodendrocytes may give significant insights into the molecular mechanisms underlying this pathological condition. We compared various calcium sensors (FuraRed, Fluo-4, GCamp5, RGECO-1, REXGECO1, and RCamp1h) in Hela cells on their sensitivity. Among these sensors, GCamp5 shows the greatest response to treatment with the drug thapsigargin, which increases cytosolic calcium by blocking the sarco/endoplasmic reticulum Ca^{2+} ATPase (SERCA), leading to release of calcium to the cytosol from the endoplasmic reticulum (ER). We then transfected various cell types with GCamp5 to compare the calcium dynamics of oligodendrocytes to more well studied cell types such as neurons. We also visualized the decrease of ER calcium concentrations in various cell types using the sensor ER-GCamp6-150. Finally, we discovered spontaneous calcium oscillations in mature rat oligodendrocytes that were exaggerated upon depolarization of the cell using 100 μM glutamate and 10 μM glycine. Given the important signaling roles of calcium, the calcium oscillations in oligodendrocytes might contribute to their vital function.

One or the Other: An Exploration of Gender Essentialism and Binary Categorization

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Gender essentialism refers to the belief that binary categorizations of gender, “man” and “woman,” are biologically driven and innate groupings. Essentialist beliefs can contribute to stereotyping and discrimination; however, research indicates these beliefs can be malleable and influenced by language. My study aims to clarify how linguistic gender categories support essentialist beliefs, which may, in turn, support inequality and discrimination. We hypothesize that participants in the binary judgment condition will report greater gender essentialism and stronger views of gender as a binary construct than those in the continuous judgment condition, with participants in the control condition falling in-between.

A Midsummer's Wet Dream: An Exploratory Artists' Book

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A Midsummer's Wet Dream is a work that explores the explicit synergy between performative text and theatrical performance. *A Midsummer Night's Dream* disrupts the canon of tragedies that populate the Shakespearian Artists' book collections. The work questions how the content and form of Artists' books act together as co-creative presences to redefine the medium of book and of theatrical text. This research project focused on Artists' books that "perform": how does the explicit presence of a "performance" in an already performative medium animate the work? What shape does that multiplicity take? Is the book's physical form an equally explicit conductor of meaning? Over the course of ten weeks, the project unfolded as a series of drafts and "sketch" books that were literary tinder for the final piece. Through mentorship with bookmaker Alicia Bailey, further iteration was made to the project, and key insight was gained in the practices of bookmaking. *A Midsummer Night's Dream* became the conduit for this work due to the "play within a play" that ultimately informed the form of the book. The final work took shape as a single edition book, comprised of a "book" shell of *A Midsummer Night's Dream* that houses a pop-up book that details the play within *A Midsummer Night's Dream*. This work has since been collected by the DU special collections library and joins in a lineage of artist books that engage deeply with theatrical texts.

Amplifying Youth Through Art

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With the rise of social activism, young people are searching for ways to engage community members and policy-makers in what they care about. Amplifying Youth Through Art (AYTA) aims to empower youth to use artistic outlets (photography and theatre) to highlight the issues they find most timely and important. Through intentional integrated social-emotional learning activities and a curriculum that promotes aesthetic learning, students strengthen their sense of self and vulnerability while deepening their perception of the issues they choose to explore. The result of this project-based research is a final community sharing determined by the youth. These final sharings are set for May and the implications of the project will be explored after that.

The Renaissance of American Big Band Jazz: An Exploration in Contemporary Presentation

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The Renaissance of American Big Band Jazz: An Exploration in Contemporary Presentation is a project aimed towards answering the question: What contemporary demands establish the guidelines of modern music consumption, and how can students apply these guidelines to the knowledge and skills acquired through the pursuit of degrees at the Lamont School of Music to proliferate the success of their professional careers? I believe that the demands of contemporary music consumption require a multimedia approach, marrying a variety of artistic forms to grab the attention of modern music consumers, who now expect to engage with art through myriad simultaneous sensory experiences. In this project, I will innovate a revitalization of big band jazz consumption. I will combine big band jazz arrangement and instrumentation with original musical composition, modern electric pop band instrumentation, live musical performance & improvisation, live visual art, and cutting-edge videography to create a singular yet multidimensional piece of art. This piece will be distributed across a variety of digital platforms, as will an alternate version consisting only of audio material. I will analyze the online world's differing engagement with each respective form (video vs. audio) with the goal of proving that a multimedia approach yields a more popular product. With this project, I intend to electrify the golden era of American big band jazz. By bringing classic big band instrumentation and musical style into a realm of presentation that is palatable to the ears and eyes of the modern consumer, I will create a more engaging experience for the audience, reintroducing intellectually and instrumentally intricate music to the popular eye.

Optical Vortex Nucleation Behind A Circular Obstruction

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From whirlpools in water to tornadoes in air, vortices are a common natural phenomenon. Vortices also occur in light, opening up the possibility of using light to study fields such as quantum computing and quantum fluids. Previously, light beams with vortices have also been used to study the spot of Arago. The spot of Arago is a landmark experiment verifying the wave nature of light by showing that a bright spot appears in the center of a beam after the beam encounters a circular obstacle. In this thesis, rather than using optical vortices to investigate the Arago spot, I instead explore using a circular Arago-like obstruction to generate optical vortices. I compare computational and experimental data where I displace a circular obstruction in the path of a Gaussian light beam, and I characterize the formation of an optical vortex pair in the far-field past the obstruction. In both sets of data, the results show that the formation of the vortex pair is dependent upon the distance of displacement of the obstruction. These results have the potential to be used to study quantum turbulence and the formation of vortices in quantum fluids containing obstacles.

Mutations in the Human VPS41 Protein and Their Effect on Insulin Secretion

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The protein VPS41 is an established subunit of the homotypic fusion and protein sorting (HOPS) complex, which acts as a tethering complex and facilitates endolysosomal fusion. However, VPS41 may function independently of this complex in the formation of insulin granules contributing to secretion of insulin, a process that is still poorly understood. The absence of VPS41 disrupts insulin regulated secretion, alters secretory granule morphology, and leads to a reduction in the number of secretory granules in pancreatic beta cells. Here we investigate how point mutations in the human VPS41 gene impact insulin secretion, HOPS complex function, and exocytosis in INS-1 cells. Notably, we found that 3 mutations (T52R, R416C, and E432K) led to a decrease in stimulated insulin secretion, and 2 of those (T52R and R416C) had no impact on HOPS function, indicating that the role of VPS41 in insulin secretion is independent of the HOPS complex. Additionally, we verified that loss of VPS41 disrupts regulated exocytosis using TIRF imaging. KO INS-1 cells, on average, had significantly fewer exocytotic events over a 1-minute period than the hWT cells did in response to glucose stimulation. Overall, these results not only add support for previous findings, but they also identify regions of interest within the VPS41 gene that should be investigated further. T52R, R416C, and E432K all reside within the GTPase-binding domain of the protein, suggesting that VPS41's role in insulin secretion may be mediated through interactions with a small GTPase. Further research should explore this possibility.

CO Releasing Organic Polymers for Biomedical Applications

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Carbon monoxide (CO) is produced in small quantities by the human body, and has proven to be an important signaling molecule (Mahan, 2012), vasodilator (Kozma et al., 1999; Johnson et al., 1995), anti-inflammatory (Motterlini et al., 2012; Otterbein et al., 2000) and tumor-suppressant. Here, we will develop a new class of polymeric carbon monoxide releasing molecules (CORMs) that efficiently release CO gas via photolysis. These CORMs will be engineered to produce non-toxic byproducts after the release of CO and are readily metabolized in the human body.

Examining Motivational Influences on Cognitive Control and Memory

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This project seeks to expand on a recent finding that cognitive control influences memory encoding (memory is better for stimuli encountered on conflict versus non-conflict trials in a cognitive control task; Krebs et al., 2015) by investigating the effect of approach versus avoidance motivation on this relationship. Motivation may have varying influences on cognitive processes depending on the type of motivational valence (i.e., reward approach versus punishment avoidance). Reward versus punishment motivation effects on cognitive performance have been associated with activity in different brain regions, but these effects typically are studied on control or memory in isolation. The effect of motivation on the relationship between cognitive control and memory encoding is currently unclear. To approach this problem, this study employs functional magnetic resonance imaging (fMRI) during performance of a behavioral task which requires participants to resolve cognitive conflict under differing motivational contexts and a follow up memory test for task stimuli. The modulation of performance on conflict tasks and subsequent memory tasks is examined in terms of activity in the brain regions of interest. fMRI findings from this study will be used in a follow-up study to target brain regions with transcranial magnetic stimulation (TMS), prior to task performance, to confirm their role in the observed differences. Preliminary analysis of the behavioral data from our first fifty participants shows that induced approach motivation decreases response time without damaging the accuracy of responses, while also improving next-day memory of stimuli. These results fit predictions based on the hypothesized mechanism of increased activation of the hippocampus via dopaminergic projections from the prefrontal cortex in potentially rewarding situations.

A Cross-Coupling Approach to Synthesis Of BEPs: Faster Access to Probe Conditions

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The Michel Group has recently reported fluorescent small molecule probes for the detection of ethylene, a hormone released during key life cycle events in plants and commonly associated with fruit ripening. To improve the sensitivity and selectivity of these probes, it is necessary to synthesize analogues and evaluate how structural changes will influence photophysical properties such as limit of detection and fluorescence turn-on. However, the previous approach to this synthesis relied on a laborious multi-step process that requires significant time and resource commitments for each new probe. To overcome this synthetic challenge, we developed a convergent synthetic approach that reacts two advanced intermediates using a Palladium (Pd)-catalyzed cross coupling. Initially, a series of coupling partners, catalysts, and reaction conditions were evaluated to optimize the cross-coupling reaction. Once conditions were favorable, a series of different substituents on the aromatic rings of the probe were tested for their influence on photophysical properties. Results indicate that structural modifications can improve the brightness of the BODIPY fluorophore, but more data is needed on how they can be used to strengthen other properties such as lowering background fluorescence turn-on and limit of detection. Overall, a convergent synthetic approach increases the accessibility of BODIPY Ethylene Probe (BEP) analogues, allowing for more rapid evaluation of these structural modifications. Additionally, the reported cross-coupling conditions are valuable to other researchers working in fluorescent probe synthesis.

Homophobia, Politics, and Public Health Protection: HIV Criminalization Law in California from 1985-1998

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Despite there being an extensive amount of scholarship on the history of the HIV/AIDS epidemic, little has been written about the history of the criminalization of HIV status. This thesis seeks to help fill that gap in the field through a study of the history of HIV criminalization in California. This project uses archival documents and newspapers to help explain how and why criminalizing legislation was put in place. Conservative legislators in California proposed criminalizing legislation under the guise of protecting public health in order to gain support. While politicians and legislators presented legislation as essential to public health protection, evidence proves that they were motivated by fears surrounding the epidemic, most specifically homophobia. Homophobia was a clear motivating factor in HIV criminalization as conservative legislators sought to have some sort of social control over high-risk groups, HIV positive individuals, and gay men in particular. Many public health officials actively objected conservative arguments, but this did not prevent legislators from achieving some level of success in their efforts to enact criminalizing legislation. This success was partly enabled by the political climate leading up to the 1988 election, as AIDS was used as a key issue in political discourse. This thesis provides ample evidence to demonstrate the different motivations and enabling factors in enacting HIV criminalization.

The Effects of Reason for Wrongful Conviction on Perceiver Stereotype Endorsement and Hiring Judgments

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The proposed work examines the effect of wrongful conviction and the reason for wrongful conviction (i.e., false confession vs. eyewitness misidentification) on employment-based discrimination. Participants will read a job application from either a) an exoneree whose conviction is attributed to false confession, b) eyewitness misidentification, or c) an individual with no criminal history before completing measures of stereotype endorsement and employment qualification. I hypothesize that stereotype endorsement and job fit impression will serially mediate the relationship between applicant condition and starting wage offered as well as hiring decision, with the false confession exoneree being evaluated more negatively than the misidentified exoneree and both exonerees being evaluated more negatively than individuals with no criminal record. The results after completing this study found that our hypothesis was partially supported. The false confession exoneree was evaluated most negatively on all dependent variables compared to the misidentified exoneree and the individual with no criminal history, which did not differ significantly. Further, we found a significant serial mediation where stereotype endorsement and job fit impression mediated the relationship between applicant type, starting wage offered, and hiring decision. A disturbing implication of our results is that there may be a reluctance to hire exonerees who falsely confessed because there may be negative stereotypes of this group and thus perceived as less hireable.

Stressful Life Event Effect on Sleep and Emotion Regulation

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High levels of stress can negatively impact both physical and mental health. Emotion regulation is critical for coping adaptively with stress. Research studies have shown that stressful events may disrupt sleep, which in turn may decrease positive affect and increase negative affect, which may be products of emotion regulation success. The relationship between perceived stress and emotion regulation has not been examined when looking at sleep as a mediator. Using a dataset examining self-reported physical health and positive and negative affect in the aftermath of a stressful life event, we will examine relationships between perceived stress, positive and negative affect (measured using the PANAS questionnaire), and sleep. We hypothesize that participants who have experienced a recent stressful life event will have lower emotion regulation success. Moreover, we predict that poor sleep will mediate the relationship between perceived stress and affective outcomes. This study will contribute to knowledge about the effects of physical health on stress and cognitive functioning, and further understanding of the importance of healthy sleep as a way of coping with stress.

Primary Caregiver, Sibling Acceptance of LGBTQIA+ Family Members

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Religion has been shown to help mitigate negative mental health outcomes by promoting positive coping styles and spiritual support (Brewster et al., 2016); however, it is important to understand potential negative impacts religion may have on the LGBTQIA+ community considering many religious beliefs labeling sexual or gender minorities as sinful (Macbeth et al., 2021). There is extensive research outlining the mental health disparities that the LGBTQIA+ community faces and explanations for the disparities. One such example is that it is estimated that 40% of the LGBTQIA+ community has been rejected by a family member or close family friend (Pew Research Center, 2021). The current study aimed to investigate how primary caregiver and sibling acceptance may predict internalized stigma and non-suicidal self-injury (NSSI) frequency within LGBTQIA+ individuals who grew up in religious households. The motivation behind this project was to contribute to improving the mental health outcomes of LGBTQIA+ individuals who grew up in highly religious households by investigating how familial support may decrease internalized stigma and NSSI. I approached this project by measuring acceptance of primary caregivers and siblings with the Family Acceptance Scale (Miller et al., 2020) and openness of the LGBTQIA+ individual with their family using the Openness Inventory (Mohr & Fassinger, 2000). Additionally, I measured the participants' internalized stigma levels with the Lesbian, Gay, Bisexual Internalized Stigma scale (Mohr & Kendra, 2011) and their NSSI frequency levels with the Self Injurious Thoughts and Behaviors revised scale (Fox et al., 2020). Results demonstrated that primary caregiver support predicted NSSI but not internalized stigma whereas sibling support predicted internalized stigma but not NSSI. This study demonstrates that family acceptance does carry weight. Moreover, having primary caregivers and sibling acceptance predicting different things may denote that there may be different mechanisms at play.

Site-Directed Mutagenesis to Characterize Manganese Binding Site of SARS-CoV-2 NSP15 Protein

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To carry out successful infection, coronaviruses must avoid detection from their host's immune system. All vertebrates infecting *Coronaviridae*, like SARS, MERS, and the novel SARS-CoV-2 (COVID-19), contain homologous versions of Nsp15, a specialized endoribonuclease enzyme that preferentially targets uridine nucleotides (EndoU) which assists coronaviruses in avoidance of the immune system throughout the viral lifecycle. Nsp15's function and activity are dependent on the divalent metal manganese, thus we investigated the potential location and biochemistry of the metal-binding site (which is currently unknown). In fact, in the absence of NSP15 coronaviruses are not viable and if the metal manganese is not present, NSP15 consistently lacks activity (Bhardwaj et al., 2004; Ancar et al., 2020; Deng et al., 2017; Kindler et al., 2017). Four amino acid residues were mutated on NSP15, three of which represent putative metal-binding sites, and the fourth catalytically dead mutant were generated using a specific Polymerase Chain Reaction technique, Site-Directed Mutagenesis. Mutated plasmids were propagated in *Escherichia coli*, cultured, and induced to produce wild-type and mutant NSP15s. Each protein was purified by Fast-Paced Liquid Chromatography (FPLC) incorporating Nickel Immobilized Metal Affinity (Ni IMAC), glutathione-S-Transferase (GST), and size exclusion chromatography techniques. Future research will focus on biochemically characterizing and determining the precise location of the manganese binding site within NSP15, which may be necessary for developing novel treatments for inhibiting SARS-CoV-2 replication among other related viruses containing NSP15.

Structure/Function Studies on the MRAP1 of *Amia calva*

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Previous studies of the N-terminal domain of mammalian MRAP1 indicated that the amino acid motifs LDYI (i.e., the activation motif), and YEYY (i.e., the secondary activation motif) are essential for facilitating the activation of mammalian MC2R, a critical component of the mammalian hypothalamus/pituitary/adrenal axis. This study tested the hypothesis that the corresponding motifs (i.e., Y¹⁸D¹⁹Y²⁰I²¹, Y¹⁴E¹⁵Y¹⁶F¹⁷) in the N-terminal of the MRAP1 ortholog of the neopterygian fish, *Amia calva* (i.e., the bowfin) are essential for facilitating the activation of bowfin MC2R, a critical component of the bowfin hypothalamus/pituitary/interrenal axis. To test this hypothesis a series of alanine-substituted mutants of bfMRAP1 were made. Alanine substitution at every position in the Y¹⁸D¹⁹Y²⁰I²¹ motif completely blocked activation of bfMC2R. Single alanine substitution in this motif indicated a gradient in the inhibition of activation: Y¹⁸ > D¹⁹ > I²¹ > Y²⁰ (percent inhibition 80% > 52% > 25% > 10%). These results confirm that the Y¹⁸D¹⁹Y²⁰I²¹ motif is the activation motif for bfMRAP1. Surprisingly, single alanine substitution at the Y¹⁴E¹⁵Y¹⁶F¹⁷ motif also completely blocked activation. Perhaps this motif is required for the structural integrity of the N-terminal of bfMRAP1. In any event, this study supports the hypothesis that bony vertebrate MRAP1 orthologs must have a δ DY δ motif in the N-terminal domain to facilitate the activation of bony vertebrate MC2R orthologs. Hence, the MC2R/MRAP1 heterodimer is a critical component of the hypothalamus/pituitary/adrenal – interrenal axis.

Ground-Air Robot Cooperative Tracking of an Adversarial Agent

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From nursing homes to war zones, losing track of someone's location can mean bad news. Keeping a close eye on someone's whereabouts is invaluable, and sometimes it is necessary. The use of security cameras or even ground robots would be ideal, however lack of control of the environment in which you want to locate people would prohibit cameras. Further, in situations where the environment is unknown or unpredictable, previous knowledge of the layout would not be available, which would be extremely challenging for a single ground robot to simultaneously navigate and track an agent. To address these challenging constraints, I created a multi-robot system composed of a ground robot capable of image-based object recognition and an agile aerial robot with rudimentary navigation and sensing capabilities. The system utilizes the object recognition capabilities of the ground robot to locate and begin tracking an agent, in our case a human, and spatially tasks the aerial robot to get within close proximity of the human to then begin tracking. When implementing this solution, I addressed multiple challenges regarding identifying and tracking a human from both ground robots' perspective and the aerial robots' perspective. I have currently addressed the challenges of the ground robot identifying and tracking a human and spatially tasking the aerial robot towards the human. Future challenges to tackle involve the aerial robot tracking the human using only rudimentary navigation and sensing capabilities. Implications include utilizing both the ground robot sensors and the aerial robot sensors to get a more accurate estimate of the true position of a human and scenarios where the human has moved to a location where it is not feasible for the ground robot to navigate to it, but the aerial robots maintain tracking of the human.

Machine Learning and Cybersecurity Applications

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Intrusion detection systems (IDS) are a specific branch of cyber-security that scans for malicious activity within a network. With the help of machine learning, a more efficient detection process can be created. Through the different combinations of neural nets, the accuracy of an IDS could potentially be optimized. The CICIDS2017 dataset was utilized to study certain cyber-attacks (DDoS, Brute Force FTP, Brute Force SSH, DoS, Heartbleed, Web Attack, Infiltration, and Botnet) by simulating certain web traffic over the course of five days. Various combinations of dense layers were used to view the changes in accuracy within this IDS. The losses and accuracy of each trial were displayed on multiple line graphs. To acquire the most efficient results, it was of the utmost importance to not design the neural network with an abundance of hidden layers. The IDS required a balance within the complexity of the network to produce superior results. This coincides with the Bias-Variance Dilemma: a tradeoff between how much predicted values differ from true values and how predictions made on the same value vary on different realizations of the model.

Saving the Sparkle: Conserving Schlumberger Jewelry and Drawings, circa. 1950-70

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The Virginia Museum of Fine Arts (VMFA) owns the largest collection of jewels, drawings, and decorative objects by French designer Jean Schlumberger in the world. His colorful, whimsical, and nature-inspired pieces remain in dazzling condition due to consistent preservation efforts by the museum's conservation staff. As a VMFA paper conservation intern in the summer of 2021, I researched the life and work of Schlumberger and performed treatments on his tracing paper drawings. Working side-by-side with conservators on this project, I learned the value of surface cleaning, washing, and properly housing art objects. These conservation treatments, among others, removed the harmful dirt, adhesives, and acids that contributed to the degradation of the drawings. Post-treatment, conservators housed the drawings and art objects in archival standard frames, boxes, or cases so that the objects maintain physical and chemical stability and patrons and researchers can enjoy them for years to come.

The Effect of Temperature on the Phenology of Fall Webworm

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As global temperatures rise, climate change is expected to have significant effects on Earth's ecosystems and insect populations. Specifically, heatwaves are starting to increase in intensity and frequency, which negatively impacts insects as insects are particularly sensitive to temperature variation. Increasing temperatures and heatwaves can affect plant-insect synchrony as well as the timing of important life-history events. The generalist insect herbivore fall webworm (*Hyphantria cunea*) is a moth species local to Colorado, and it can occur in diverse environments and feed upon a variety of host plants. It is known that fall webworm larvae can have considerable variance in their performance when reared on different host plants. It is unknown the extent to which the type of host plant affects the development of fall webworm larvae under different thermal conditions. This project investigated how fall webworm performance is affected by thermal stress (climate change) through elevated temperatures and heatwave conditions. Performance was measured by survival, development time, and pupal mass. Further, this project examined whether larval development and mortality vary depending on the type of host plant. The results suggest that increased temperatures had an overall negative effect, but that diet could mitigate these effects. Additionally, there was a significant interaction between host plant type and heatwave duration, which means that larval performance during a heatwave was dependent on host plant. This project supports the evidence that higher temperatures and heatwaves have negative effects on insect populations, but the extent may vary depending on quality of diet.

Tippling in Hotel Housekeeping

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Researchers have investigated variables associated with tipping in restaurants for decades, but few have investigated the tipping of guest room attendants (GRAs) – also known as housekeepers – in hotels. Unlike in hotel housekeeping, tipping norms in the restaurant industry are well established, and restaurant servers are visible to the guests they serve and who tip them. Typically, GRAs have no direct contact with the guests and thus are “invisible.” Given the invisibility of GRAs, they must find a unique way to “touch” guests to evoke immediacy and intimacy. In addition, since a majority of GRAs belong to a minority group, especially Latinx, it is important to investigate how race/ethnicity impacts customer tipping. My experimental design captured 316 respondents through “Centiment” and tested the relationship between multiple variables associated with tipping intentions and tipping amounts for GRAs in the context of (in)visibility as well as race/ethnicity. Generally, the results showed that there was no statistically significant difference between the tipping amounts for the white or Latina housekeeper. However, the participant’s perception of room cleanliness, feeling of empathy, and the social presence of the tent card were all associated with higher tipping amounts. When the participant felt manipulated after viewing the tent card, they tipped less, which had the highest correlation from the results. Fundamentally, my research tested the theory of social presence which has never used to bring visibility to invisible employees. Future research will hopefully expand on this theory in a similar light and add to existing findings.

Between Populism and Settler Colonialism: A US Case Study

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United States political history is a uniquely populist and settler one. While there is plenty of scholarship on populism and on settler colonialism separately, there is a significant gap in understanding how the political phenomena are connected. To begin to remedy this gap, I argue that particularly in the US political context, populist and settler colonial sociopolitical logics are both historically and theoretically interconnected. Both political phenomena are central to understanding the foundations of American socio-political life. Working in a theoretical-historical mode, I identify five ways in which settler colonialism and populism have intersected, and in the process produced a set of functions: to categorize, stigmatize, dismiss, authorize, and defy. These function reveal a mirrored internal logic to populism and settler colonialism. Using this theoretical analytic, I will then discuss four major moments of populist politics in the US: Shay’s Rebellion, Andrew Jackson’s presidency, the emergence of the People’s Party, and Donald Trump’s presidency. Ultimately, this thesis will reveal that both populist and settler colonial political logics are interdependent, foundational, and continuous features of US politics and that, therefore, populism and settler colonialism in the US context ought to be considered in tandem.

Bridging the Gap: Connecting Resources to Underserved Schools

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When I first entered as a Puksta Scholar my freshman year, I was interested in tackling the subject of mental health amongst immigrant communities. However, after spending a year working for the Denver Workforce Center as an intern, I became aware of a different need within my community. Growing up I attended a K-8 school which served many people from lower to middle income groups. However, I attended high school in a much more affluent area. This made me aware of the differences, not only in the quality of education, but in the way in which students are connected to potential opportunities and resources to better their future. I only became aware of some of the opportunities and resources available to middle and high school students after my time with the city. Job fairs, mentorship, and internship opportunities as well as summer tech camps with full scholarships and free laptops. These are tools that would have been extremely helpful to me while I was attending my previous K-8 school. Students should not feel like they cannot succeed because of their economic background. And by simply exposing students from these underserved schools to the very resources intended to support them, they may find that they are capable of more than they thought. These tools are intended to equip the youth with the tools they need to meet their future career goals and find a job they truly like and are passionate about. I am in the process of establishing a connection with my former supervisor and colleagues with the city and plan on reaching out to my old school as well (as a starting point). My goal is to host talks that share what kinds of resources are available, particularly for students about to enter high school as this could give them a strong advantage when applying for college and jobs in the future. I experienced several delays and disruptions due to the COVID pandemic but hope to move forward as circumstances continue to improve.

Modelling the Effect of Tethering on Exosome Secretion

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Exosomes are small membrane vesicles that are found inside larger vesicles called multivesicular bodies (MVBs). Exosomes contain cargo molecules which they transport between cells. This is used by many natural processes in the human body as well as some diseases. Understanding exosomal transport can help explain the mechanisms of these processes and lead to new targets for intervention in diseases. An important part of this process is the secretion of exosomes from the cells. When exosomes leave cells, MVBs fuse with the cellular membrane, exosomes are subsequently released. Recent research uncovered an interesting property of this process: the exosomes take a significantly longer time to leave the site of the MVB fusion than they would if they were allowed to move freely after the fusion. It appears that there is something that constrains their movement and holds the exosomes in place for some time. Recent work determined that one possible cause of this is due to a protein called tetherin that holds exosomes to the cell surface. In our work, we approached this slow release from the fusion site by developing a computer simulation of how exosomes move away post fusion. The simulation modelled this as diffusion, which leads to an exponential decay of number of exosomes left at the fusion site in time. Experimentally determined parameters were used to simulate the decays. The simulation was able to accurately replicate the experimental decays and determine properties of these exosomal tethers such as their lifetime, fractions of tethered exosomes and how do these properties vary with temperature. The properties suggested by the simulation can be used to more accurately describe how exosomes leave cells, which will provide insight into the mechanisms used by different diseases to propagate and a better understanding of the human body in general.

One Star, Two Star, Red Star, Blue Star: Probing the Binary Status of the Wolf-Rayet Stars WR 12 and WR 71 with Spectropolarimetry

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Massive stars lose their mass through high stellar winds which create dense circumstellar structures of dust and gas around the star. The mass and angular momentum lost from the star shapes its future evolution. In the case of massive Wolf-Rayet (WR) stars, they may show periodic variability due to rotation or interaction with an O-star or compact companion. By studying how light is scattered in their stellar winds, through time-dependent polarimetry, we can begin to constrain the geometry and mass loss process of these systems. Our team obtained spectropolarimetric data from several southern hemisphere WR systems using the Robert Stobie Spectrograph (RSS) on the Southern African Large Telescope (SALT). I analysed data pertaining to two of these systems, WR 12 and WR 71, whose binary status is not confirmed. I investigated the radial velocities of each WR star, as well as the time dependence of both continuum and line polarisation behaviour, including estimating interstellar polarisation (ISP) contributions, which have not been estimated before. The radial velocity calculations shed light on the current ephemerides for these two objects, suggesting that the ephemeris for WR 71 needs to be redefined. The continuum polarisation behaviour does not follow the expected variations based on the generally-accepted BME model for either system. The integrated line polarisation values show evidence for an elongated outer wind structure in WR 12 but not in WR 71, suggesting that the WR star in WR 12 may be a rapidly rotating potential gamma-ray burst progenitor. To better characterise the polarised emission line profiles, I developed a technique to assess the asymmetry of each profile. These results indicate large differences between emission lines of different ionic species, as well as between emission lines of same species between the two different targets. I discuss the implications of these findings in the context of the geometry and binary status of WR 12 and WR 71.

Contextual Influences on Trust: Automatic Deception Detection

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Despite the social importance of trust, studies show that humans are poor at explicitly distinguishing between when a person is lying versus telling the truth. However, people exhibit different physiological responses to lies versus truths. We propose that people unknowingly monitor their environments for deception, and such monitoring informs the degree to which those people expect others to be deceptive. Therefore, being in an environment of lies (vs. truths) would cause people to have less trust in others. We manipulated the environment by randomly assigning participants to watch videos of people (2, 4, 8, or 12) lying or telling the truth. Participants then read a paragraph about an individual (Bob) and rated how trustworthy he seemed. Participants rated Bob as less trustworthy after being exposed to lies (vs. truths), suggesting that being in a deceptive environment might make people distrustful even if they do not realize they are surrounded by liars.

A Novel Online Robot Design Research Platform to Determine Robot Mind Perception

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A common issue encountered by practitioners of Artificial Intelligence (AI) and Machine Learning (ML) is a lack of salient data to use in training. A common issue in Human-Robot Interaction is a gap in understanding how robot designs are perceived by the user. The “D U Want to Build A Bot” (Build-A-Bot) project is developing a novel robotic design research platform implemented as a web-accessible 3D game that will allow us to quickly gather many user-provided robot design examples. These examples are then used to train ML models to better evaluate robot designs, predict how a design will be perceived, and create new robot designs. It is anticipated that we use Convolutional Neural Networks (CNNs) to predict how an existing robotic design will be perceived, and Generative Adversarial Networks (GANs) to create new robot designs based on the user provided examples. This paper outlines the current and future work accomplished by an interdisciplinary student team at the University of Denver consisting of 14 undergraduate students across Computer Science, Music, Emergent Digital Practices, Psychology, and other related STEM fields that have created Build-A-Bot.

The Impact of Spermine on Alpha-Synuclein Aggregation and Cell Viability in Parkinson’s Disease

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Alpha-synuclein (α S) is a dopamine-regulating protein in the brain that can form aggregates, clusters of misfolded proteins, and cause neurodegeneration in the form of Parkinson’s Disease (PD). This research project explored the hypothesis that α S aggregates in the presence of the polyamine spermine – of which there are elevated levels in PD patients – induces toxic forms of α S aggregates and promotes cell death. With a better understanding of the interactions between naturally existing brain chemicals and the protein that causes PD, we will be that much closer to finding more effective treatments, or possibly a cure. I went about researching α S with three assays: an MTT cell viability assay, a ProteoStat aggregation assay, and immunofluorescence staining. We found that spermine can be shown to increase the level of aggregation of α S, as well as decrease cell viability, implying increased toxicity. These findings provide a new point of attack for Parkinson’s Disease research. With spermine now available as a clear target, we can work on developing other biomolecules that will inhibit the effects that spermine has on protein aggregation. These findings open the door barring a cure incrementally more, and give us a stepping stone from which to launch new hypotheses and research projects.

Financial Feasibility Analysis on Asteroid Mining

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My thesis is built around identifying key elements that are we are running out of on Earth but are found in high quantity up in space. I chose rare earth elements as they are increasing in usage on a rate of 10% per year with an already established limited supply. I then used research from Professor Elroy from the university of Carlton to identify what the cost of an autonomous self-replicating mining facility. This was then utilized to find what the return on investment would be for mining each of those elements. I then averaged the profits between all the elements and accounting for inflation and subsidies totaled the value to identify after how many years it would take for the investment to start profiting. I then came up with a second analysis based on the four most profitable rare earth elements and what the rate of return would be if they were exclusively mined. As such my analysis concluded that the year Asteroid mining would become profitable would be in 2045 which lined up with when for national security reason it would become necessary to find alternative sources of crucial elements.

Elucidating the Relationship Between Amyloid Aggregation and Inhibition of Polyamine Synthesis and Senescence in Down Syndrome Fibroblasts

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Down syndrome (DS) is a genetic condition characterized by a full or partial copy of chromosome 21 (T21) resulting in premature aging and a variety of neurodevelopmental and physical disabilities. Recent published data by others indicate that senescence-associated phenotypes in DS are linked to a global transcriptional dysregulation. The number of pathways leading to increased senescence in DS is broad and the many components involved are not well defined in their relationship with aging. Polyamines (PA), which are polycationic small molecules involved with cell proliferation, gene regulation, autophagy, and apoptosis, have been reported to be beneficial for aging. While a larger percentage of DS cells in a population becomes senescent faster than normosomic cells, we have found that they also carry a significantly increased presence of PAs. Thus, there is a lack of consensus regarding the role of PA in aging, and in this study, we investigate how PA impacts cellular senescence in DS using flow cytometry to reliably and rapidly measure levels of senescence and death. We prevented endogenous PA production through the addition of α -difluoromethylornithine (DFMO), an inhibitor for the enzyme ornithine decarboxylase, which is the rate-limiting enzyme in the PA synthesis. Next, we added exogenous PA (putrescine, spermidine, spermine) individually to investigate how each PA impacts senescence in human DS and control fibroblasts. Early experimentation showed neither PA nor DFMO alone was sufficient in altering senescence. Interestingly, when we combined DFMO with the exogenous introduction of individual PA (putrescine and spermine), senescence in trisomic cells was significantly reduced. This data describes how the altered production of PAs relates to aging and related diseases. Further dissection of the role of PAs in DS-induced cellular senescence could reveal novel therapeutic targets for altering senescence rates, a common mechanism in many age-related diseases.

Female Age-related Brain Immune Changes And Numbness

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The motivation for this project is to further understand cellular mechanisms that are responsible for Female Age-related immune Changes and Numbness. The information that is available regarding immune changes in correlation to numbness is limited; this information is even more limited for the brains of females. My project investigated how immune cells in the hippocampus region of the brain contributed to neurodegeneration over time in female rodents. The hypothesis was that increased levels of immune cells in the brain contributed to worse cognitive outcomes associated with aging. I focused on two immune cell populations, microglia and t-cells, as both can regulate brain inflammation in the hippocampus. The approach to the project was to obtain brain slices from mice, stain the slices, and quantify the amount and shape of the microglia. Viewing the microscope slide was important to visually analyze microglia and t-cells. The quantification of the microglia is still in process. Given that research would be able to find a correlation between immune changes and numbness, there could be further research about how this relationship could be mitigated to prevent aging females from experiencing increasing feelings of numbness over time.

Revealing the Structure of Wolf-Rayet Binary Systems: WR47 and WR62a

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Wolf-Rayet stars are massive highly luminous stars with incredibly strong winds. These stars often occur in binary systems with main sequence O-type stars. The interaction between the WR and O-type stars creates conic wind collision regions that rotate with the binary system. Using polarimetry to measure the polarization of the light from these stars can provide insight into how these winds interact, their shape and orientation, and what they're made of. Comparison of the polarization behavior of strong emission lines with one another and with the continuum helps determine where the lines arise and scatter within each system. The specific stars I focused on are WR47 and WR62a. I found polarimetric evidence for non-axisymmetric colliding winds in each system and derived some system parameters including their orientations on the sky and the opening angle of the shock cone in WR47. The two systems behave differently from one another and from V444 Cyg, a well studied WR+O binary of similar type.

Exploration of Cobalt Catalysts as Catalytic Chain Transfer Agents in Crosslinked Photopolymers

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This scholarship seeks to evaluate the ability of a specific set of catalysts to alter the mechanical properties of crosslinked polymers formed with light. These catalysts will be derived from inexpensive, easily prepared cobalt species and will allow control over the material's crosslinking density, material properties, and network topography without losing the positive effects of photopolymerization. Traditionally, the free-radical polymerization of methyl-methacrylate (MMA) produces a high molecular weight poly(methyl methacrylate) (PMMA) which is further processed into very hard, transparent plastic goods (e.g. Plexiglass). In the 1970s cobalt(II) complexes were shown to greatly reduce the molecular weight of the free-radical polymerizations of various methacrylate based monomers in catalytic quantities (ppm levels) to produce high viscosity liquids. To date, this catalytic technique, frequently dubbed Catalytic Chain Transfer (CCT), has only been extended to reduce the molecular weight of linear polymeric methacrylates and has not been explored in crosslinked polymers. Here, we will investigate the ability of cobalt(II) complexes to catalytically alter the material properties of crosslinked, methacrylate-based photopolymers. We anticipate that this catalytic technique will find application in dentistry and 3D printing to create plastic goods with material properties not currently accessible with commercial formulations.

How Do Quadruplexes Help Proteins Fold?

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Protein aggregation is the underlying cause of neurodegenerative disorders like Alzheimer's, Huntington's, and Parkinson's disease. Certain proteins have been found to prevent aggregation or promote folding; these are called chaperones. The Horowitz lab has shown through research with G-quadruplexes that these nucleic acids act as chaperones to decrease protein aggregation and appear to promote folding due to their structure. Based on these previous findings we looked deeper at how chaperone impacts folding structure. CD experiments showed that G-quadruplexes were able to help proteins not misfold when heated. This is a critical part in understanding how these diseases occur and can be prevented in the future. During the CD experiments, the proteins that were combined with G-quadruplex only unfolded partially, compared to fully unfolding without the G-quadruplexes. Once they were heated, CD spectra were also taken during the cooling process. From these initial experiments we found that two proteins when combined with a certain G-quadruplex were able to reform a greater degree of structure upon cooling to room temperature. These quadruplexes will be used for further research that looks into measuring their folding through activity assays. We will be focusing on the two proteins that showed the highest amount of recovered structure after heating. For a protein to be functional it needs to be in its native state. The activity assays will be able to determine how much of the protein is active and functional after heating.

Synthesis of Neopentoxy Boron Dipyrromethene Ethylene Probe-4 (Neo BEP-4) and Evaluation of its Optical Characterizations

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Ethylene is an important plant hormone responsible for plant growth and development due to which several current ethylene detection techniques have been developed but are not suitable for its detection at the cellular level. Michel Lab at DU has synthesized two pro-fluorescent BODIPY Ethylene Probes (BEP) i.e., BEP-4 and BEP-5 to quantify ethylene gas through fluorescence. These 1st gen probes, however, have relatively slow turn-on rates which limits their sensitivity. We hypothesized that varying R group attached to the chelating O atom can develop more sensitive ethylene detection probes. BEP-4 analogues such as MBEP-4 and Phenoxy BEP-4 have already been developed, but their higher reactivity with ethylene decreases probe stability. Probes with faster turn-on rates and better stability are preferred since they have an improved limit-of-detection (LOD), and many biological activities in plants respond to a low level of ethylene. Specifically, my research project is focused on synthesizing Neo BEP-4 following the synthetic route comprised of six steps. After its synthesis, this faster probe analogue will be evaluated for its quantum yield, LOD, and turn-on rates in response to ethylene gas. We predict that a neopentyl group will maintain a faster reaction rate, and the increased group size will limit probe decomposition. Additionally, this work will show the structure-activity relationship (SAR) which could be utilized to help design better and more sensitive probes.

Cadherin Conservation and Localization in Sponge Tissue (Porifera)

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Cell adhesion proteins are required to maintain the structural integrity of multicellular organisms. Cadherins are a highly conserved class of transmembrane proteins that form cell-cell adhesions known as adherens junctions. They are characterized by extracellular cadherin repeat domains that bind to other cadherin molecules and a cytoplasmic tail that is complexed with cytoskeletal proteins such as F-actin. Transcriptome sequencing in the sponge *Ephydatia muelleri* has shown that sponges express two putative classical cadherin homologs – members of the subfamily involved in homophilic adhesion at the adherens junction. Whether cadherin localization or function are conserved in sponge cell-cell junctions is unknown. Immunostaining and confocal microscopy were used to visualize cadherin localization in *E. muelleri* tissues using peptide antibodies raised against both extracellular and cytoplasmic epitopes of both expressed cadherins. Various fixation methods, as well as deglycosylation and antigen retrieval, were used to optimize antibody staining procedures. None of the antibodies labeled cell-cell junctions, but some showed differential staining patterns, labeling discrete structures (such as flagella) or cell types (migratory stem cells). Because there was no consistency between antibodies raised against different antigens from the same protein, we expect that these staining patterns are non-specific, but they may still be useful as cell-markers in future studies if their binding targets can be identified.

Therapeutic Potential of a Red Dragon Fruit, *Hylocereus polyrhizus*, Ethanol Extract in an hSOD1^{G93A} Mouse Model of Amyotrophic Lateral Sclerosis: Isolation and Characterization of Other Novel Red Dragon Fruit Extracts Enriched in Betacyanin Compounds

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Amyotrophic lateral sclerosis (ALS) is a progressive, fatal neurodegenerative disease that leads to death of upper and lower motor neurons via increases in factors like oxidative stress, neuroinflammation and dysfunctional antioxidant enzymes, amongst others. Progressive cell death results in a reduction of voluntary muscular function and eventual respiratory failure. Supplementation with natural compounds like flavonoids and other polyphenols has exhibited therapeutic effects in addressing some of the underlying mechanisms in ALS pathology. Betacyanins, a class of polyphenol, are found in high concentration in red dragon fruit (RDF) and have shown notable anti-inflammatory and antioxidant effects *in vitro*, but *in vivo* studies are lacking. The effects of RDF ethanol extract supplementation on survival, bodyweight, and motor function were assessed in an hSOD1^{G93A} mouse model of ALS. RDF flesh contains flavonoids and betacyanins, so a novel acid-base extraction of RDF was conducted and spectrophotometrically analyzed to aid in future procedures to investigate synergistic effects of these compounds. Additionally, a formic acid-ether extraction of RDF was completed with a crude purification via FPLC to determine concentration of betanin in fruit samples. LC-MS analysis was conducted in order to characterize the predominant compound(s) in all three extraction methods. Oral administration of RDF ethanol extract resulted in significant elongation of lifespan, preservation of bodyweight and increases in grip strength and motor function in treated hSOD1^{G93A} ALS mice. HPLC analysis determined relative betanin and isobetanin quantities in various extracts. Formic acid-ether extraction and purification exhibited high betanin and isobetanin yield confirmed by LC-MS analysis. Abundant deglycosylation of betanin in ethanol and acid-base extracts was confirmed via LC-MS analysis. Implications include a lack of knowledge of the actual molecular mechanisms of these polyphenolic compounds in mice, as well as the apparent degradation of betanin in the ethanol and acid-base extracts. Future experiments will address these issues.

Toxicity and Binding of TAR DNA-Binding Protein 43

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Present in many neurodegenerative diseases, specifically Amyotrophic Lateral Sclerosis (ALS), is a mutation of the protein TAR DNA-Binding Protein 43 (TDP-43). This protein is key in managing transcription of DNA and shuttling RNA through a cell. When a mutation in this protein occurs, healthy cells, specifically neurons, do not function and usually undergo apoptosis. When this occurs in the motor neurons of a patient, this causes ALS; if this occurs in the central nervous system, then Frontotemporal Dementia occurs. As such, discovering a therapeutic to target the mutation and toxicity of TDP-43 is one of the best methods to aiding patients. Before any drugs can be finalized, an understanding of TDP-43 toxicity is vital. To help characterize the disease qualitatively, toxicity is expressed and rescued using yeast as a neuronal model. After some microbiological work was done to express the toxicity of TDP-43 and the rescue capability of RNA, then biochemical work was conducted to explore the binding of TDP-43, both in dimers and RNA/DNA binding. As seen in the results, TDP-43 is seen to form a dimer, but it is still unclear where the dimerization occurs. Furthermore, TDP-43 does have binding capacity to both DNA and RNA, but further work needs to be done to create a construct of the protein that does not have a tag. Currently, the methods for producing a TDP-43 construct without a tag is currently underway, and this will help model the character of the protein.

An Exploration Of Admissions Inequalities at CU Boulder

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This project will address inequitable admissions processes in the University of Colorado (CU) system. We will focus on the low enrollment rates of low-income students in the system. Compared to public universities in other states, the CU system enrolls far fewer low-income students on average, which contributes to stagnation and generational poverty by severely limiting the educational and economic opportunities of Colorodans in impoverished communities. We will examine data from the Colorado Department of Higher Education, such as percentages of enrolled students who are Pell Grant recipients and/or come from families with combined incomes below the poverty line, to determine the extent of this disparity. Via interviews with staff and students at CU Boulder, the system's flagship institution, we will identify the enrollment barriers low-income students face and the types of supports or interventions that make college more accessible. Through this data, we will evaluate the effects of these low enrollment rates on the educational and economic outcomes of low-income students, which in turn, will help us understand how these issues should be approached through policy solutions.

The Effects of Reward Anticipation on Cognitive Control and Memory Encoding Processes: A Meta-Analysis

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Reward anticipation has been shown to influence cognitive control and memory encoding, but a wide variety of cognitive task designs have been used to investigate this relationship without being systematically accounted for when examining variability in reward effects on performance. To investigate effects of reward anticipation across both cognitive control and memory domains, and the influence of varying task paradigms and design elements within these domains, we are conducting a meta-analysis. Specifically, studies were extracted from the databases of Pubmed, Psycinfo and Web of Science. The search resulted in 124,905 studies. After removing duplicate studies and screening the titles, abstracts, and full texts against specific criteria (i.e., participant age), 161 studies remain. Of the remaining studies, 98 examine the effect of reward anticipation on cognitive control while the other 63 studies examine the effect of reward anticipation on memory encoding. The effect of the interaction between reward (high vs. low reward or high vs. no reward) with cognitive control or memory performance is currently being extracted from each study, along with specific design element data (i.e., time between reward cue and target presentation). The data will be inputted into the meta-analysis software "R" to determine the significance of the reward with cognitive control and the reward with memory performance interactions. We will then investigate how different task design elements may act as potential moderators affecting the strength of the relationship between reward and task performance. This research is the first of its kind using a meta-analysis approach to systematically quantify reward anticipation effects on cognition across both cognitive control and memory domains.

Discovering New Zinc Permeable Ion Channels

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Zinc is crucial to all living organisms as well as the second most abundant element in the environment. Zinc has been found to carry out many essential functions in the body and biological processes—ultimately, it functions as a signaling molecule for intercellular and intracellular processes including catalytic and structural pathways. Homeostasis of zinc is important to understanding how the molecule goes about physiological and pathological functions as it is strictly regulated in all aspects of the body from the cellular level up. Using the Qin lab's GZnP3 sensor, zinc can be recorded in nanomolar ranges, offering a better understanding of which ion channels are truly permeable or not. Here, the TRP family is tested using a baseline, zinc addition, and agonist to supposedly open up the ion channels for zinc to flow through. This has proved successful in many of the Trp channels explored and can lead to future work, include following zinc through homeostasis to understand the mechanisms behind it.

Peer Support Buffering for Post-Institutionalized vs Non-adopted Children on Psychosocial Outcomes

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The project aims to understand whether peer functioning can help to reduce the negative outcomes of early life stress in the form of institutional (e.g., orphanage or hospital) care. Previous research suggests that early life institutional care is considered an early life stressor due high risk for social, physical, and emotional deprivation (Maclean, 2003). Although it is known that high social support is associated with better social and emotional outcomes for teens, there is some evidence that youth adopted from institutions may not receive the same physiological benefits from social support as non-adopted teens raised in their biological families (Hostinar et al., 2015). However, the effectiveness of peer support on emotional and behavioral outcomes for post-institutionalized youth has rarely been explored. As a result, the current study examines whether peers can buffer from negative socioemotional and academic outcomes following stress. To investigate, 50 post-institutionalized adolescents, 33 non-adopted adolescents, and their primary parent came into the lab to answer a series of questionnaires. Parents and adolescents provided information about the number of negative life events in the past 12 months, peer functioning, and internalizing symptoms, externalizing symptoms, attention-deficit/hyperactivity disorder (ADHD) symptoms, and academic functioning. Overall, PI youth reported greater internalizing, externalizing, and ADHD symptoms, and poorer academic functioning. Greater peer functioning predicted lower internalizing symptoms and greater academic functioning. There was no evidence that peer functioning was less effective in reducing emotional and behavioral problems in the context of life stress for PI youth. The results suggests that future research should focus on how to support post-institutionalized youth and how to strengthen peer relationships to improve emotional and behavioral outcomes.

Trade Liberalization and the Social Determinants of Health: A Case Study of NAFTA's Impact on Mexico from 1994 to 2005

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Given the increased transnationalization of borders and economic interdependence between countries in the Global North and South, it is imperative to address how these trends impact the health and well being of the populations involved. The conventional neoliberal economic framework, however, falls short in explaining these dynamics due to its overemphasis of proximal determinants of health as direct consequences of commodification and free market activities. In congruence with those theoretical limitations, there is a limited assessment of more distal determinants – the social determinants of health (SDOH) – that are arguably more consequential for health and are interrelated with the dynamics of political economies. The relationship between trade liberalization and SDOH, therefore, deserves greater examination through said framework. This thesis seeks to address the aforementioned gaps by assessing the impacts of trade liberalization on SDOH within a case-study analysis of the North American Free Trade Agreement (NAFTA) and its impact on Mexican SDOH pathways in the period between 1994 and 2005. I identify three SDOH pathways for the analysis of NAFTA: employment, regulation, and agricultural commerce. By analyzing the intended impacts of NAFTA and Mexican policies, the quantitative primary, and the qualitative secondary data of the actual outcomes, I find that NAFTA's impact on SDOH was incredibly nuanced. The agreement produced mixed outcomes on an aggregate basis, but poorer outcomes for specific groups of people. But, the ultimate conclusion of this analysis is that the true impact of trade liberalization on SDOH cannot fully be examined in isolation, for each SDOH factor is inextricably linked with the other and is broadly interrelated with the domestic and global political economies. These findings have implications for further research in identifying SDOH as variables of concern within theories of political economy, as well as variables of concern for future trade and development policies.

Priming pain expression intensity influences intent to seek physical health-care

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Increasing help-seeking behavior is extremely important as healthcare avoidance is associated with poorer healthcare outcomes (e.g., progression of cancer, worsening symptoms) (Taber et al., 2015). Previous work suggests healthcare avoidance may be associated with socialized norms (McDermott et al., 2018). Indeed, endorsement of masculine norms like restrictive emotionality (RE) predicts lower intent to seek help (Himmelstein & Sanchez, 2016). In two studies the current work examines the role pain expression and social norms play in self-reported intent to seek care. In Study 1 participants ($N = 128$) were randomly assigned to one of two pain expression conditions: exaggerated and suppressed. Participants then watched four 5-second-long videos of the same targets (two men, two women) experiencing pain. Conditions differed only in intensity of expression (i.e., exaggerated or suppressed). Afterwards, participants self-reported on a measure of trait RE. Participants subsequently self-reported their intent to seek care for common symptom arrays observed in emergency medicine (Weis et al., 2014). In Study 2 we aim to replicate Study 1. However, in Study 2, we test an alternate mediator (endorsement of RE norms), introduce a control condition, employ a larger stimulus set (20 targets), and recruit a larger sample (planned $N = 200$). Other aspects of the design will mirror Study 1. In Study 1, participants who viewed exaggerated (compared to suppressed) pain expressions subsequently reported greater intent to seek care ($p = .031$, $d = .48$). In Study 2, we will conduct a one-way ANOVA and mediation analysis to examine similar questions to Study 1. We predict participants in the exaggerated condition will express greater intent to seek care than those in the control condition than those in the suppressed condition. Taken together, these studies further our understanding of healthcare avoidance, pain disclosure, and emotional expression norms.

Vietnamese Diaspora

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Post-Vietnam war, hundreds of thousands of Vietnamese people migrated to the United States in order to escape political persecution and/or pursue the “American Dream.” Using still photography and video, my project will document the experiences of many Vietnamese-Americans, pre- and post-migration, to the US. The project will revolve around portraying the stories of the Vietnamese culture and migration as an American story – not an international one. I was compelled to start this project as an exploratory exercise through photography and videography; on top of this, I am a first-generation Vietnamese-American and wanted to learn more about my family’s history and community. For my project, I will concentrate on the substantial Vietnamese community in Denver – specifically my family’s story. My process will be to utilize photographs and a documentary as a means to encourage sharing life experiences. So far, with this project, I have been compiling a three-part documentary and a complete photo collection of my grandparents’ story and their motivations for moving here to America and how that has affected their lives thus far. My grandparents moved here to the U.S. 25 years ago and have been fostering the family that I am surrounded by today. Through this project, I have learned a lot about our family’s history – from political prosecution in Vietnam to my grandpa dealing with depression over here, I have understood my family’s history more than I have ever understood before. I hope to be able to continue this project and finish up the documentary when summer comes.

Interconnectedness with Nature and Human Emotional Response to Biodiversity

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Previous research has found that perceived interconnectedness with nature is associated with positive mental health and well-being. I tested the idea that self-nature interconnectedness is related to the degree to which nature affects human well-being using photos of riparian sites containing native and non-native vegetation, the latter mainly in the genus *Tamarix*. *Tamarix* has been a major focus of restoration activities in riparian systems in the southwest region of the United States. There is rising concern about the effects of aesthetic and biodiversity on human perceptions of the restoration, as well as human psychological well-being. Previous research has found that perceived biodiversity is positively correlated to its effect on mood; I tested the hypothesis that this impact of biodiversity would be dependent upon how connected to nature a person feels. To test my hypothesis, we collected data from students at the University of Denver using an online survey in which participants were asked to rate the attractiveness and biodiversity of a series of images. I used the Inclusion of Nature in Self (INS) scale to cognitively measure and quantify the participant’s self-nature interconnectedness and the Positive Affect-Negative Affect Scale (PANAS) as a measure of participant mood pre- and post-survey. I found that rather than biodiversity, it was the participants own connection with nature that was associated with mood change, with more connected people having a positive mood shift and less connected people having less or even negative changes in mood over the course of the survey. These findings will help inform health care practitioners, ecologists and conservation biologists about how nature affects the human populations surrounding an ecosystem.

The Wolf's Bite: Investigating The Shapes Of Colliding Wind Regions In Wolf-Rayet Binary Star Systems

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Wolf Rayet (WR) stars are a type of evolved star at the end of its life that is shedding large amounts of mass from its outer layer. Sometimes, these stars form binary systems with very large main sequence stars, which cause even more gas from the WR star to be shredded. This interaction is thought to be the cause of the catastrophic cosmic gamma ray burst (GRB) events, where gamma rays, the most energetic form of the electromagnetic spectrum, are shot out across extreme distances. This explosion can depend on how much mass is being lost by the object, which can be discovered by examining the interaction between the two stars in the binary, particularly the gas being shed by the WR partner. The polarization of light coming from these systems is a great way to examine the various behaviors and qualities of different binary objects. That was the goal of this project, where I examined the object WR21 and WR31 in detail. I did this by using data our research team had collected from the RSS Spectropolarimeter located at the SALT observatory in South Africa. Then, using the coding program Python, I was able to examine the polarization of different lines throughout the orbital period that showed up in the spectrum (corresponding to what elements were present). I was able to examine various spectral lines of interest, such as C IV at 5805 angstroms and N IV at 7125 angstroms, and to see how these emission lines behaved differently from the continuum and to locate which place in the system they formed. From this, further analysis can be conducted to examine if the mass loss of this particular object is enough for it to be a GRB progenitor.

Childhood Experiences and Future Expectations During the COVID-19 Pandemic

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The current work investigates whether adverse childhood experiences (ACEs) and benevolent childhood experiences (BCEs) are associated with predictions of emotional states (affective forecasting) and future events (event prediction) during the COVID-19 pandemic. We hypothesized that higher ACEs and lower BCEs would independently be associated with predictions of a longer pandemic duration and more negative affective forecasting. We predicted the association between ACEs and predicting a longer pandemic and more negative affective forecasting would be weaker for individuals with higher BCEs than those with lower BCEs. Participants were undergraduate and graduate students (N = 502) who completed online questionnaires in May 2020 about mental health, the COVID-19 pandemic, and childhood experiences. Results indicated that BCEs were associated with forecasting of more happiness, less stress, and less loneliness. ACEs were not associated with affective forecasting. For those with less childhood adversity, an increase in benevolent childhood experiences was associated with predictions of a faster return to normal from the pandemic. While, among those with more childhood adversity, an increase in benevolent childhood experiences was not associated with predictions of faster return to normal from the pandemic. Our findings suggest that the number of BCEs may be more associated with predictions about the future than ACEs. Additionally, the number of BCEs may play an important role in influencing whether an individual potentially reacts to a major stressor with more optimism.

Environment, Endocrine Function and Embryos: How Exposure to Environmentally Compromised Regions Impact Critical Steps of Human Development and the Disproportionate Impacts of these Effects on the Global South

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Endocrine disrupting chemicals or EDCs are chemical compounds that interfere with the functioning of the endocrine system; a feedback loop of hormonal compounds released by the human body to regulate system functioning. This ranges from support for mood/emotions, development, growth, and plays a critical role in the development of human life. Through the context of pregnancy, hormones such as progesterone and oestrogen experience large fluctuations in their levels, and the placenta, a critical organ for a healthy pregnancy, functions as a temporary endocrine gland throughout the duration of gestation. The delicate balance of hormones from the pregnant individual to the developing embryo is essential to ensuring healthy psychological and physiological development. However, as our planet and our environment continue to become more polluted and shift into more extremes, these particularly specific and rather sensitive hormonal pathways of communication can be easily disrupted, compromising the ability for mother and fetus to transmit information, and creating potential increase of risk for subsequent issues in the time between fecundation through birth and onward. Toxic chemical exposures through air, soil, and water pollution, utilizations of endocrine disrupting materials such as specific plastics, textiles and personal care products, and other sources of contact to EDCs can all facilitate these disturbances. Through this paper, the effects of these exposures through the sensitive windows of pregnancy will be explored, as well as recognizing the disproportionate impact of these exposures on the global south from both a frequency and rate of EDC protection/production standpoint. Finally, an argument for the significance of these impacts paired with the lack of research surrounding these issues will be made, and advocacy will be done to support the notion that these issues should be further investigated.

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