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Dear Reader,

Some may view undergraduate research as simply the contribution to an existing body of literature by undergraduate students; I disagree. While this is partially true, it neglects what makes undergraduate research so critical to the academic community and to the authors themselves – opportunity. As a student myself I have experienced, and seen in those around me, the desire to enter the world of professional research for academic, professional, or personal gain. The mission of DUURJ is to recognize and celebrate that desire.

Throughout this journal, you will find a variety of work from nearly all facets of undergraduate research. The works include mechanical properties of cardiac and arterial tissue, analyses of gender diversity in the workplace, the use of postfeminist literature for analysis in a modern case study, insights into honor culture and sexual violence against women in Yemen, carbon sequestration in peatlands, the origins of Colorado statehood, research in drosophila neuromuscular junctions, studies of identities in modernity, and media conservation strategies. This is followed by an interview with Dr. Scott Montgomery, an esteemed professor in the School of Art and Art History. Finally, it concludes with a series of abstracts representing other undergraduate work done at the University of Denver.

This year the journal has made many changes, the foremost being a move from biannual to annual publication. This allowed us to spend more time on training for our team and a much longer editorial process, benefitting our editors and authors. We were able to work closely with the Writing Center, Research Center, and members of DU administration to help better prepare our incoming editors, streamline our existing processes, and create an overall better publication. This did not come without its complications as we had to completely restructure how both trainings and editorial processes ran without a model to look to. Many members had to take on roles they did not anticipate, but did so with grace, skill, and resilience.

Each and every member of the editorial team has made a significant and substantial contribution to this journal, and the success of this publication lies in their work throughout the year. While we differ in background, experience, academic year, and personal passions, we are united by one common desire – to help support you, our fellow students. Throughout this year, there has been nothing more impressive than watching the team's growth, personally and professionally. To our editors, I say this – be proud in what you have accomplished, proud of what you have learned, and proud in taking your first step – to whatever goal that may be.

If there is one message that I can emphasize, it is to seize opportunity, and hold on with all your might. Take your first step and do so boldly. Take pride in your accomplishments and learn from your failures. While reading this journal, try and see each article and artwork not just as well defined, significant, and respected research and art, but as a statement to the bravery and desire of each author and artist showing their passion to the world, building their own capabilities, and taking their first step towards greater goals.

Thank you,

Joseph Sniezek

Joseph Sniezek
Editor in Chief



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Passive Mechanical Properties of Cardiac and Arterial Tissue: A Paired Comparison Study in a Calf Model

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Abstract

Purpose: The mechanical behavior of heart tissue plays a crucial role in elucidating cardiac physiology and pathophysiology. Accurate measurement of the mechanical properties of cardiac and arterial tissues is indispensable for advancing computer simulations and developing medical devices. This study aimed to assess the passive mechanical properties of cardiac and arterial tissue in a calf model using a paired comparison method.

Methods: A planar biaxial stretching device was used to determine the mechanical characteristics of 84 square specimens obtained from 14 different anatomical regions. Cauchy stress-Green strain curves were constructed for each anatomical area, and a Fung-type constitutive model was applied to fit the raw data. The strain energy and anisotropy index were subsequently calculated.

Results: The experimental results indicated that all tissue specimens exhibited nonlinear responses to biaxial stress. Comparison based on the magnitude of the strain energy function revealed that the aorta showed the highest strain energy, followed by the left ventricles, pulmonary artery, right ventricle, left atrium, and right atrium, respectively. Among the different areas, the left ventricle displayed the highest level of tissue anisotropy. These observations align with previous investigations on human heart tissue.

Conclusion: We comprehensively characterized the mechanical behavior of various heart chambers and significant arteries using rigorous quantitative analysis. The outcomes of this research provide valuable insights for advancing our understanding of heart physiology and exploring potential therapeutic approaches for cardiovascular diseases.

Keywords: *Passive Mechanical Properties, Planar Biaxial Testing, Cardiac and Arterial Tissue, Anisotropy*

LIST OF ABBREVIATIONS

LVA: Left ventricle anterior
LVP: Left ventricle posterior
LVL: Left ventricle lateral
LVS: Left ventricle septal
RVA: Right ventricle anterior
RVP: Right ventricle posterior
LAA: Left atrium anterior
LAP: Left atrium posterior
RAA: Right atrium anterior
RAP: Right atrium posterior
AA: Aorta anterior
AP: Aorta posterior
PAA: Pulmonary artery anterior
PAP: Pulmonary artery posterior

1 INTRODUCTION

Understanding how heart and artery tissues respond to force is crucial for comprehending their normal function within physiological contexts. Changes in soft tissue mechanical properties, which are demonstrated by how tissues handle loading, can contribute to cardiovascular diseases. Investigating these mechanical properties is essential for developing effective treatments and interventions. Biological tissues exhibit complex mechanical behavior, necessitating the consideration of various structural responses, such as nonlinear stress-strain relationships, mechanical anisotropy (the directional dependence of mechanical properties within soft tissues), and viscoelasticity (time-dependent mechanical properties displaying both viscous and elastic behavior)¹. It is essential to develop robust constitutive models to accurately model and understand these tissues for physiological, diagnostic, and therapeutic applications. Early investigations primarily relied on uniaxial tensile tests^{2,3}; however, due to the mechanical anisotropy of cardiac and arterial tissues, uniaxial data is inadequate for parameter estimation of three-dimensional constitutive models as it focuses solely on one direction. Soft tissues, in general, exhibit anisotropic mechanical behavior, which varies in three dimensions based on the tissue's location in the body. Biaxial tests have been used successfully for parameter estimation of nearly incompressible materials, including biological tissue, where thin sections can be obtained or prepared^{4,5,6,7}. In addition, triaxial testing systems have been employed to investigate the mechanical properties of biological tissue under a multi-axial stress state^{8,9,10}. The triaxial tests can provide a comprehensive data set for the characterization of thick-walled organs. However, the availability of triaxial equipment is limited, and the mounting of tissue is challenging. These advanced testing methodologies offer superior physiological relevance and provide crucial direction-dependent mechanical information about the tested specimens.

The mechanical properties of cardiac and arterial tissues are essential for their proper functioning and are intimately linked to various pathophysiological conditions (e.g., heart failure, aortic aneurysm, aortic dissection, etc.). Despite their identical embryonic origin, the mechanical properties of cardiac and arterial tissue undergo dynamic changes throughout growth and adulthood. Prior studies have primarily examined specific anatomical regions, necessitating additional research to comprehensively characterize the mechanical properties of all heart chambers and major arteries using a paired-matched analysis. This comprehensive understanding of mechanical behavior has significant implications for designing innovative medical devices and assessing treatment modalities for cardiovascular diseases. In this study, we employed a calf model to quan-

titatively assess the passive mechanical properties (i.e., response to mechanical forces without active muscle activation) of cardiac and arterial tissue. The calf model was chosen due to its similarity to the human heart regarding functional characteristics and established use in device-related investigations, such as left ventricular assist devices¹¹. Our goal was to comprehensively characterize the mechanical behavior of various heart chambers and significant arteries using quantitative analysis.

2 MATERIALS AND METHOD

2.1 Biaxial Testing Sample Preparation

Six fresh healthy calf hearts were purchased from a nearby slaughterhouse on harvest morning and frozen at -20°C for later analysis. The hearts were thawed in a 37°C water bath before testing. The left and right ventricles were cut open, and thin slices were obtained from the middle layer of the ventricular free wall using a commercial meat slicer (Chef'sChoice Model 632 Gourmet Electric VariTilt Food Slicer, Avondale, PA, USA). Square specimens were excised from six anatomical regions:

1. Left ventricle anterior (LVA), posterior (LVP), septal (LVS), and lateral (LVL),
2. Right ventricle anterior (RVA) and posterior (RVP),
3. Left atrium anterior (LAA) and posterior (LAP),
4. Right atrium anterior (RAA) and posterior (RAP),
5. Aorta anterior (AA) and posterior (AP),
6. Pulmonary artery anterior (PAA) and posterior (PAP).

Samples from the heart chambers were cut so that the edges were parallel and perpendicular to the predominant fiber direction as judged by the eye. Samples from the aorta and pulmonary arteries were cut so that the edges were parallel and perpendicular to the circumferential direction of the arteries. By testing in both the fiber and cross-fiber directions, we can gain a comprehensive understanding of the tissue's anisotropic mechanical behavior under different loading conditions. A digital caliper (Mitutoyo Model 500-754-10, Aurora, IL, USA) measured sample thickness and length. Following the measurements, the specimens were stored in a phosphate-buffered normal saline solution (Research Products International, Mount Prospect, IL, USA) at 37°C.

2.2 Biaxial Testing System

The mechanical characteristics of the specimens were assessed using a two-dimensional (planar) biaxial test system (CellScale BioTester, Waterloo, ON, Canada). The steps involved in the biaxial testing protocol have

already been described by Javani et al.⁷. Briefly, the samples were mounted on the CellScale BioTester equipped with four high-performance actuators to move the arms, along with two inline load cells (Honeywell Load Cells Model 31, Columbus, OH, USA). To mimic physiological conditions, the samples were completely immersed in a normal saline bath at 37°C. Graphite powder was also added to the top surface of tissue samples to track tissue deformation with a camera mounted on the top at a rate of 15 Hz. The load cells were zeroed before loading started. Then, the specimens underwent ten cycles of 10% equi-biaxial strain at 0.5 Hz as a preconditioning procedure. Subsequently, each sample underwent an equi-biaxial strain of up to 50% with a 4 s stretch and a 4 s recovery duration. After the biaxial testing, the deformation of the specimens was obtained using CellScale LabJoy image tracking software.

2.3 Constitutive Modeling

The specimens were assumed to be incompressible because soft tissue is mostly composed of water¹². Cauchy stresses (T_{11} , T_{22}) in the fiber and cross-fiber directions were calculated from planar forces (F_{11} , F_{22}) obtained by the two load cells. Cauchy stress represents the force per unit area acting on a surface within a deformable body.

$$T_{11} = \lambda_1 \frac{F_{11}}{t_0 l_0}, \quad \text{and} \quad T_{22} = \lambda_2 \frac{F_{22}}{t_0 l_0} \quad (1)$$

where t_0 signifies the tissue the initial thickness and the stretch ratio = $\frac{l}{l_0}$ of the deformed tissue l to the length of the tissue at rest l_0 . Using the following equations, elements of the green strain tensor (E) were determined:

$$E_{11} = \frac{1}{2}(\lambda_1^2 - 1) \quad \text{and} \quad E_{22} = \frac{1}{2}(\lambda_2^2 - 1) \quad (2)$$

Green strain is a measure of deformation in the material. The stress-strain data were fitted using a four-parameter Fung exponential strain energy function¹³.

$$W = \frac{C}{2}(e^Q - 1), \quad Q = c_{11}E_{11}^2 + 2c_{12}E_{11}E_{22} + c_{22}E_{22}^2 \quad (3)$$

E_{11} and E_{22} signify the green strains in the x and y directions, correspondingly. Additionally, c_{11} , c_{22} , c_{12} , and C present the material coefficients. The Fung strain energy function is a mathematical model commonly used to describe the hyperelastic behavior of soft biological tissues. Cauchy stresses were found using the following equations:

$$\begin{aligned} T_{11} &= \frac{1}{2}(c_{11}E_{11} + c_{12}E_{22})Cexp(Q) \\ T_{22} &= \frac{1}{2}(c_{12}E_{11} + c_{22}E_{22})Cexp(Q) \end{aligned} \quad (4)$$

A Levenberg-Marquardt least squares algorithm in MATLAB software (Natick, Massachusetts, USA) was

used to fit the strain energy function to the experimental data.

Although the arm displacement rates for the circumferential and longitudinal directions were equal, the strain applied to the specimen's center was not exactly equivalent due to the tears in the tissue began to form and spread at the borders where the tungsten wires were fastened. As a result, the following stress-strain correlations in the equi-biaxial strain state were found:

$$\begin{aligned} T_{11}^{equi} &= (2E + 1)E(c_{11} + c_{12})Cexp[(c_{11} + c_{22} + 2c_{12})E^2] \\ T_{22}^{equi} &= (2E + 1)E(c_{12} + c_{22})Cexp[(c_{11} + c_{22} + 2c_{12})E^2] \end{aligned} \quad (5)$$

where the equi-biaxial condition was indicated by the superscript *equi*. Moreover, tissue anisotropy was calculated using the difference in material coefficients between the two orientations as follows:

$$K = \frac{2|c_{11} - c_{12}|}{(c_{11} + c_{22} + 2c_{12})} \quad (6)$$

2.4 Data Averaging and Statistical Analysis

The proper method for computing the nonlinear material characteristics of biomedical materials is curved averaging instead of coefficient averaging¹⁴. As a result, Cauchy stresses at evenly spaced intervals of strain were obtained using Equation 5 to create average curves for each anatomical region. All statistical analyses were carried out in IBM-SPSS 2022 software, and all values were reported as mean \pm standard deviation (SD). A p -value less than 0.05 was considered significant for these values. The Shapiro-Wilk test was carried out on each model to check normality¹⁵. A paired-sample t -test was carried out for normally distributed groups. Additionally, a one-way ANOVA followed by a Games Howell post hoc test were used to compare strain energy values among three groups. A non-parametric Wilcoxon test was used for non-normally distributed groups.

3 RESULTS

A planar biaxial stretching device was used to determine the mechanical characteristics of 84 square specimens obtained from 14 anatomical regions. The average length and thickness of the specimens are presented in Table 1a. In addition, the experimental raw data, representing the biaxial stretching of tissue specimens from the aorta and pulmonary artery, are depicted as Cauchy stress–Green strain plots in the circumferential and longitudinal directions in Figure 1. Figure 2 presents the stress–strain response of tissue specimens from the left and right atria in the fiber and cross-fiber directions. Figure 3 also displays the Cauchy stress–Green strain plots

obtained from the left and right ventricles in the fiber and cross-fiber directions. In these figures, the y-axis represents Cauchy stress, which measures the internal forces acting within a material when subjected to external force, while the x-axis represents Green strain, which measures the deformation occurring within a material when subjected to stress. It is important to note that all regions exhibited a nonlinear response to strain during the testing protocol.

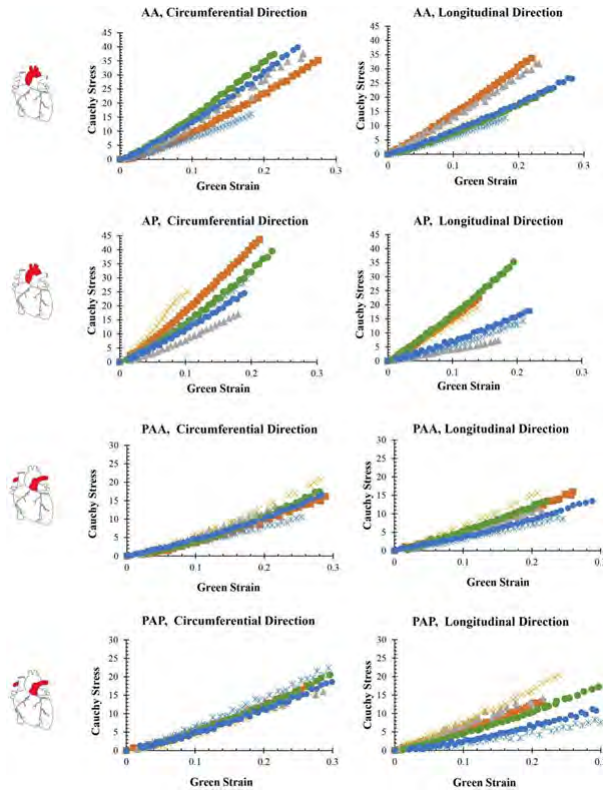


Figure 1. Cauchy stress (KPa)-Green strain data for tissue specimens obtained from anterior and posterior sides of the aorta and pulmonary artery in circumferential and longitudinal fiber directions (six samples represented by distinct colors).

The Fung strain energy function was employed to fit the Cauchy stress-Green strain data for each sample, resulting in the determination of material coefficients. The specific coefficient set for each tissue specimen is provided in the appendix section. Figure 4 illustrates the equibiaxial stress-strain curves for specimens obtained from the anterior and posterior sides of the aorta and pulmonary artery, along with the average curve. Similarly, Figure 5 presents the equibiaxial stress-strain curves and average curves for specimens obtained from the left and right atria. Figure 6 depicts the equibiaxial stress-strain curves and average curve for samples obtained from the left and right ventricles. In these figures, solid lines represent the actual experimental results, while the dashed line corresponds to outliers with stress values exceeding the average stress plus

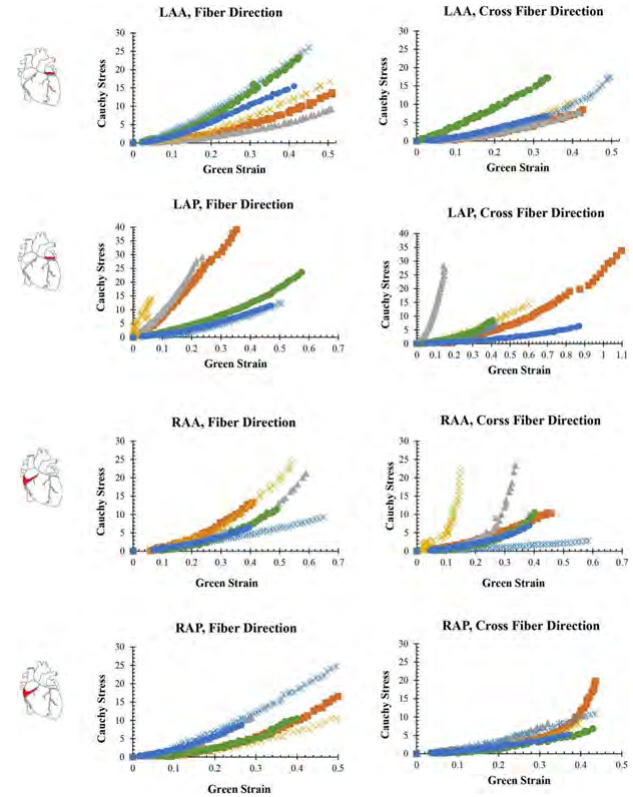


Figure 2. Cauchy stress (KPa)-Green strain data for tissue specimens obtained from anterior and posterior sides of the left and right atria illustrating the effects in fiber and cross fiber directions from both anterior and posterior sides (six samples represented by distinct colors).

three times the standard deviation.

To quantitatively assess and compare the passive mechanical properties of the anatomical regions, the magnitude of strain energy was calculated for all the specimens at equibiaxial strains of $E_{11} = E_{22} = 0.10, 0.15$, and 0.20 . Table 1b presents the mean value and standard deviation of strain energy for each anatomical region. Strain energy refers to the potential energy stored within the specimen when undergoing deformation under applied loads. The comparison between different anatomical regions was conducted in two steps. Firstly, the anterior and posterior portions of all anatomical regions were compared together (for the left ventricles, the lateral and septal sides were also included in the statistical analysis). Secondly, each anatomical region from the left side of the heart was compared with the corresponding region from the right side.

Figure 7A summarizes the statistical analysis, presenting the mean and standard deviation of strain energy storage at a strain of 0.15 . A one-way ANOVA test was performed to compare the strain energy of different regions of the left ventricles, namely the anterior, posterior, lateral, and septal regions. The analysis indicated no statistically significant difference in strain energy storage between the different portions

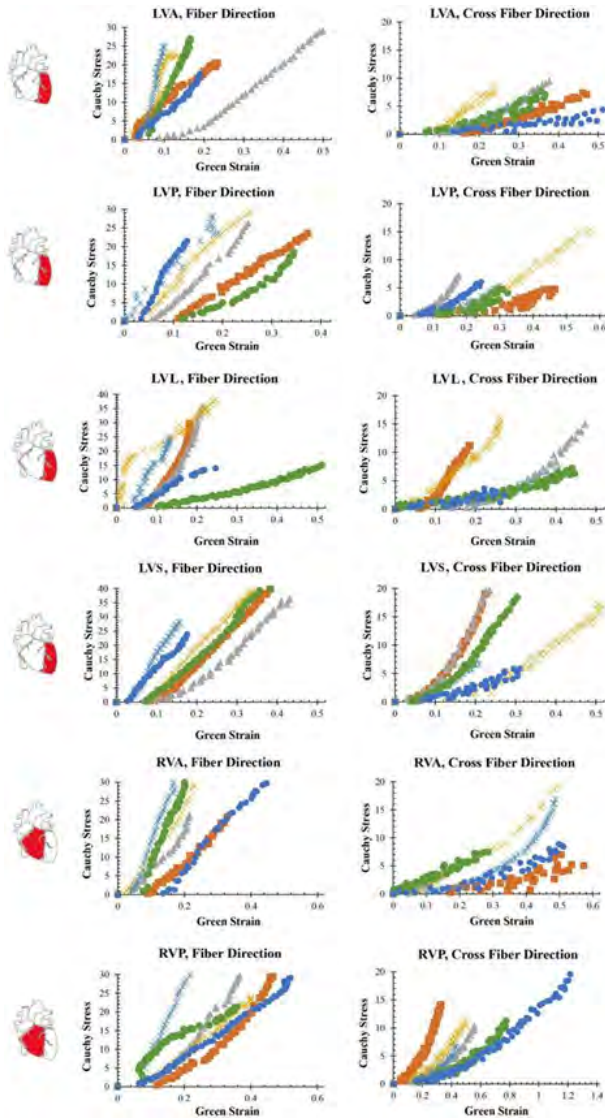


Figure 3. Cauchy stress (KPa)-Green strain data for tissue specimens obtained from the left and right ventricles illustrating the effects in fiber and cross fiber directions (six samples represented by distinct colors).

($df = 3$, Mean Square = 0.089, $F = 0.288$, Sig. = 0.833). Furthermore, paired sample t-test and Wilcoxon test were conducted to compare the strain energy storage between the anterior and posterior portions of the left atrium and aorta. The results revealed no statistically significant difference in strain energy storage between the anterior and posterior portions ($p = 0.278$ and $p = 0.345$, respectively). Additionally, a comparison was made between the three anatomical regions on the left side of the heart: the left ventricle, the left atrium, and the aorta. Data from the anterior and posterior portions of the anatomical regions were averaged into one representative dataset for each region (including the lateral and septal sides of the left ventricles). The statistical analysis showed no significant difference in strain en-

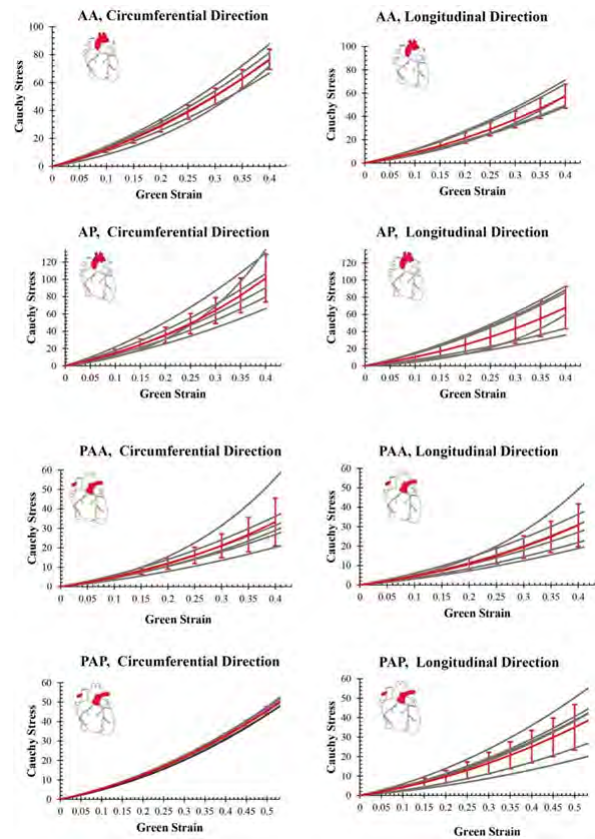


Figure 4. Equibiaxial stress (KPa)-strain curves and the average curve (presented in red) for specimens obtained from the anterior and posterior sides of the aorta and pulmonary artery considering circumferential and longitudinal directions.

ergy between the left ventricles and left atria ($p = 0.142$). However, there was a statistically significant difference in strain energy storage between the left atria and the aorta ($p = 0.001$), as well as between the left ventricles and the aorta ($p = 0.014$).

Figure 7B illustrates the statistical comparison between the regions of the right heart. The paired sample t-test and Wilcoxon test results indicated significant differences in strain energy between the anterior and posterior portions of the right ventricles ($p = 0.046$). However, the differences between the anterior and posterior portions of the right atrium and the anterior and posterior portions of the pulmonary artery were not statistically significant ($p = 0.463$ and $p = 0.355$, respectively). Data from the anterior and posterior parts of the anatomical regions were averaged into one representative dataset for each position. The paired sample t-tests were conducted to statistically compare the groups. The results revealed significant differences between the right ventricles and right atrium ($p = 0.017$), significant differences between the right atrium and pulmonary artery ($p < 0.001$), and no significant difference between the right ventricles and pulmonary artery ($p = 0.3$). Furthermore, Figure 7C presents the t-test comparison between

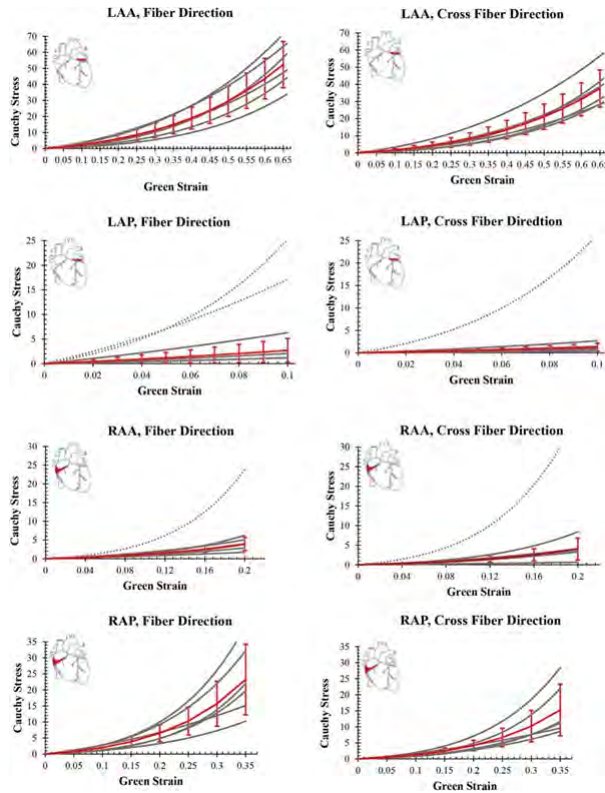


Figure 5. Equibiaxial stress (KPa)-strain curves and the average curve (presented in red) for specimens obtained from the anterior and posterior sides of the left and right atria, with solid lines representing experimental results and dashed lines indicating outliers.

the corresponding areas on the left and right sides. The left and right ventricles showed no significant differences ($p = 0.068$); however, the left atrium and aorta showed significant differences ($p = 0.046$), and the aorta and pulmonary artery showed significant differences ($p < 0.001$).

Lastly, the anisotropy index (K) was determined using Equation 6 which quantifies the degree of directional dependence of the physical characteristics. This index is particularly relevant for fibrous tissues as they exhibit a certain orientation of tissue fibers that leads to directional certainty in their mechanical characteristics¹⁶. When the K value is 0, the material has the same properties in all directions, indicating isotropy. A K value greater than 0 indicates some level of anisotropy, with higher values indicating higher anisotropy. Table 1c presents the average and standard deviation of tissue anisotropy for all the anatomical regions. It was observed that the left ventricles had the highest K value ($K = 1.451 \pm 0.289$) while the pulmonary artery had the lowest K value ($K = 0.106 \pm 0.070$). A normality test was conducted for all K values, and paired sample t-tests were used to compare the left regions to their corresponding right regions. The results showed no significant difference in tissue anisotropy between the left

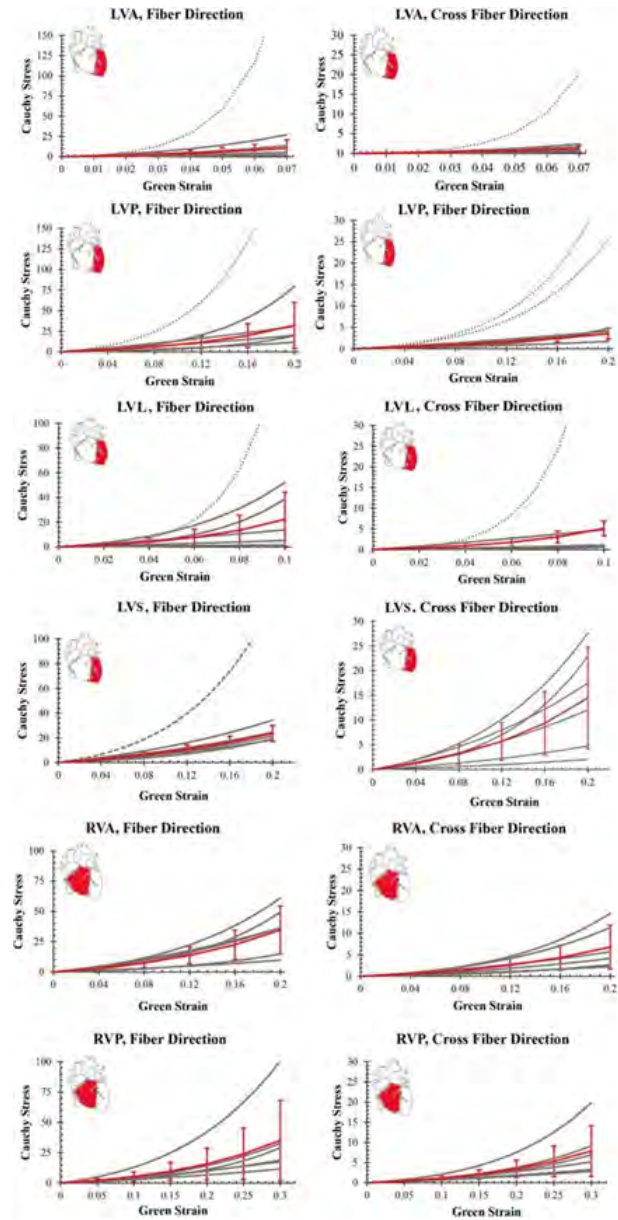


Figure 6. Equibiaxial stress (KPa)-strain curves and the average curve (presented in red) for specimens obtained from the left and right ventricles, distinguishing experimental results (solid lines) from outliers (dashed lines).

and right ventricles, left and right atria, or the aorta and pulmonary artery ($p = 0.878$, $p = 0.249$, and $p = 0.086$, respectively). Furthermore, paired sample t-tests revealed no statistically significant difference in anisotropy between the anterior and posterior portions of different anatomical regions. For the left ventricles, a one-way ANOVA test showed no statistically significant difference in anisotropy between the anterior, posterior, lateral, and septal areas.

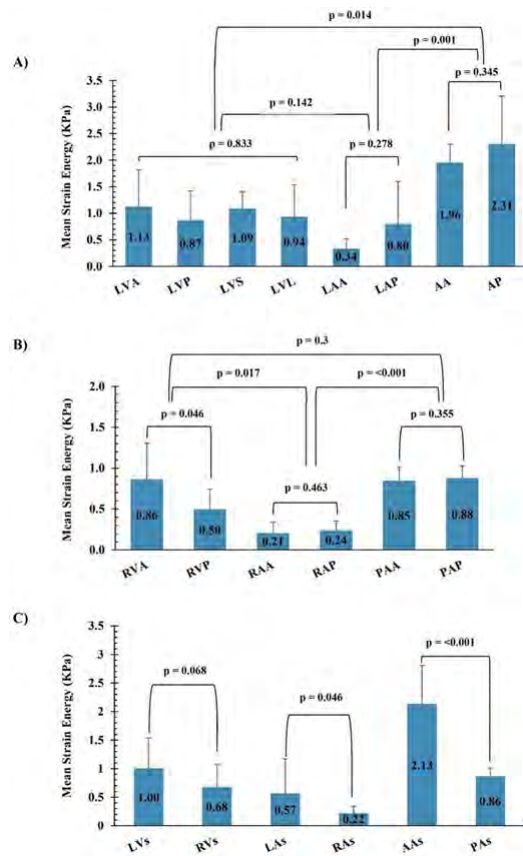


Figure 7. Mean values \pm SD of strain energy storage at strain of 0.15 for anatomical regions of the left side (A) and right side (B) of the heart. (C) The results of t-test between corresponding regions from the left and right sides of the heart, with * indicating a non-parametric test and ** signifying one-way ANOVA.

4 DISCUSSION

This study aimed to assess the mechanical properties of various anatomical regions in the calf heart using planar biaxial testing. The experimental data of these regions were fitted to a Fung-type strain energy function. The root mean square (RMS) values of the curve fitting process were found to be low, indicating an excellent fit of experimental data to the model. Subsequently, the material coefficients were utilized to calculate the anisotropy index and then the equibiaxial stress-strain curves. Statistical analysis revealed that the heart's left chambers exhibited significantly higher strain energy than their right counterparts. Other than the anterior and posterior regions of the right ventricle, no statistically significant differences in strain energy storage were observed between the anterior and posterior portions of the same heart regions. The ventricles had higher anisotropy than the other regions, with the left ventricle being the most anisotropic among all.

The mechanical properties of heart tissue show similarities between humans and animals. A study conducted by Sommer et al.¹⁰ aimed to investigate the

mechanical properties of various regions within the human myocardium by using biaxial extension tests. The results demonstrated that all tissue specimens exhibited greater stiffness in the fiber direction compared to the cross-fiber direction. Specifically, the stiffness of the human myocardium in the fiber direction was approximately twice as high as that in the cross-fiber direction, as observed on average. In our study, we also observed similar behavior, where tissue in the fiber direction displayed greater stiffness compared to tissue in the cross-fiber direction, except for the anterior region of the right atrium. Comparing different animal models, similar behavior was observed in another study involving animal models. Javani et al.⁷ conducted a study to investigate the passive mechanical properties of the sheep heart. Their statistical analysis revealed that the chambers on the left side of the heart exhibited significantly greater stiffness compared to those on the right side. Moreover, the ventricles displayed the highest amount of strain energy storage, while the appendages and atria showed lower levels. This consistent trend was observed on both sides of the heart.

Understanding the impact of age on the mechanical behavior of heart tissue is crucial for developing age-specific interventions and treatments for cardiac conditions^{17,18}. In a study conducted by Ahmad et al.⁶, the focus was on characterizing the mechanical behavior of neonatal cardiac tissue in porcine models to better understand the differences between neonatal and mature cardiac tissue. Through uniaxial testing, the study revealed that neonatal porcine cardiac tissue was approximately half as stiff as mature tissue and about one-third as stiff in biaxial testing. The authors observed that age-related changes in the cardiac matrix, such as increased collagen fibril cross linking and assembly, contribute to the increased stiffness observed in mature tissue¹⁹. Therefore, evaluating and comparing the mechanical properties of heart tissue across different age groups is essential for a comprehensive understanding of the influence of age on cardiac tissue mechanics, which implies the need for future investigation. This knowledge can inform targeted interventions and treatments tailored to specific age-related cardiac conditions.

The current study is subject to certain limitations that should be considered. Firstly, the small sample size, involving only 14 regions from six hearts, reduces the statistical power and may underestimate some differences between the study anatomical regions²⁰. To address this, future research should aim to utilize larger sample sizes to enhance the statistical analysis power and facilitate more robust comparisons between the cardiac and arterial tissue. Another limitation of the study is that the specimens used were fresh frozen samples, which may influence their mechanical properties. Frozen tissues tend to exhibit increased stiffness and higher anisotropy compared to fresh tissues²¹.

Table 1

| Region | RVA | RVP | LVA | LVP | LVS | LVL | AA |
|------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| Avg. length \pm SD (mm) | 15.215 \pm 0.698 | 15.132 \pm 0.574 | 14.864 \pm 0.515 | 15.282 \pm 0.641 | 14.657 \pm 0.643 | 15.654 \pm 0.679 | 14.325 \pm 0.619 |
| Region | AP | PAA | PAP | LAA | LAP | RAA | RAP |
| Avg. length \pm SD (mm) | 14.334 \pm 1.086 | 14.773 \pm 0.736 | 14.638 \pm 0.632 | 14.999 \pm 1.518 | 13.699 \pm 1.348 | 13.969 \pm 1.157 | 13.924 \pm 0.832 |
| Region | RVA | RVP | LVA | LVP | LVS | LVL | AA |
| Avg. thickness \pm SD (mm) | 2.254 \pm 0.517 | 2.053 \pm 0.231 | 2.392 \pm 0.261 | 2.563 \pm 0.365 | 2.690 \pm 0.343 | 2.605 \pm 0.255 | 3.198 \pm 0.448 |
| Region | AP | PAA | PAP | LAA | LAP | RAA | RAP |
| Avg. thickness \pm SD (mm) | 3.043 \pm 0.372 | 3.094 \pm 0.422 | 3.242 \pm 0.567 | 4.160 \pm 1.310 | 4.050 \pm 0.772 | 4.115 \pm 0.508 | 3.954 \pm 0.868 |

(a) Average length and thickness with standard deviation (SD) for the specimens in stress-free condition.

| Region | W 10% | W 15% | W 20% |
|--------|-------------------|-------------------|-------------------|
| AA | 0.869 \pm 0.155 | 1.957 \pm 0.344 | 3.484 \pm 0.602 |
| AP | 1.024 \pm 0.403 | 2.307 \pm 0.902 | 4.108 \pm 1.590 |
| LAA | 0.149 \pm 0.081 | 0.338 \pm 0.181 | 0.605 \pm 0.322 |
| LAP | 0.345 \pm 0.337 | 0.801 \pm 0.798 | 1.491 \pm 1.532 |
| LVA | 0.441 \pm 0.231 | 1.128 \pm 0.691 | 2.535 \pm 2.114 |
| LVP | 0.375 \pm 0.236 | 0.870 \pm 0.551 | 1.623 \pm 1.048 |
| LVL | 0.387 \pm 0.265 | 0.936 \pm 0.602 | 1.882 \pm 1.135 |
| LVS | 0.473 \pm 0.132 | 1.086 \pm 0.317 | 1.989 \pm 0.621 |
| PAA | 0.376 \pm 0.076 | 0.847 \pm 0.169 | 1.510 \pm 0.301 |
| PAP | 0.391 \pm 0.066 | 0.880 \pm 0.148 | 1.566 \pm 0.263 |
| RAA | 0.089 \pm 0.056 | 0.206 \pm 0.134 | 0.385 \pm 0.263 |
| RAP | 0.105 \pm 0.050 | 0.240 \pm 0.112 | 0.437 \pm 0.199 |
| RVA | 0.376 \pm 0.196 | 0.862 \pm 0.445 | 1.575 \pm 0.805 |
| RVP | 0.218 \pm 0.108 | 0.497 \pm 0.248 | 0.899 \pm 0.457 |

(b) Mean and standard division of the strain energy for different anatomical regions at 0.10, 0.15, and 0.20 strain levels.

| Region | RVA | RVP | LVA | LVP | LVS | LVL | AA |
|---------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|------------------|
| Avg. \pm SD | 0.317 \pm 0.214 | 0.418 \pm 0.307 | 0.325 \pm 0.218 | 0.84 \pm 0.528 | 1.451 \pm 0.289 | 1.353 \pm 0.212 | 0.93 \pm 0.673 |
| Region | LVL | RAA | RAP | RVA | RVP | PAA | PAP |
| Avg. \pm SD | 1.277 \pm 0.534 | 0.346 \pm 0.299 | 0.409 \pm 0.333 | 1.359 \pm 0.174 | 1.179 \pm 0.434 | 0.106 \pm 0.070 | 0.33 \pm 0.310 |

(c) Index of tissue anisotropy (K) for different anatomical regions.

Previous studies have indicated that the freeze/thaw process decreases the fibril area²². Therefore, caution should be exercised when extrapolating these findings to fresh cardiac tissue samples. This said, it is important to note that these limitations do not invalidate the study's main conclusion, which demonstrated that tissue from the left side of the heart exhibited significantly higher strain energy storage than the corresponding tissue from the right side. Furthermore, the left ventricle displayed the highest level of tissue anisotropy compared to other regions.

5 CONCLUSION

In summary, this study involved conducting planar biaxial stretch tests on tissue samples obtained from various regions of a healthy calf's heart. Cauchy stress–Green strain curves were constructed for each anatomical area, and a Fung-type constitutive model was applied to fit the raw data. The results indicated that all tissue specimens exhibited nonlinear responses to biaxial stress, attributed to the microstructure's reaction and the involvement of fibers as stretching progresses. Among the different areas, the left ventricle displayed the highest level of tissue anisotropy compared to other regions. Additionally, a comparison based on the magnitude of the strain energy function revealed that the aorta exhibited the highest strain energy, followed by the left ventricles, pulmonary artery, right ventricle, left atrium, and right atrium, respectively. Investigating the mechanical properties and composition of cardiac and arterial tissue is crucial for a comprehensive understanding of the cardiac function and for evaluating potential treatments for cardiovascular diseases. Biomechanical variables are vital determinants of cardiac function, both in healthy and diseased hearts²³. Utilizing mechanical indicators such as tissue stiffness and strain enables medical professionals to identify patients who could benefit from surgical interventions.

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7 EDITOR'S NOTES

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Appendix A

| AA | | | | | AP | | | | |
|---------------------|---------------------|---------------------|--------------|----------------|---------------------|---------------------|---------------------|--------------|----------------|
| Model 1 c_{11} | Model 1 c_{12} | Model 1 c_{22} | Model 1 C | Model 1 RMS | Model 1 c_{11} | Model 1 c_{12} | Model 1 c_{22} | Model 1 C | Model 1 RMS |
| 0.003 | 0.003 | 0.004 | 17476.3 | 0.528 | 0.01 | -0.001 | 0.009 | 16015.87 | 0.522 |
| Model 2 c_{11} | Model 2 c_{12} | Model 2 c_{22} | Model 2 C | Model 2 RMS | Model 2 c_{11} | Model 2 c_{12} | Model 2 c_{22} | Model 2 C | Model 2 RMS |
| 0.002 | 0.002 | 0.002 | 37350.5 | 1.2 | 1.442 | 0.366 | 0.439 | 36.418 | 0.331 |
| Model 3 c_{11} | Model 3 c_{12} | Model 3 c_{22} | Model 3 C | Model 3 RMS | Model 3 c_{11} | Model 3 c_{12} | Model 3 c_{22} | Model 3 C | Model 3 RMS |
| 0.014 | 0.006 | 0.007 | 5806.91 | 0.404 | 0.002 | 0.001 | 0.001 | 75516.96 | 1.371 |
| Model 4 c_{11} | Model 4 c_{12} | Model 4 c_{22} | Model 4 C | Model 4 RMS | Model 4 c_{11} | Model 4 c_{12} | Model 4 c_{22} | Model 4 C | Model 4 RMS |
| 0.422 | 0.222 | 0.3 | 97.171 | 0.284 | 0.016 | 0.005 | 0.005 | 5464.33 | 0.422 |
| Model 5 c_{11} | Model 5 c_{12} | Model 5 c_{22} | Model 5 C | Model 5 RMS | Model 5 c_{11} | Model 5 c_{12} | Model 5 c_{22} | Model 5 C | Model 5 RMS |
| 0.023 | 0.007 | 0.01 | 4016.01 | 0.443 | 0.007 | 0.005 | 0.007 | 11136.02 | 0.584 |
| Model 6 c_{11} | Model 6 c_{12} | Model 6 c_{22} | Model 6 C | Model 6 RMS | Model 6 c_{11} | Model 6 c_{12} | Model 6 c_{22} | Model 6 C | Model 6 RMS |
| 0.004 | 0.002 | 0.002 | 21799.58 | 0.545 | 0.011 | 0.004 | 0.006 | 6690.64 | 0.585 |
| LAA | | | | | LAP | | | | |
| Model 1 c_{11} | Model 1 c_{12} | Model 1 c_{22} | Model 1 C | Model 1 RMS | Model 1 c_{11} | Model 1 c_{12} | Model 1 c_{22} | Model 1 C | Model 1 RMS |
| 0.804 | 0.187 | 0.48 | 9.748 | 0.45 | 0.257 | 0.031 | 0.037 | 176.227 | 1.538 |
| Model 2 c_{11} | Model 2 c_{12} | Model 2 c_{22} | Model 2 C | Model 2 RMS | Model 2 c_{11} | Model 2 c_{12} | Model 2 c_{22} | Model 2 C | Model 2 RMS |
| 0.616 | 0.3 | 0.585 | 7.363 | 0.243 | 2.628 | 2.19 | 2.831 | 16.294 | 0.907 |
| Model 3 c_{11} | Model 3 c_{12} | Model 3 c_{22} | Model 3 C | Model 3 RMS | Model 3 c_{11} | Model 3 c_{12} | Model 3 c_{22} | Model 3 C | Model 3 RMS |
| 0.628 | 0.315 | 0.378 | 13.917 | 0.455 | 1.754 | 0.135 | 0.162 | 60.769 | 1.392 |
| Model 4 c_{11} | Model 4 c_{12} | Model 4 c_{22} | Model 4 C | Model 4 RMS | Model 4 c_{11} | Model 4 c_{12} | Model 4 c_{22} | Model 4 C | Model 4 RMS |
| 0.486 | 0.159 | 0.19 | 39.055 | 0.77 | 0.98 | 0.384 | 0.46 | 6.026 | 0.47 |
| Model 5 c_{11} | Model 5 c_{12} | Model 5 c_{22} | Model 5 C | Model 5 RMS | Model 5 c_{11} | Model 5 c_{12} | Model 5 c_{22} | Model 5 C | Model 5 RMS |
| 0.174 | 0.118 | 0.142 | 102.091 | 0.594 | 0.51 | 0.137 | 0.164 | 24.374 | 0.268 |
| Model 6 c_{11} | Model 6 c_{12} | Model 6 c_{22} | Model 6 C | Model 6 RMS | Model 6 c_{11} | Model 6 c_{12} | Model 6 c_{22} | Model 6 C | Model 6 RMS |
| 0.512 | -0.028 | 0.317 | 39.583 | 0.516 | 0.525 | 0.082 | 0.099 | 15 | 0.18 |
| LVA | | | | | LVP | | | | |
| Model 1 c_{11} | Model 1 c_{12} | Model 1 c_{22} | Model 1 C | Model 1 RMS | Model 1 c_{11} | Model 1 c_{12} | Model 1 c_{22} | Model 1 C | Model 1 RMS |
| 0.002 | 0.001 | 0.001 | 41722.52 | 1.567 | 1.553 | 0.114 | 0.137 | 16.903 | 1.256 |
| Model 2 c_{11} | Model 2 c_{12} | Model 2 c_{22} | Model 2 C | Model 2 RMS | Model 2 c_{11} | Model 2 c_{12} | Model 2 c_{22} | Model 2 C | Model 2 RMS |
| 1.311 | 0.274 | 0.329 | 12.959 | 1.448 | 5.95 | 1.024 | 1.229 | 6.442 | 1.23 |
| Model 3 c_{11} | Model 3 c_{12} | Model 3 c_{22} | Model 3 C | Model 3 RMS | Model 3 c_{11} | Model 3 c_{12} | Model 3 c_{22} | Model 3 C | Model 3 RMS |
| 7.962 | 0.72 | 0.864 | 13.77 | 2.583 | 0.002 | 0.001 | 0.001 | 36333.88 | 1.992 |
| Model 4 c_{11} | Model 4 c_{12} | Model 4 c_{22} | Model 4 C | Model 4 RMS | Model 4 c_{11} | Model 4 c_{12} | Model 4 c_{22} | Model 4 C | Model 4 RMS |

| | | | | | | | | | |
|---|---|---|----------------------------|------------------------------|---|---|---|----------------------------|------------------------------|
| 42.673 | 1.804 | 2.165 | 2.131 | 1.723 | 0.005 | 0.001 | 0.001 | 24116.09 | 2.304 |
| Model 5 c₁₁ | Model 5 c₁₂ | Model 5 c₂₂ | Model 5 C | Model 5 RMS | Model 5 c₁₁ | Model 5 c₁₂ | Model 5 c₂₂ | Model 5 C | Model 5 RMS |
| 9.573 | 0.571 | 0.686 | 7.624 | 1.567 | 6.443 | 0.812 | 0.974 | 1.567 | 0.737 |
| Model 6 c₁₁ | Model 6 c₁₂ | Model 6 c₂₂ | Model 6 C | Model 6 RMS | Model 6 c₁₁ | Model 6 c₁₂ | Model 6 c₂₂ | Model 6 C | Model 6 RMS |
| 3.474 | 0.11 | 0.166 | 13.898 | 0.673 | 9.05 | 0.621 | 0.745 | 11.206 | 1.664 |
| LVS | | | | | LVL | | | | |
| Model 1 c₁₁ | Model 1 c₁₂ | Model 1 c₂₂ | Model 1 C | Model 1 RMS | Model 1 c₁₁ | Model 1 c₁₂ | Model 1 c₂₂ | Model 1 C | Model 1 RMS |
| 0.667 | 0.397 | 0.476 | 48.726 | 3.803 | 28.589 | -1.573 | 11.934 | 1.259 | 1.006 |
| Model 2 c₁₁ | Model 2 c₁₂ | Model 2 c₂₂ | Model 2 C | Model 2 RMS | Model 2 c₁₁ | Model 2 c₁₂ | Model 2 c₂₂ | Model 2 C | Model 2 RMS |
| 1.973 | -0.089 | 2.813 | 14.383 | 2.294 | 21.789 | -2.814 | 3.376 | 2.407 | 1.075 |
| Model 3 c₁₁ | Model 3 c₁₂ | Model 3 c₂₂ | Model 3 C | Model 3 RMS | Model 3 c₁₁ | Model 3 c₁₂ | Model 3 c₂₂ | Model 3 C | Model 3 RMS |
| 1.239 | -0.315 | 0.391 | 77.348 | 2.252 | 0.002 | 0.001 | 0.001 | 87447.44 | 5.934 |
| Model 4 c₁₁ | Model 4 c₁₂ | Model 4 c₂₂ | Model 4 C | Model 4 RMS | Model 4 c₁₁ | Model 4 c₁₂ | Model 4 c₂₂ | Model 4 C | Model 4 RMS |
| 5.356 | 0.472 | 0.566 | 20.012 | 1.973 | 13.569 | -0.807 | 0.968 | 9.364 | 1.506 |
| Model 5 c₁₁ | Model 5 c₁₂ | Model 5 c₂₂ | Model 5 C | Model 5 RMS | Model 5 c₁₁ | Model 5 c₁₂ | Model 5 c₂₂ | Model 5 C | Model 5 RMS |
| 0.98 | -0.137 | 0.692 | 58.703 | 2.402 | 0.402 | 0.115 | 0.138 | 24.545 | 0.538 |
| Model 6 c₁₁ | Model 6 c₁₂ | Model 6 c₂₂ | Model 6 C | Model 6 RMS | Model 6 c₁₁ | Model 6 c₁₂ | Model 6 c₂₂ | Model 6 C | Model 6 RMS |
| 1.331 | 0.09 | 0.108 | 62.418 | 1.15 | 0.282 | 0.031 | 0.037 | 134.29 | 1.029 |
| RAA | | | | | RAP | | | | |
| Model 1 c₁₁ | Model 1 c₁₂ | Model 1 c₂₂ | Model 1 C | Model 1 RMS | Model 1 c₁₁ | Model 1 c₁₂ | Model 1 c₂₂ | Model 1 C | Model 1 RMS |
| 0.873 | 0.512 | 0.614 | 7.93 | 0.625 | 1.391 | 1.151 | 1.381 | 2.477 | 0.753 |
| Model 2 c₁₁ | Model 2 c₁₂ | Model 2 c₂₂ | Model 2 C | Model 2 RMS | Model 2 c₁₁ | Model 2 c₁₂ | Model 2 c₂₂ | Model 2 C | Model 2 RMS |
| 1.598 | 1.332 | 2.601 | 1.936 | 1.08 | 1.804 | 0.66 | 1.091 | 6.251 | 0.55 |
| Model 3 c₁₁ | Model 3 c₁₂ | Model 3 c₂₂ | Model 3 C | Model 3 RMS | Model 3 c₁₁ | Model 3 c₁₂ | Model 3 c₂₂ | Model 3 C | Model 3 RMS |
| 1.867 | 1.556 | 3.981 | 4.144 | 1.258 | 0.841 | 0.52 | 0.624 | 5.276 | 0.509 |
| Model 4 c₁₁ | Model 4 c₁₂ | Model 4 c₂₂ | Model 4 C | Model 4 RMS | Model 4 c₁₁ | Model 4 c₁₂ | Model 4 c₂₂ | Model 4 C | Model 4 RMS |
| 0.003 | -0.001 | 0.002 | 3302.011 | 0.172 | 0.298 | -0.083 | 0.219 | 104.505 | 0.476 |
| Model 5 c₁₁ | Model 5 c₁₂ | Model 5 c₂₂ | Model 5 C | Model 5 RMS | Model 5 c₁₁ | Model 5 c₁₂ | Model 5 c₂₂ | Model 5 C | Model 5 RMS |
| 1.34 | 0.95 | 1.14 | 2.497 | 0.429 | 1.974 | 0.725 | 0.869 | 2.742 | 0.342 |
| Model 6 c₁₁ | Model 6 c₁₂ | Model 6 c₂₂ | Model 6 C | Model 6 RMS | Model 6 c₁₁ | Model 6 c₁₂ | Model 6 c₂₂ | Model 6 C | Model 6 RMS |
| 1.845 | -0.646 | 2 | 5.179 | 0.233 | 2.588 | -0.131 | 0.981 | 6.941 | 0.287 |
| RVA | | | | | RVP | | | | |
| Model 1 c₁₁ | Model 1 c₁₂ | Model 1 c₂₂ | Model 1 C | Model 1 RMS | Model 1 c₁₁ | Model 1 c₁₂ | Model 1 c₂₂ | Model 1 C | Model 1 RMS |
| 3.846 | 0.349 | 0.419 | 4.698 | 1.151 | 2.426 | 0.118 | 1.619 | 6.604 | 0.898 |
| Model 2 c₁₁ | Model 2 c₁₂ | Model 2 c₂₂ | Model 2 C | Model 2 RMS | Model 2 c₁₁ | Model 2 c₁₂ | Model 2 c₂₂ | Model 2 C | Model 2 RMS |
| 4.319 | 0.673 | 0.808 | 9.715 | 0.656 | 2.167 | 0.231 | 0.277 | 11.954 | 1.176 |

| | | | | | | | | | |
|---|---|---|----------------------------|------------------------------|---|---|---|----------------------------|------------------------------|
| Model 3 c₁₁ | Model 3 c₁₂ | Model 3 c₂₂ | Model 3 C | Model 3 RMS | Model 3 c₁₁ | Model 3 c₁₂ | Model 3 c₂₂ | Model 3 C | Model 3 RMS |
| 2.2 | -0.292 | 0.51 | 44.747 | 0.882 | 0.88 | -0.145 | 0.347 | 40.358 | 1.031 |
| Model 4 c₁₁ | Model 4 c₁₂ | Model 4 c₂₂ | Model 4 C | Model 4 RMS | Model 4 c₁₁ | Model 4 c₁₂ | Model 4 c₂₂ | Model 4 C | Model 4 RMS |
| 0.877 | 0.067 | 0.081 | 111.408 | 2.933 | 2.921 | 0.126 | 0.151 | 25.427 | 1.834 |
| Model 5 c₁₁ | Model 5 c₁₂ | Model 5 c₂₂ | Model 5 C | Model 5 RMS | Model 5 c₁₁ | Model 5 c₁₂ | Model 5 c₂₂ | Model 5 C | Model 5 RMS |
| 3.575 | 0.33 | 0.396 | 22.152 | 1.751 | 0.001 | 0.001 | 0.001 | 36720.27 | 2.954 |
| Model 6 c₁₁ | Model 6 c₁₂ | Model 6 c₂₂ | Model 6 C | Model 6 RMS | Model 6 c₁₁ | Model 6 c₁₂ | Model 6 c₂₂ | Model 6 C | Model 6 RMS |
| 0.446 | 0.052 | 0.062 | 62.608 | 2.481 | 0.026 | 0.004 | 0.004 | 812.597 | 1.108 |
| PAA | | | | | PAP | | | | |
| Model 1 c₁₁ | Model 1 c₁₂ | Model 1 c₂₂ | Model 1 C | Model 1 RMS | Model 1 c₁₁ | Model 1 c₁₂ | Model 1 c₂₂ | Model 1 C | Model 1 RMS |
| 0.077 | 0.065 | 0.088 | 253.288 | 0.462 | 0.012 | 0.007 | 0.01 | 2542.296 | 0.355 |
| Model 2 c₁₁ | Model 2 c₁₂ | Model 2 c₂₂ | Model 2 C | Model 2 RMS | Model 2 c₁₁ | Model 2 c₁₂ | Model 2 c₂₂ | Model 2 C | Model 2 RMS |
| 0.014 | 0.009 | 0.011 | 1927.36 | 0.437 | 0.001 | 0.001 | 0.001 | 44113.86 | 1.512 |
| Model 3 c₁₁ | Model 3 c₁₂ | Model 3 c₂₂ | Model 3 C | Model 3 RMS | Model 3 c₁₁ | Model 3 c₁₂ | Model 3 c₂₂ | Model 3 C | Model 3 RMS |
| 0.012 | 0.003 | 0.012 | 3610.637 | 0.244 | 0.013 | 0.01 | 0.015 | 2038.455 | 0.515 |
| Model 4 c₁₁ | Model 4 c₁₂ | Model 4 c₂₂ | Model 4 C | Model 4 RMS | Model 4 c₁₁ | Model 4 c₁₂ | Model 4 c₂₂ | Model 4 C | Model 4 RMS |
| 0.003 | -0.001 | 0.003 | 12089.11 | 0.345 | 0.003 | 0.001 | 0.001 | 16003.84 | 0.847 |
| Model 5 c₁₁ | Model 5 c₁₂ | Model 5 c₂₂ | Model 5 C | Model 5 RMS | Model 5 c₁₁ | Model 5 c₁₂ | Model 5 c₂₂ | Model 5 C | Model 5 RMS |
| 0.534 | 0.358 | 0.429 | 44.46 | 0.391 | 0.053 | 0.028 | 0.037 | 555.935 | 0.214 |
| Model 6 c₁₁ | Model 6 c₁₂ | Model 6 c₂₂ | Model 6 C | Model 6 RMS | Model 6 c₁₁ | Model 6 c₁₂ | Model 6 c₂₂ | Model 6 C | Model 6 RMS |
| 0.006 | 0.004 | 0.004 | 4539.257 | 0.237 | 0.228 | -0.105 | 0.174 | 322.249 | 0.46 |

Table 2 The individual coefficient sets (C_{11} , C_{12} , C_{22} , and C) of the four parameter Fung exponential constitutive model for all the individual samples ($n = 84$) with their root mean square (RMS).



Priestess of Crete by Maria Stevens

Utilizing Existing Postfeminist Framework to Explore a Sexualized Media Test Case: “Man Needs a Woman” by Maty Noyes

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Abstract

Postfeminism is simply referred to as the most recent wave of feminism, but feminist scholars have failed to reach a standardized definition that recognizes the nuances of sexuality, media, and culture present within the field. This paper utilizes the postfeminist framework of two prominent feminist scholars: Rosalind Gill and Feona Attwood. Specifically, this paper draws from Gill’s interpretation of postfeminism and Attwood’s interpretation of the sexualization of culture and the overlap between the two theories. Rather than attempt to offer a concrete definition in such a rapidly evolving field, this paper offers a music video from a lesser-known pop artist, Maty Noyes, as a test case to operationalize the theories of Gill and Attwood. The purpose of this work is to evaluate the applicative success of Gill and Attwood while offering an example of the evaluation of a media text as a postfeminism phenomenon.

1 INTRODUCTION

Western modes of political and independent thought have become inextricably tied to overwhelming amounts of daily media consumption. Feminism is not an exception to this transformation of thought processing. A new wave developed within the past decades has been termed “postfeminism,” which recognizes the individual as a neoliberal subject; this is in contrast to previous waves that centered on symbolic societal equality between the sexes. Rather than become passive agents of this change, feminists and feminist scholars alike must actively analyze the texts informing such a change. Therefore, this paper acts as a test case to apply the theories of Feona Attwood’s sexualization of media and Rosalind Gill’s postfeminism to a singular piece of media—the music video “Man Needs a Woman” by artist Maty Noyes. The purpose of such an application is to explore how a seemingly innocuous piece of media could be interpreted as a display of sexualized postfeminism. While other applications may apply to media pieces reaching wide audiences or deemed as culturally influential, this paper offers an analysis of an isolated media piece that could be applied to a wider range of similarly isolated texts.

One of the hallmark changes that occurred within academic discussions regarding feminism is the inclusion of the sexualization of media as a defining feature. While there is some dissensus among scholars as to what shape this new form of sexualization has

taken, there is general agreement about its results. At the most basic level, the sexualization of media is the mainstreaming of sex through the development of new forms of public intimacy that view sexual practices as a form of both play and pleasure¹. This newfound public intimacy stands in direct contrast to former views of sexual acts as inherently dirty, meant to be hidden and contained privately within heterosexual, monogamous partnerships.

While the direct impacts of public sexualization have not yet been empirically studied, theories surrounding long-lasting side effects have been presented. Feminist scholars, including Attwood and Gill, have compiled possible side effects, including the illusion of empowerment, self-surveillance, the inability to contest modern feminist viewpoints directly, and the resocialization of younger generations. This process of resocialization can be seen in the prominence of surgical alterations to fix what is deemed broken and by targeting children and adolescents with ads that flaunt sexuality as required for femininity—just two examples of the increasing prominence of sexualization in society heightened by media influence. The sexualization of culture has, therefore, made it more difficult to grasp what it means to be a woman outside of conventional displays.

The primary debate within modern feminism lies in relation to the restrictive nature of postfeminism. As Attwood explores in her work, current debates regarding sexualization highlight whether an increased

sexualized culture has the potential to democratize sexual discourse or reduce sexual pleasure to a commodified performance—"an impersonation of sex"¹. There lies a problem within this debate structure as it continues to categorize sexualization as fitting into an either/or response¹ without necessary extension beyond the binaries that feminism originally sought to deconstruct—man versus woman; masculine versus feminine; superior versus inferior; and now sexual versus sexualized.

Therefore, there needs to be contextual analyses of individual examples of sexualized media to understand the extent to which current debates lack a much-needed answer. The theoretical frameworks of Feona Attwood and Rosalind Gill offer a structured method to explore the intersection between sexualized media and postfeminism. Ultimately, this paper acts as a test case to apply such theoretical frameworks and determine the extent to which this particular media could be deemed postfeminist—offering a starting point and method to resolve existing debates.

2 MEDIA TEST CASE

With approximately 100,000 views on YouTube², "Man Needs a Woman" is not a particularly influential piece of media in comparison to music videos such as "Dark Horse" by Katy Perry or "WAP" by Cardi B and Megan Thee Stallion, but it provides insight into a small celebrity's interpretation of sexuality, not yet entirely constrained by popular culture expectations. This intermediate boundary between celebrity and ordinary provides a unique, untouched insight into the effects of media sexualization.

The singer, Maty Noyes, rose to minor notoriety after being featured on The Weeknd's Grammy Award-winning song "Angel." Her most recent album, *The Feeling's Mutual*, released in September of 2021, focused on the exploration of romance as an individualized journey. In interviews discussing the release of her debut album, Noyes described music as an outlet to hyper-analyze her experiences, heal through things, and understand herself³. Her recent album specifically analyzes her experiences in relationships—both romantically and platonically.

One of the few songs from her debut album granted an accompanying music video, posted in 2021, is "Man Needs a Woman"². It centers on the conclusion of a recent relationship and a woman's feelings of being used. The song's lyrics lay out several transgressions committed by the male counterpart as he "only loved [her] for [her] body" and "only listen[s] when [she's] naked"⁴. Here, the singer positions herself as worthy of a relationship absent of sex and physical intimacy. Ultimately, Maty Noyes describes the relationship as a needed learning experience "because [she] learned so

many lessons from [his] love"⁴. The visual music video is where the majority of the overt sexualization occurs.

The video begins with Noyes laying seductively across the floor, surrounded by objects such as fruit, which she will later stroke while watching the camera; playing cards—of which she will later burn the king; flowers; an open clam shell with a pearl; and a large anaconda. Most of the objects seem to be related to commonly known symbols of femininity and womanhood, both good and bad, such as fruit representing fertility, flowers representing a traditional delicate woman, a clam representing natural aphrodisiacs, and a snake representing Eve's biblical transgressions (Figures 1 and 2). Alongside consistent symbolic allusions, there is a repetitive focus on certain aspects of Noyes's body. She changes clothing several times, but all the outfits are intentionally provocative and include sheer bodysuits, metallic panels, and emphasize her breasts and vagina. Only one outfit exclusively covers these regions.



Figure 1. A still photo from the opening scene of the music video.



Figure 2. A still photo from the opening credits of the music video.

The filming aesthetic is that of an amateur filmmaker, utilizing shaky zoom-ins, blurry movements, and a harkening to old film static, all of which is reminiscent of amateur-style pornographic filming—an element central to Attwood's discussion of the emerging prominence of porn-style imagery in mainstream media¹ (Figures 2 and 3). As the camera focuses on Noyes's

lips, breasts, and hips, she enhances her movements by spreading her legs, laying forward on her stomach, and stroking herself and the objects surrounding her (Figures 1 and 4). When her lips are included in close-up shots, she appears to gasp the lyrics as she sings, amplifying the sexual emphasis she places on certain words. Perhaps the most sexually explicit scenes are paired with running water as she dances seductively in a diamond thong with orchid flowers used as nipple coverings (Figure 5).

None of the near nudity appears crude, however, as it follows societal conventions by covering explicit sexual organs and is paired with “classy” diamonds emanating a sense of wealth (Figures 4 and 5). However, this interpretation of “crude” could be swayed by her positioning as a white woman, with women of color not given the same abilities to push the boundaries of “graceful” sexuality; unfortunately, Attwood and Gill do not delve directly into discussions of intersectionality in the texts used for this analysis.

The music video was directed and edited by Anastasia Velicescu, and the creative designer behind the concept was Paige Strabala, both women². The fact that the main creative individuals behind the concept and shooting of the video were women lends itself to both Gill and Attwood’s argument of self-sexualization—explored later in this paper. Maty Noyes has an Instagram following of around 150,000; although she does not have enough coverage to receive comments other than those praising her work regularly, it is notable to mention that the most interacted-with post leading up to the release of the single is one in which she is clad in the aforementioned diamond thong and flowers⁵ (Figure 5).



Figure 3. A still photo from the music video featuring a closeup of lips and artist name.

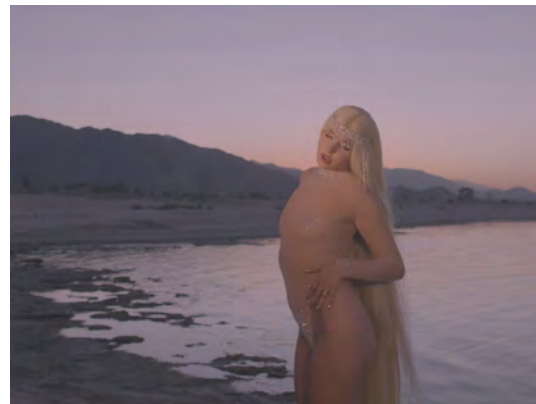


Figure 4. A still photo from the music video including Noyes in glitter bodysuit.



Figure 5. A still photo from the music video featuring Noyes in a diamond thong, stroking her body; the photo was posted on Instagram.

3 FRAMEWORK: ROSALIND GILL POSTFEMINIST MEDIA

This paper specifically utilizes the 2007 work of Rosalind Gill titled *Postfeminist Media Culture: Elements of a Sensibility*. While published almost seventeen years ago, the piece is a hallmark analysis of postfeminism by providing a unique definition continuously used in contemporary discussions of feminism, particularly in relation to media texts. Gill specializes in analyzing the interplay between psychology, media studies, and feminist theory to provide a longstanding method of analysis for media texts, ranging from social media posts to movies. Her most recently published works, not utilized in this paper, explore both the expansive definition of postfeminist media and the meaning of an increasingly sexualized culture by using media as the moderating piece between the two fields—providing a successful example of the application of her early scholarship explored in this paper. Therefore, her initial analysis of postfeminism, alongside her application to feminist media, provides a strong theoretical framework for studying the specific media text in this paper.

Gill begins her definition of postfeminism by analyzing the existing causes of dissensus among scholars, namely the way it has been used to describe a theoretical position, the birth of a new form of feminism, and/or a regressive political stance. Previous scholars have been unable to provide a holistic definition of postfeminism that avoids ignoring the arguments of one aspect or utilizing the arguments of two contradictory aspects. For example, postfeminism cannot exist as a practiced political stance while simultaneously existing as a theoretical framework. Similarly, postfeminism cannot be defined as a purely theoretical position without actively ignoring its implications outside of academia. Therefore, rather than trying to fit postmodern feminism into one of the existing categories, Gill proposes a new way to imagine postfeminism: as a sensibility. Here, Gill uses the term sensibility to mean a cultural or emotional way to perceive the world via feelings, experiences, and perceptions. Within this framework, postfeminism is not a fixed ideology—as other scholars have attempted to define it—but rather an evolving method of coping with and understanding modern gender ideologies.

Gill also ventures into the concept of sexualization and provides a stable definition for analysis. She defines sexualization as two-fold. The first aspect refers to the proliferation of discourse surrounding sex and sexuality, particularly by media. The second aspect is the presentation of erotic female bodies in public spaces, once again proliferated by media. Therefore, sexualization has infiltrated both the discussions and physical manifestations of media.

A defining feature of postfeminism and modern sexualization centers around the articulation of sexualization as an empowering choice. Previous modes of feminism have posited sexualization as something to abhor—a coerced manipulation of the body. In contrast, postmodern feminism depicts sexualization as a form of power rather than oppression, representing a shift in the operation of power from an external, uniquely male gaze to a self-policing gaze inherent to the woman⁶.

Gill connects postfeminism and a false sense of power by arguing that postfeminism operates as a form of neoliberalism. Gill argues that postfeminism operates between articulations of feminism and anti-feminism, distinctly dependent on a language of individualism inherent to neoliberalism⁶. Gill is articulating a direct connection between the illusion of power provided to the subject in both neoliberalism and postfeminism.

Gill defines neoliberalism as a type of governmentality that emphasizes free will, individualism, and empowerment at the expense of recognizing societal inequities⁶. Postfeminism operates within neoliberalism as it utilizes the concept of free will and individualism to exploit gendered expectations placed on women. For example, popular culture expects women to fit within a

binary of accepted femininity while deceptively displaying it as a choice. As Gill posits, if women are following individually and autonomously generated desires, why does the desired final result look so similar⁶? Therefore, the “ideal disciplinary subject of neoliberalism is feminine” as male bodies are not expected to conform to the same social scripts as female bodies⁶. Postfeminism victimizes the submissive subject under the guise of self-empowerment.

Ultimately, Gill outlines eight stable features of postfeminism within her definition as a sensibility: (1) femininity as bodily property; (2) a shift from objectification to subjectification; (3) emphasis on self-surveillance; (4) focus on individualism and empowerment; (5) a makeover paradigm; (6) resurgence of natural sexual difference; (7) sexualization of culture; (8) consumerism and commodification. This paper will emphasize Gill’s first, second, third, and fourth pillars of postfeminism to analyze the media text while maintaining her seventh pillar as a connecting thread to Attwood.

4 APPLICATION OF GILL

4.1 Femininity as Bodily Property and Objectification to Subjectification

Beginning with femininity as bodily property, Gill recognizes a recent belief of possessing a freely sexualized body as a crucial source of self-identity, which parallels Attwood’s later discussion of sex being central to the creation of self. Gill explores this theory through the lens of the body as an artistic canvas that creates an image having little to do with how one feels. Inside the text, this concept is supported by the discrepancy between the delicate, emotional intensity of the song paired with a sexualized image of the singer. Noyes’s original lyrically emotional intimacy is replaced with a visual sexual façade. The question arises as to why the creative direction of the video adopted this form. Gill supplies an answer through her second concept of a shift from objectification to subjectification. Postfeminism offers an interpretation of female sexuality as a transition from being sex objects to desiring sexual subjects:

Women are not straightforwardly objectified but are portrayed as active, desiring sexual subjects who choose to present themselves in a seemingly objectified manner because it suits their liberated interests to do so” which “represents a shift in the way that power operates from an external, male judging gaze to a self-policing narcissistic gaze⁶.

Noyes embodies this through her decision to pair an intimate song with sexualized images. She pairs the statement that the sexual manipulation and abuse she

experienced throughout the relationship caused her to “[seek] help ‘cause [he] put [her] through hell” alongside imagery of her spread legs². Rather than recover from the trauma of forced sexualization that occurs while being used for her body, she gives into the gaze and attempts to utilize it to her advantage.

By being labeled “active agents,” Gill explores the phenomena of women becoming monitors of sexual and emotional relationships⁶. Here, she is employing the concept that women, rather than men, are the actors that must maintain purity regarding sexual acts—such as avoiding pregnancy and sexually transmitted diseases—as well as guard their sexual reputations and partners’ sexual self-esteem. Noyes becomes a monitor since she “learned so many lessons from [his] love”⁴ and is responsible for growing from them. Despite the unloving and arguably abusive relationship Noyes experienced, she was still expected to grow and learn from the experience to become—what Gill terms—a new ethical self. This point is further emphasized as Noyes repeatedly states that she will become a better woman for another future relationship, indicating that the search for a new ethical self is for an external entity—another man—rather than for her personal growth.

4.2 Self-Surveillance

Gill describes self-surveillance as not only surveillance of the body but of what constitutes womanhood and femininity, with postfeminism exhibiting an increased intensity of self-surveillance, surveillance in new spheres of life, and the requirement to transform interior life. Surveillance, in this case, relates to Maty Noyes’s decision to display her private feelings, emotions, and experiences for a general audience as a highly unnatural human act. Noyes’s work has a multitude of examples pertaining to the rising intensity of self-surveillance as she employs societal principles expected of women. Through her lyrics, Noyes states that she did not love him for his money—so she was morally intact, not desiring sex—a constant idea that women must restrain the desires of men and that she learned from the love—which implies that she needed the lesson regardless of its impact. At times, she appears almost apologetic in nature, falling into the status quo of a respectable, surveilled woman.

The creation of the song and accompanying music video pertain to postfeminism’s surveillance in new spheres of life. As Noyes has mentioned in interviews³, her purpose for writing the song was to explore and understand her past relationships. Therefore, the music video acts as a publicly open-ended exploration into Noyes’ personal life, possible only in a society built on prolific media distribution. The third concept of transforming interior life is seen in Noyes’ self-made requirement to learn from the relationship and the earlier dis-

cussed necessity to become a new ethical self.

4.3 Individualism and Empowerment

A unique aspect of postfeminism is the shift from femininity as a sociocultural concept to one defined by bodily property. This shift culminates in an understanding of sexuality as a source of innate power within feminine bodies. Noyes displays her body as a method of liberation from a past relationship. The sexualization of her body through poses and clothing acts as a message of liberation and freedom from both her past relationship and societal expectations of how she should present herself. However, the feminine body is only allowed to be a source of unruly power within certain limitations set by the societal norms Noyes aims to evade.

As Gill mentions in her work, women’s bodies are scrutinized to a larger extent than men’s bodies and become at constant risk of “failing.” A feminine body can either operate successfully under societal expectations or ineffectually while transcending expectations. Therefore, the body as a source of innate power is an illusion; it is either afforded power within a patriarchal system or stripped of power outside of one. Noyes presents her body openly to display her innate feminine power. Yet, certain areas must remain covered—lest her video be deemed pornographic—and her body is displayed in a specific way to please the audience. Alongside the further implication of self-surveillance, Gill points out that postfeminism has constructed the female body as “a window to the individual’s interior life,” thus further deconstructing the idea of the body as individual power⁶.

Gill ironically utilizes the text of a colleague who states, “If a thong makes you feel fabulous, wear it”⁷ to provide an example of the illusion of empowerment defined by the watchful eye of male desire. Noyes explicitly falls into this trap as she wears a thong to appear sexually empowered, but thongs have no innate correlation to self-empowerment; rather, they are a marketed commodity made to sexualize women in the bedroom. Her disillusion is displayed by her contradictory self-empowerment paired with lyrics stating that she still needs a man, just not this one⁴.

5 FRAMEWORK: FEONA ATTWOOD

This paper specifically utilizes excerpts from Feona Attwood’s 2009 work *Mainstreaming Sex: The Sexualization of Western Culture*. Feona Attwood is a professor of media and culture studies with published work emphasizing the interplay between media texts—specifically porn studies—and the increased sexualization of culture. Attwood loosely defines sexualization of culture as the proliferation of visible sexuality and sex within mainstream culture. She includes a unique perspective

regarding the impact of technology within the space of sexualized media by exploring how technology has been particularly influential in accelerated distribution.

Attwood explores the transformation of sexualization and culture through a similar vein of sensibilities as Gill. Attwood argues that sex has absorbed a new meaning outside of cultivating a relationship between two individuals. Sex now exists, she argues, as a form of self-expression and transient pleasure—a unique facet of modern feminism. Attwood's articulation of the sexualization of media is presented in contrast to existing discussions of sexualization as a social problem. Defining it as a social problem, Attwood argues, ignores its complexity, cultural context, and risks moral panic and censorship. Sexualized media should instead be approached as the complex and implicative concept it is.

The purpose of her development of an alternative framework is to dive further into the discussion of cultural sexualization as a method for reading media texts such as the one explored in this paper. Her understanding of postfeminism aligns with Gill's as she agrees with the concept of overlapping neoliberalism and postfeminist understandings of empowerment. Similar to Gill, Attwood explores the context of neoliberalism as a false form of individualism parallel to modern feminism. However, she also offers a further exploration through the concept of sexual citizenship, and she warns against abandoning media as a site for contextualizing sex and disrupting narratives of 'good' or 'bad' sex. In other words, Attwood explores an alternative to inevitable neoliberalism by offering it as an existing pathway to the development of informed citizenship and expansion of sexual conceptions beyond academia to produce informed sexual media consumers. This paper's utilization of Attwood's framework is less structured than Gill's, but it offers an expanded exploration into the specifically sexualized nature of the media text.

6 APPLICATION OF ATTWOOD

6.1 Pornographic Imagery

Attwood forefronts the argument that sex has become a weakened form of self-pleasure, and there needs to be a reimagining of sexual ethics applicable to recurring discussions of media sexualization. She stresses the idea that a pure rejection of sexualization would be a failure to the advancement of feminist studies in an effort to remind her readers that sexualization is an inescapable part of modern media. Aversion amplifies negative consequences operating through ignorance.

She supports this thesis by discussing the proliferation of pornographic styles within mainstream media, including music videos. As mentioned in the exploration of the test case, the filming style of the music

video recalls amateur pornography with shaky zoom-ins, homemade video static, and overly zoomed-into segments of Noyes' naked body. Furthermore, Noyes utilizes a "porn look" in her video by including images of sexualized symbols, wearing clothing that would have once been relegated to sex workers, and dancing seductively for a general audience.

The music video follows Attwood's idea of commercial sex being gentrified within the "high street"¹. Noyes is extraordinarily successful at presenting her sexuality as something that avidly avoids disgraceful connotations of nudity by covering societally "crude" body parts and adorning her body with objects of wealth. Although she is wearing a thong, it is made of individual diamond stones and paired with gold rings complimenting her "tasteful" makeup and flowery pasties. She is afforded the ability to present her sexuality in this way with little pushback and gentrify porn-like clothing into symbols of wealth and status due to her operation within white feminism.

6.2 Sexualized Self-Value

The sexualization of media has resulted in the publicization of intimacy in a way that forces individuals to rely on their sexualized bodies for self-value:

Whether it is domesticated in intimate relationships between couples or let loose in hedonistic and uncommitted sexual episodes, sex is often now seen as central to the creation and expression of an individual's self¹.

Noyes embodies both situations explained by Attwood. Noyes describes the story of an intimate, domesticated relationship where the male partner used his girlfriend as a source of consistent sexual pleasure. She would give him what he desired as a way to feel loved and in control since he would "only listen when [she's] naked"⁴. The sex expected of her from her partner became a direct method of her self-expression as it was a necessary precursor for her to share her otherwise ignored emotions. The visuals of the music video approach Attwood's other example of uncommitted sexual episodes as Noyes strokes her body and publicly displays her sexuality to regain control of the "self."

Attwood's point about the dangers of finding individuality through explicit sexuality is solidified by Noyes stating that she will "be the woman for someone who's nothing like you"⁴. This is where it becomes apparent that Noyes was simply relying on the illusion of self-empowerment as she is still committed to finding a new relationship in which she can define herself through mutual sexuality once again. Therefore, Noyes falls into the consequence that Attwood outlines as the disciplined, sexy female body becoming the key display of women's

power within modern feminism, which, rather than empowering, requires an internalization of an unattainable and oppressive view of female sexuality¹.

At the most basic level, Noyes's display of sexuality is a display for the male gaze to spite her former lover and attract the next. The sexualization of media calls for the incorporation of sexualized bodies in spaces that they did not previously occupy. While Noyes may feel privately empowered by her body, her display of it alongside the lyrics in the video calls into question the reason for including the images of her body. This is where the text becomes a test case for the debate within postfeminism: to either advocate for an anti-porn stance to avoid unnecessary sexualization of bodies or to advocate for a pro-porn stance to correlate bodies with empowerment. Ultimately, Attwood argues that both cases fail to recognize the nuances of texts such as "Man Needs a Woman." Attwood offers a solution to the issues she presents in her work—to "analyze the role of porn industry in the mainstreaming of sex"¹ and its subsequent consequences. Thus, recognizing the façade of sexual power presented in this music video becomes a first step in the application of Attwood's theory.

7 CONCLUSION

The proliferation of sexualized media has undoubtedly transformed the discourse within modern feminism, and it has resulted in a new wave of feminism that struggles to articulate a solidified stance regarding such media. Some feminist scholars view widespread sexualization as a form of oppression and degradation of women. However, other scholars believe such arguments operate under the category of "prudish" as there is a blurred line drawn between correct and incorrect forms of sexual liberty. Ultimately, the combination of Rosalind Gill's and Feona Attwood's works surrounding postfeminism and the sexualization of media offer a new way of understanding texts such as "Man Needs a Woman."

It is not the display of sexuality within the music video that presents a problem; it is the underlying reason for this display. This is why both Gill and Attwood forefront the concept of postfeminism as a sensibility and exploration into how existing social structures, expectations, and the history of feminism are necessary confounding factors in the creation of sexualized media texts. The music video explored in this paper does not exist within a vacuum of overt versus covert sexuality. Rather, it operates within the complex ways women have come to understand their sexuality and choose to display it.

Ultimately, "Man Needs a Woman" can be understood as a postfeminism text—through the framework of Gill—that operates within the sexualization of me-

dia—through the framework of Attwood. It is through the exploration of singular pieces of texts that feminist scholars can begin to resolve the vast divide between anti-feminist prude and pro-porn liberation as they search for the underlying reasons for displays of public sexuality and how such displays ultimately affect the individual. Further explorations into similar media texts, both influential and isolated, should utilize a more robust collection of existing feminist scholarship to develop a conversation between scholars and continue to expand the debate.

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This paper began as a paper written for Dr. Rachel Liberman's "Media, Power, and Sexualization" undergraduate course. It makes no value statement regarding the media test case but, instead, offers it as the basis for a method of exploring existing postfeminist frameworks.

9 EDITOR'S NOTES

This article was peer-reviewed.

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Gender Diversity in the Workplace: Pronouns, Gender-Stereotyped Job Listings, and Perceptions of Hireability

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Abstract

Past research has investigated the impact of gender and gender biases on hiring decisions for cisgender individuals. However, there is a lack of research on how perceptions of gender diverse individuals impact hiring decisions. The current work explores how a job applicant's gender pronouns may impact the likelihood of the applicant getting hired. We also investigated whether this likelihood varied depending on the job description—specifically whether it included content related to gender stereotypes (e.g., “nurturing” versus “leadership capabilities” as a desired trait in job applicants). Ninety-six participants were randomly assigned to view an application package including she/her, he/him, or they/them pronouns, then rated the hireability of the applicant for two gender-stereotyped job listings (masculine, feminine) and one no-trait job listing (referenced as job trait: masculine, feminine, unspecified). We predicted that applicant pronouns would bias judgements of hireability, with nonbinary being rated least hireable, and further that this effect may be moderated by gendered job characteristics. Results indicated that there was no main effect of gender on hireability, nor an interaction between job applicant gender and job trait. Our study furthers the discussion on conceptualizations of nonbinary people and how others ascribe gendered traits to them.

Keywords: *hireability, pronouns, gender minorities, hiring discrimination, nonbinary*

1 INTRODUCTION

Gender identification outside the binary (i.e., a gender identity that is not exclusively man or woman¹; see Appendix A) is becoming increasingly common, as nonbinary people made up 11.1% of the United States (US) adult LGBTQ+ population as of 2021², an increase from 2-10% in data from 2016-2018³. Despite increasing representation in the population, gender diverse people (i.e., people with a non-normative gender identity—normative being cisgender men and women⁴) continue to face high levels of discrimination^{5,6}. Gender diverse individuals report barriers in educational environments, healthcare settings, and the workplace^{7,8,9}. Of particular interest is the workplace, as the average American spends a significant amount of time—40.5 hours a week—at their place of employment¹⁰, and workplace outcomes can have a significant impact on mental and physical health^{11,12}. 27% of employed trans and nonbinary people reported some form of workplace

discrimination, including having limited access to bathrooms, being misgendered, experiencing verbal and physical abuse, being socially excluded, being fired, and being denied promotion^{7,8}. Trans and nonbinary people also report taking measures to avoid mistreatment, such as quitting their jobs or discontinuing or delaying gender-affirming care—access to which can decrease negative health outcomes such as depression and suicidality and increase life satisfaction¹³. Such chronic experiences of discrimination are linked with poorer health and well-being¹⁴. Indeed, gender-nonconforming individuals are particularly at risk for negative health outcomes (e.g., depression, suicidality, and chronic stress); 39% of transgender (trans; i.e., people whose gender identity differs from the sex assigned to them at birth and/or conceptualizations of gender within their culture¹⁵) and nonbinary Americans reported serious psychological distress compared to 5% of the general U.S. population^{7,16,17}.

The adversity described above is only encountered if

gender diverse people can gain access to employment, as the gender discrimination present in the workplace poses additional barriers in the hiring process. At 15%, the unemployment rate for trans and nonbinary individuals was three times higher than in the general U.S. population (at 5%) as of 2016⁷. Unemployment can result in negative mental health outcomes for gender diverse people (i.e., anxiety, mood disorders, and suicidality¹⁸) and can affect long-term finances (i.e., lifetime earnings, homeownership, etc.¹¹). Employment can also provide benefits like health insurance, which eases the financial burden of potentially life-saving health care for nonbinary individuals (i.e., gender-affirming care, treatment for HIV, and mental health resources¹⁵). Hence, understanding barriers to employment and equitable treatment in workplace contexts are critical for determining the mental and physical health outcomes as well as the long-term financial outcomes of gender diverse individuals. The current work aims to extend experimental research on the biased and discriminatory treatment of gender diverse individuals in hiring contexts. Specifically, we focus on nonbinary individuals, a relatively understudied and underserved population with respect to hiring equity.

1.1 Binary Gender, Hireability, and Workplace Perceptions

Past literature has demonstrated the prominent role that the gender of an applicant plays on perceptions of judgements of whether a candidate is fit for hiring (referred to as hireability hereafter), fit for a position, and professional competence, which are theorized to influence hiring decisions. For example, in a study by Francesco and Hakel¹⁹, men were perceived as most hireable compared to women in an experimental context, and in another by González and colleagues²⁰, men were perceived as more hireable than their equally qualified women counterparts. These results are consistent with historic and current gaps in the employment of women compared to men — as of 2023, 57.1% of U.S. women participate in the labor force compared to 62.6% of men²¹. Further, once hired, male-stereotypic traits are often viewed as those most desirable in the workplace²⁰, and men are most readily assumed to fit these stereotypes. Women are perceived to be a poor fit for male-dominated positions, as they are assumed not to possess the typically masculine traits that are considered necessary for success²². As a result, women are subject to more negative performance expectations in their job than men.

Despite consistent evidence that there is bias for hiring cisgender (i.e., those whose gender identity aligns with the sex assigned to them at birth) men relative to those of other gender identities, past research demonstrates that the effect of gender on hireability is context-

dependent. Certain jobs are gendered (e.g., dominated by men or women or associated with gender's stereotyped traits)¹⁹. Puwar's Bodies Out of Place theory states that based on gender stereotypes, we bring to mind an individual who would be the "natural" choice for a certain job, and those who have a congruent gender presentation to this "perfect fit" will be perceived as most hireable²³. Those who have a mismatch between their gender identity and a position's gendered traits may be perceived as less hireable than applicants whose gender aligns with the stereotypes of the position^{24,25}.

In the U.S., men make up significantly more of the workforce in masculine-dominated fields, such as microfinance, and are deemed more competent in their roles than their female counterparts²⁶. In the study previously mentioned by Heilman et al., women were ranked lower than men on performance expectations due to perceived incongruity between female stereotypes and masculine role expectations²². On the other hand, women are more likely to be hired for and make more of the workforce for feminine stereotyped positions, such as caregiving and nursing, due to perceptions that they fit the required traits such as warmth²⁷.

The literature reviewed above is almost exclusively limited to perceptions of men and women. Since nonbinary individuals may not be perceived to fit jobs stereotyped as either masculine or feminine or dominated by men or women, it is unclear the positions for which they are seen as most suitable or those in which they will experience the most discrimination. Because we predict that perceptions of nonbinary people may be informed by associations between nonbinary individuals and binary identities, it is critical that we draw from past workplace bias to understand how it may impact gender diverse people in their careers.

1.2 Theoretical Framework on Nonbinary Perceptions

There are several theoretical frameworks regarding beliefs about gender—belief in gender as a binary concept, androcentrism, and general gendered assumptions—that can provide an explanation for perceptions of nonbinary individuals and how this may impact their employment opportunities. The belief that gender and sex are fundamentally binary and determined by biological features may contribute to prejudice towards nonbinary individuals^{28,29}, as nonbinary identities contrast with the ideology that gender is innate and is rooted in sex. This belief could lead to negative perceptions of gender diverse individuals regardless of context³⁰ or job traits.

Similarly, androcentrism might also impact gender discrimination. Androcentrism refers to the idea that men and their needs and values are prioritized as the center of society³¹, meaning that men are the default

in society. Neutral terms such as “human” and “person” are perceived as masculine, as such men may be inferred when gender-neutral language is used³². Due to this tendency to assume gender-ambiguous language is referring to men, this effect may extend to the use of they/them pronouns. When using ambiguous pronouns (i.e., they/them) for an unknown person (e.g., “someone left their phone here”), the individual in question may be assumed to be a man and therefore more likely to possess stereotypically masculine traits and fit a masculine job³³.

Another possibility is that gendered perceptions of nonbinary people could be formed on the basis of assumptions regarding gender and sex. Often, nonbinary individuals may be assumed to be assigned female at birth (AFAB; see Appendix A) because relative to masculinity, femininity is viewed as more flexible³⁴. Further, in male-dominated contexts, an individual AFAB may even be more positively perceived when they transgress feminine stereotypes and display masculine appearances and behaviors³⁵. Because masculinity is valued in broad culture and more specifically within the workplace²², transgressing the stereotypes associated with being assigned male at birth (AMAB) is viewed as more threatening and less justified by displaying the traits associated with a higher social status³⁶. From this theoretical framework, we predict that gendered assumptions about nonbinary people (i.e., associating nonbinary individuals with masculine or feminine traits) could lead to perceptions of their hireability following associations between nonbinary individuals and binary identities.

1.3 Nonbinary People in the Workplace

Previous workplace discrimination research narrowly defines gender and is usually restricted to comparisons between cisgender men and women, underscoring the need to expand research on gender diverse individuals. However, emerging evidence suggests that gender diverse people may also be affected by biased hiring decisions. For example, Francesco and Hakel included an androgynous job applicant in their design, which was rated lower for hireability than the male applicant¹⁹. Prentice and Carranza provide a possible explanation for these hiring biases: those who display traits that don't fit prescriptive gender stereotypes are perceived negatively compared to those who do³⁷. Because gendered traits are typically conceptualized within a man/woman dichotomy³⁸, those who show incongruence with binary traits may be perceived more negatively as compared to those who fall within the binary. This is particularly apparent in the workplace, where gender stereotypes may be applied to those seen as the best fit for certain positions. As binary people don't fit into gendered categories as explicitly as a cis man or woman might, the extent to which gendered job stereo-

types will influence perceptions of nonbinary individuals' fit for certain positions. We want to explore if the effect of gender pronouns on hireability is moderated by gendered job traits.

1.4 Overview of the Present Study

The current work aims to address the gaps in research on nonbinary people in the workplace by evaluating the impact of gender pronouns on perceptions of hireability. More specifically, we are interested in the differences in perceived hireability of binary gender pronouns (he/him, she/her) and nonbinary pronouns (they/them). Further, we want to investigate the effects of pronoun manipulation on hireability interaction with gendered job traits. For example, we will explore whether individuals using he/him pronouns are seen as hireable depending on if the job description fits masculine stereotypes. Of particular interest is whether people using they/them pronouns are seen as more suitable for positions characterized by masculine or feminine traits or neither. Thereby, this work aims to inform literature on gender-based inequities in hiring and stereotype application (e.g., leadership as a masculine trait and warmth as a feminine trait) with a more inclusive operationalization of gender.

To test these questions, participants were randomly assigned to an application package using one of three pronouns (he/him, she/her, or they/them) and gendered experiences (e.g., girls mentorship, boys mentorship, and LGBTQ+ youth mentorship). Participants then rated the applicant's fit for three job listings that provided desired gender-stereotypic traits (masculine or feminine) and a no trait condition.

Given past findings on impact of gender on perceptions in the workplace^{22,36}, we predicted that the applicant that uses they/them pronouns would be perceived as less hireable across job posting conditions compared to applicants with binary pronouns (she/her and he/him), and the applicant with he/him pronouns would be rated most hireable overall. We predicted that applicant pronouns and gender-stereotypic job listings would interact such that hireability ratings would be highest when the applicant's gender was perceived as congruent with the gender-stereotyped job listing traits, and the lowest ratings would result from a perceived incongruence³⁷. Specifically, the participants viewing the application package featuring he/him pronouns would rate the applicant as most hireable for the masculine job trait condition, followed by the no trait control condition, and least hireable for the feminine trait condition. Whereas, the participants viewing the application package using she/her pronouns would rate the applicant most hireable for the feminine trait condition, followed by the no trait control condition, and least hireable for the masculine trait condition.

Within this interaction, our question of interest is centered around the simple effect observed in the they/them condition, under which we hypothesized three possible patterns based on varied theoretical perspectives.

1. *Androcentrism*. Based on the concept of androcentrism (e.g., the idea that masculinity is the default in Western language and culture), nonbinary people who use they/them pronouns may be perceived as more masculine³³. The applicant with they/them pronouns may resemble the pattern of results from the applicant with he/him pronouns, so the applicant would be rated most hireable for the masculine job trait condition, followed by the no trait control condition, and least hireable for the feminine trait condition.
2. *Flexibility of Femininity*. As femininity is viewed as more flexible than masculinity, people may be more likely to assume that someone who identifies as nonbinary was AFAB³⁵. The ratings of the applicant with they/them pronouns may resemble the pattern of results from the applicant with she/her pronouns, so the applicant would be rated most hireable for the feminine trait condition, followed by the no trait control condition, and least hireable for the masculine trait condition.
3. *Overall Discrimination*. As nonbinary people are subject to both interpersonal and societal discriminations, applicants that use they/them pronouns may be considered less hireable regardless of job traits. The applicant with they/them pronouns may be rated significantly lower across all job listing conditions relative to the applicants with he/him and she/her pronouns.

2 METHOD

All methods were pre-registered on AsPredicted. View the preregistration here: [Aspredicted.org/yt3x6.pdf](https://aspredicted.org/yt3x6.pdf).

2.1 Participants

The present study's sample size was limited by funding constraints. We recruited as many participants as possible within the study budget.¹ A total of 110 participants were recruited via the CloudResearch platform and paid \$1.25 as compensation. Participants were excluded from analyses if they failed an attention check question or self-reported that their data was of poor quality (indicated by a response to the question "how carefully did you complete this study?" of less than four on a five-item Likert Scale from 1 (not at all) to

5 (very)), resulting in a sample size of 96 participants included in analyses. Ages ranged from 22 to 72 ($M = 38.16$, $SD = 9.86$). One participant was excluded from the calculation of age descriptive statistics because they entered an invalid age. Mean annual household income was \$60,588 ($SD = \$33,984$). Table 1 provides data on participant gender, sex assigned at birth, race/ethnicity, sexual orientation, educational attainment, and political ideology. A sensitivity power analysis conducted in G*Power³⁹ indicated this sample size ($N = 96$) could detect a medium effect of $\eta_p^2 = .08$ or greater at 95% power using the average correlation among repeated measures.

| Variable Name | N | % |
|--|----|------|
| Current Gender ($n=96$) | | |
| Men | 58 | 38.5 |
| Women | 37 | 38.5 |
| Prefer Not to Say | 1 | 1.0 |
| Ethnicity ($n=96$) | | |
| White/European American | 75 | 78.1 |
| Black/African American | 8 | 8.3 |
| East Asian | 7 | 7.3 |
| Hispanic/Latin American | 3 | 3.1 |
| South Asian | 1 | 1.0 |
| Prefer Not to Say | 1 | 1.0 |
| Other | 1 | 1.0 |
| Sexual Orientation ($n=96$) | | |
| Heterosexual | 88 | 91.7 |
| Bisexual | 6 | 6.3 |
| Lesbian/Gay | 1 | 1.0 |
| Other | 1 | 1.0 |
| Level of Educational Attainment ($n=96$) | | |
| High School Equivalent | 16 | 16.7 |
| Some College, No Degree | 16 | 16.7 |
| 2-Year College Degree | 10 | 10.4 |
| 4-Year College Degree | 36 | 37.5 |
| Graduate or Professional Training | 18 | 18.8 |
| Political Ideology ($n=96$) | | |
| Strongly Liberal | 18 | 18.8 |
| Liberal | 21 | 21.9 |
| Somewhat Liberal | 14 | 14.6 |
| Both Liberal and Conservative | 15 | 15.6 |
| Somewhat Conservative | 10 | 10.4 |
| Conservative | 13 | 13.5 |
| Strongly Conservative | 5 | 5.2 |

Table 1 Demographic Data for Participants

2.2 Materials

Application Package Vignette

Participants were randomly assigned to read one of three application packages. Application packages were identical except for applicant pronouns and gendered

¹This study was conducted as part of a class project. The class was allocated \$500 and three small group studies were conducted. Thus \$166 was allocated to this study.

activities (more below). Each package included a summary of the applicant with age (22), education level (bachelor's degree), and type of position the applicant is applying for (full-time position). The package also included a resume with the following information: college-level education with majors and minors occluded and GPA (3.65); professional experience of a summer internship (with the company name occluded); and two gendered campus engagement activities (more below). The final component of the application package was a two-sentence endorsement from a previous manager using the applicant's pronouns.

Across the three conditions, the gender varied. In the he/him condition, parenthetical pronouns read (he/him), the two campus engagement activities were titled men's club soccer and boys leadership, and the endorsement included he/him pronouns. In the she/her condition, parenthetical pronouns read (she/her), the two campus engagement activities were titled women's club soccer and girls leadership, and the endorsement included she/her pronouns. In the they/them condition, parenthetical pronouns read (they/them), the two campus engagement activities were titled all-gender club soccer and LGBTQ+ leadership, and the endorsement included they/them pronouns. See Appendix B to view the full application packages.

Job Listing Vignette

Participants viewed three hypothetical job listings in a randomly determined order. The job listings were all titled "entry level post," posted by ABC Corporation, describing a full-time, salaried position in Denver, Colorado, requiring a college degree in a related field. The listings varied only by preferred traits listed. The masculine-stereotyped job listing included "solid business sense, takes initiative, and decisive." The feminine-stereotyped job listing included "interpersonal skills, creativity, and skilled communicator." The control job listing stated "no traits listed." Stereotyped traits included were based on a study by Born and Taris assessing gendered perceptions of traits included in job listings⁴⁰. See Appendix C to view the full job listings.

Hireability Scale

We adapted the Hireability Scale used by Madera and colleagues⁴¹. The modified scale included five items used to evaluate the perceived hireability, fit, and belonging of the applicant for each of the three job listings on a nine-point Likert scale from 1 (not at all) to 9 (very much). Example items included "How likely would you be to hire the candidate for this job?" and "How likely is it that the candidate will make an effective employee at this job?" One original item was removed ("Is it likely that this candidate will make an effective employee at [company]?") and replaced with "To what degree do you feel that the candidate would belong at this job?" to

better assess perceptions of belonging. One additional item was added to assess perceptions of fit: "How good of a fit is the candidate for this position?" The five items were averaged to create a composite variable for hireability ($M = 6.88$, $SD = 1.47$). Consistent with the original scale ($\alpha = .99$)⁴¹, the modified scale had high reliability in the present study ($\alpha = .97$).

Interpersonal Comfort

To assess participants' feelings regarding interacting with nonbinary people as an individual difference measure, we used the Interpersonal Comfort (IC) subscale of the Nonbinary Attitudes and Beliefs Scale (NABS; modified from Transgender Attitudes and Beliefs Scale (TABS))⁴². The original scale (TABS) was modified into NABS to replace the word 'transgender' with 'nonbinary' in each item (e.g., "I would be uncomfortable if my boss was transgender" was changed to "I would be uncomfortable if my boss was nonbinary"). The Interpersonal Comfort subscale is a 14-item scale with eight reverse-scored items. Participants responded on a seven-point Likert scale from 1 (strongly disagree) to 7 (strongly agree). The 14 items were averaged to create an Interpersonal Comfort composite score ($M = 5.49$, $SD = 1.64$). Consistent with past use ($\alpha = .93$)⁴², in the present study, the Interpersonal Comfort subscale had high internal reliability ($\alpha = .97$).

2.3 Procedure

Researchers posted the surveys to a paid survey website, CloudResearch. Participants were told that they were tasked as a job recruiter who must read an application package that includes a brief introduction to the prospective employee, a snippet from their resume, and part of a letter of recommendation from a previous employer. They were then randomly assigned to one of three pronoun conditions (i.e., he/him, she/her, or they/them) which they were asked to read carefully. Participants then completed the modified Hireability Scale⁴¹ three times—one time for each job listing (i.e., masculine, feminine, and no traits). The order of job trait presentation was randomly determined for each participant. After answering questions about hireability, participants completed the Interpersonal Comfort factor of the Nonbinary Attitudes and Beliefs Scale (NABS; modified from Transgender Attitudes and Beliefs Scale (TABS))⁴² with the order of items randomized. The survey ended with a demographics questionnaire, an attention check, and a debrief on the goals of the study.

3 RESULTS

This study investigated how pronouns used in a resume package and job traits (feminine versus masculine) impacted perception of applicant hireability. We predicted

a main effect of pronouns on hireability (i.e., participants assigned to the nonbinary condition would evaluate the candidate more negatively than those assigned to the binary conditions), with he/him pronouns rated higher than she/her pronouns. We also predicted that there would be an interaction between pronoun condition and job trait condition. Applicants using binary gender pronouns (i.e., she/her and he/him) may be rated as most hireable for the job listing if the pronoun matches the gendered job listing. That is to say, the she/her applicant would be rated most positively for the feminine job listing, followed by the no traits job listing, and least positively for the masculine job listing. We also had multiple predictions for the simple effect of the nonbinary pronoun condition (i.e., *Androcentrism*, *Flexibility of Femininity*, and *Overall Discrimination*).

To test whether pronoun, job traits, or the interaction between the two impacts hireability, we used a 3 (pronoun: he/him, she/her, they/them) \times 3 (job traits: masculine job traits, feminine job traits, no traits control) mixed model ANOVA on hireability. A composite hireability variable was created for each gender-stereotyped job listing condition to create three variables: hireability for masculine job listing, hireability for feminine job listing, and hireability for no traits condition. We observed no significant main effect of pronoun condition on hireability, $F(2,93) = 8.48$, $p = .432$, $\eta^2 = .02$. Descriptively, the they/them condition ($M = 7.11$, $SE = 0.26$) was evaluated as most hireable, followed by the she/her condition ($M = 6.92$, $SE = 0.25$), and followed by the he/him condition ($M = 6.64$, $SE = 0.25$). There was no significant main effect of job trait on hireability, $F(1,93) = 0.92$, $p = .341$, $\eta_p^2 = .01$. Descriptively, the feminine job trait condition ($M = 7.08$, $SE = 0.16$) resulted in the highest hireability evaluations, followed by the no trait condition ($M = 6.87$, $SE = 0.19$), followed by the masculine job trait condition ($M = 6.71$, $SE = 0.16$). Finally, there was no significant interaction between pronouns and job traits, $F(4,186) = 0.57$, $p = .686$, $\eta_p^2 = .01$. These results indicated that neither pronouns nor gendered job listing had a significant effect on perceptions of hireability. Further, these two variables did not interact to inform perceptions of candidate hireability.

Next, we aimed to examine whether scores on interpersonal comfort with nonbinary individuals moderated pronoun condition effects on hireability. This measure was added to determine if participants who rated nonbinary applicants as less hireable did so due to their lack of interpersonal comfort or because of the applicant's perceived lack of fit. A moderation analysis was conducted via PROCESS MACRO⁴³ in which hireability was regressed onto pronoun condition (more below on multicategorical treatment), interpersonal comfort with nonbinary people (mean centered), and interaction terms. Pronoun condition includes three levels; thus, multicategorical analyses were warranted. We em-

ployed sequential contrast coding (pronoun condition X1: he/him = 0, she/her = 1, they/them = 1; pronoun condition X2: he/him = 0, she/her = 0; they/them = 1) where the first condition coding compared dominant (he/him) versus low status (she/her and they/them) groups, and the second compared binary (he/him and she/her) versus nonbinary (they/them) conditions. The model included interaction terms between interpersonal comfort and both condition contrasts. The overall model was significant, $F(5, 90) = 4.11$, $p = .002$. Main effects and interactions from this analysis are depicted in Table 2. Notably, there was a marginal interaction between pronoun condition and IC on hireability, $F(2, 90) = 2.65$, $p = .076$. This interaction is depicted in Figure 1. Based on contrast coding, this interaction was best characterized by a comparison between he/him versus she/her and they/them, $t(5, 96) = 1.92$, $p = .058$. To this point, IC was positively correlated with hireability ratings for those assigned to the they/them ($r = .54$, $p = .002$) and she/her ($r = .49$, $p = .005$) conditions, but not to those assigned to the he/him condition ($r = -.01$, $p = .977$). In sum, interpersonal comfort seems associated with responses to low status groups (i.e., those who use they/them and she/her pronouns) but not dominant groups (i.e., those who use he/him pronouns) in judgments of hireability.

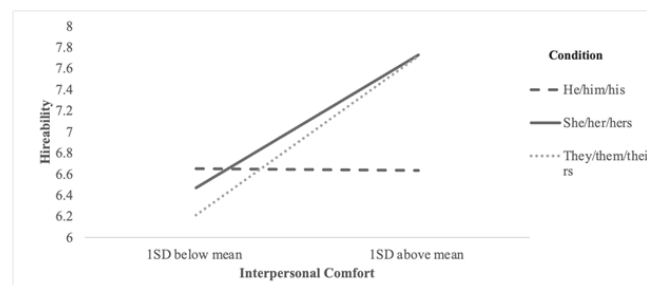


Figure 1. Differences in interpersonal comfort scores do not affect perceptions of hireability for those in the he/him condition. However, for those in the she/her condition and they/them condition, perceptions of hireability are significantly affected by interpersonal comfort, with higher interpersonal comfort resulting in higher perceptions of hireability across all job listings.

| Test | Coefficient | <i>df</i> | <i>t</i> | 95% CI | <i>p</i> |
|----------------------|------------------|-----------|----------|---------------|----------|
| Main effect of X1 | <i>b</i> = 0.48 | (5,96) | 1.41 | [-0.19, 1.15] | .162 |
| Main effect of X2 | <i>b</i> = -0.13 | (5,96) | -0.37 | [-0.81, 0.86] | .712 |
| Main effect of IC | <i>b</i> = -0.01 | (5,96) | -0.03 | [-0.33, 0.32] | .975 |
| Interaction Using X1 | <i>b</i> = 0.39 | (5,96) | 1.92 | [-0.01, 0.81] | .058 |
| Interaction Using X2 | <i>b</i> = 0.08 | (5,96) | 0.38 | [-0.32, 0.47] | .706 |

Table 2 Main Effects and Interactions of Second Analysis on Hireability. Pronoun condition X1: he/him = 0, she/her = 1, they/them = 1. Pronoun condition X2: he/him = 0, she/her = 0; they/them = 1. IC = interpersonal comfort with nonbinary individuals.

4 DISCUSSION

The present study aimed to measure the effects of job applicant gender identity and job characteristics (i.e., whether the job required gender-stereotypic skills) on hireability. Contrary to our predictions, we observed no main effects of pronoun condition on hireability and job listing on hireability, nor an interaction between pronouns and the job listing on hireability. That said, exploratory analyses indicated a marginal interaction between interpersonal comfort (IC) with nonbinary individuals and pronoun condition on hireability. Results showed that differences in IC scores were not associated with perceptions of hireability for those in the he/him condition, while perceptions of hireability for she/her and they/them pronouns were significantly predicted by IC. Thus, IC may be an important measure when investigating perceptions of people holding marginalized gender identities in the future.

4.1 Implications

Though our primary hypotheses were not supported, this work opens the door for new research examining how nonbinary individuals are perceived in the workplace. Past research^{44;20;22;37} on gender expression in the workplace has been largely limited to binary identities, focusing on binary gendered stereotypes and how they influence the hiring and workplace experience of men and women; yet, these studies lack individuals with diverse gender expression and identity. The present study included a nonbinary pronoun condition, opening up a discussion about how individuals with nonbinary identities are perceived in different contexts.

While our main analyses examining the impact of gender pronouns and stereotyped job contexts on hireability did not yield significant results, our auxiliary analysis offered novel insights into how the association between pronouns on perceptions of hireability may be dependent on one's interpersonal comfort with nonbinary people. Comparing the dominant group (he/him) versus the lower status groups (she/her and they/them), we found that participants who had high IC with nonbinary people were more likely to rate the she/her and they/them conditions as more hireable

than those with low IC were. However, the IC levels did not influence the hireability of the he/him condition. We theorize that IC in our study could characterize a broader phenomenon where individuals who have more positive feelings towards both nonbinary individuals may also feel positively towards low status groups generally (i.e., women, trans individuals, etc.).

These results suggest the potential positive effect of increasing comfort for decreasing prejudice towards unfamiliar groups. This phenomenon could occur with increased exposure to minoritized groups such as nonbinary people. This could be executed via intergroup contact, as Allport's contact hypothesis suggests that regular contact between groups can reduce intergroup prejudice⁴⁵. There is evidence that intergroup contact is an effective intervention in reducing prejudice towards other minority groups, as Crystal and colleagues⁴⁶ found that children who had more contact with other-race individuals reported that exclusion of other races was wrong. Because intergroup contact is an effective intervention in this case, one could infer that it could be an effective intervention for gender bias. We theorize positive contact interventions could enhance IC and thereby prosocial treatment of nonbinary individuals.

4.2 Limitations and Future Directions

While our study explored an understudied area regarding hireability perceptions of nonbinary people, it was underpowered. The sensitivity power analysis indicated that our study could detect an effect size of $\eta_p^2 = .08$ or greater, and the greatest effect size in our main analysis was below this threshold, $\eta_p^2 = .02$. Thus, the findings should be interpreted with caution.

Regarding our manipulation of job listing traits, the vignettes we used were simplistic, vague, and lacking realism. This limited information is not entirely representative of real job listings, and therefore our results may not accurately reflect hiring contexts. Further, our within-subjects manipulation of job characteristics (a design decision reflective of budget constraints and power concerns) may have also undermined realism, as job recruiters are not likely to compare the hireability of one applicant for multiple job listings. Because of the lack

of ecological validity discussed, participants possibly disengaged from seriously evaluating the applicants as a job recruiter would, perhaps causing them to respond in a way they would not in an actual recruitment decision. Additionally, our pool of participants were not required to have a background in hiring, therefore, their assumptions are not based on real-world experience. These design choices were made in service of internal validity, as we aimed to control for potential confounds.

We must also acknowledge that we used they/them pronouns as a proxy for nonbinary individuals; however, gender pronouns are only one aspect of gender presentation. While gender pronouns have certain implications, they do not fully encapsulate one's gender identity. Information on an individual's gender identity manifests in many forms, and many of them are not visible in a limited social context⁴.

Morgenroth and Ryan describe several facets of gender identity unacknowledged by only pronouns, including the costume (appearance and presentation of the body) and the script (gendered behaviors) that an individual embodies⁴. Simply reading pronouns on an application does not provide these facets of information about the applicant's gender, which further affect perceptions of them.

Another limitation regarding pronouns is the use of only they/them pronouns to represent a nonbinary applicant. While they/them pronouns are the most common pronouns used by nonbinary people⁴⁷, there are many other possibilities for pronouns that individuals may use. Other pronouns also likely activate different evaluations of an individual when encountered⁴⁸.

Neopronouns (e.g., xe/xim) are less commonly used and multiple pronouns (e.g., she/they) are infrequently studied in research than they/them pronouns, and people are likely even more unfamiliar with them now than they are with they/them pronouns. Research shows that unfamiliarity can heavily impact levels of comfort⁴⁹, which we theorize likely contributes to discrimination towards gender nonconforming individuals. The subliminal mere exposure effect refers to the idea that people generally feel more positive towards and/or more comfortable with familiar stimuli compared to unfamiliar stimuli⁵⁰. Further, future studies could investigate how increased exposure to unfamiliar pronouns (i.e., neopronouns) could increase positive feelings towards those pronouns and by extension individuals who use those pronouns.

Expanding the pronouns used could both help make future studies more inclusive as well as delve deeper into how nonbinary people experience the world. Future studies could apply our framework to these additional pronouns, and we hypothesize that neopronouns and use of multiple pronouns would be perceived as less hireable than those using they/them pronouns due

to unfamiliarity.

While we focused on one social identity (gender), intersectionality theory argues the importance of considering multiple social identities (e.g., race and gender) on access to opportunities and discriminatory treatment^{51,52,53}. Research provided support for this theory—suggesting unique and exacerbated experiences of discrimination among those holding multiple stigmatized identities. For example, a study conducted by Edelman et al.⁵⁴ found transgender people of color were 19% less likely to be hired than their white, transgender counterparts. Similarly, Suárez found that transgender women were more likely to be the subject of discrimination in the workplace if they possessed any of the following identities: being a person of color (POC), having a lower socioeconomic status, or being of lower social class⁸. Future research should follow the lead of Suárez and examine multiple stigmatized identities or incorporate considerations of multiple identities that target job discrimination, as each individual's experience will be uniquely influenced by the various facets of their identity.

4.3 Conclusion

This investigation sought to find how pronouns and gendered job descriptions might interact to predict how hireable a job candidate might appear. Though we didn't find any significant effects in our primary investigation, we found noteworthy effects related to the Interpersonal Comfort Scale, which could be a basis for future investigations on how nonbinary people might be perceived in the workplace or other domains. Thus, low status groups may depend on the comfort levels of others to improve their perceptions as more positive, and in this case, as more hireable. Further, from previous findings, one can deduce that increased contact with individuals from low status groups (i.e., nonbinary people) may increase IC. We aim to argue that this work is important in inspiring the inclusion of gender diversity in examination of gender bias and lays the groundwork for future studies that can improve upon the limitations of the current work. As a future direction, we suggest analyzing more pronouns such as neopronouns and studying whether a person with neopronouns or multiple pronouns is rated as less hireable than a person with they/them pronouns. The findings from our present study illuminate the importance of IC and the impact it may have on how nonbinary individuals are perceived. This work highlights the need for further research concerning this issue, with a focus on taking an intervention approach to reducing bias towards this community via increased contact. These discoveries indicate potential areas for intervention to reduce prejudice in the hiring process and ultimately create a more inclusive society.

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6 EDITOR'S NOTES

This article was peer-reviewed.

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Appendix A

Extra Considerations Regarding Gender

Evolving Gender Terminology

As topics surrounding gender identity become increasingly discussed due to gender diverse people feeling better represented in American culture than in past years, the language associated with gender diverse populations continues to evolve¹. The terminology we use may be outdated, enforce a binary framework where there need not be one, or convey a sense of homogeneity that is inaccurate to a community whose members' individual experiences are paramount. The terms used in this paper are based on the authors' current understandings of up-to-date terms, and we aim to contribute to the knowledge of gender diversity while hoping that it continues to evolve.

Transgender as an Umbrella Term

Many of our cited studies and statistics are based on transgender populations or group nonbinary people under the umbrella term 'transgender.' This label is not one that all nonbinary individuals feel captures their identity, and while some nonbinary people identify as trans, others do not⁵⁵. However, the experiences that follow disruption of the concept of an innate binary are lived by both binary trans people and nonbinary people. With this commonality in mind, we use literature on trans people to support our claims and develop hypotheses on nonbinary people. We relate these groups with caution due to the limited literature that specifically reports on nonbinary experiences.

Assigned Sex at Birth

The use of the terms AMAB and AFAB can be inauthentic to the experiences of nonbinary people and enforces a binary approach to sex that is inaccurate⁵⁶. Arguments against using this terminology include the way that these terms force nonbinary people into boxes of gender/sex and imply that their biological sex (also not innately binary⁵⁶) informs their current gender. Because our study involves social *perception*, and perception research provides ample evidence that perceivers are motivated to classify sex and gender using binary labels and perceive sex and gender as largely overlapping constructs⁵⁶—our language will include these terms to describe the role *inferred* biological sex may play in social judgments.

Gender-Neutral Pronouns

There are many different pronouns that nonbinary people use, including some combination of he/him, she/her, and they/them pronouns (e.g., he/they), as well as neopronouns (e.g., ze/zir), and they/them is only one possibility. For simplicity in this exploratory study, we used what is currently the most common set of gender-neutral pronouns, they/them⁴⁷, in our nonbinary condition. As we expand upon in our discussion, using only one set of gender-neutral pronouns limits the extent to which we can generalize our results to the experiences of all nonbinary people.

Appendix B

Application Package Vignettes

Name: [REDACTED] (he/him/his)
 Age: 22
 Education Level: Bachelor's Degree
 Applying For: Full-time position

EDUCATION
 University of Denver
 Bachelor of Arts in [REDACTED] Minors in [REDACTED] Denver, CO
 June 2024

- Overall GPA: 3.65
- Accomplishments: Cherrington Global Scholar; Microsoft Office Excel Certified
- Study Abroad: Charles University, Prague, Czech Republic Sept. 2022 – Dec. 2022

PROFESSIONAL EXPERIENCE
 [REDACTED] Organization
 Summer Intern, May 2022 – Sept. 2022

- Engaged with customers or clients and provided service and/or sales
- Learned and became proficient with company's internal systems and processes

CAMPUS ENGAGEMENT, UNIVERSITY OF DENVER
 Men's Club Soccer
 Player, Oct. 2020 – Oct. 2022

- Helped schedule practices and maintain team goals
- Committed approximately 10 hours per week to training, meetings, and travel while maintaining full course load

Boys Mentorship: Teen Mentorship Program Oct. 2020 - Present

- Aids boys in creating concrete goals in order to achieve future plans
- Strives to provide constructive feedback to teens

"He was a fabulous addition to our team and I am confident that he will succeed in his next pursuit. He was consistently on time and went the extra mile to ensure that all of his work was completed by the end of every shift."
 - Previous Manager

Figure 2. The He/Him Condition

Name: [REDACTED] (she/her/hers)
 Age: 22
 Education Level: Bachelor's Degree
 Applying For: Full-time position

EDUCATION
 University of Denver
 Bachelor of Arts in [REDACTED] Minors in [REDACTED] Denver, CO
 June 2024

- Overall GPA: 3.65
- Accomplishments: Cherrington Global Scholar, Microsoft Office Excel Certified
- Study Abroad: Charles University, Prague, Czech Republic Sept. 2022 – Dec. 2022

PROFESSIONAL EXPERIENCE
 [REDACTED] Organization
 Summer intern, May 2022 – Sept. 2022

- Engaged with customers or clients and provided service and/or sales
- Learned and became proficient with company's internal systems and processes

CAMPUS ENGAGEMENT, UNIVERSITY OF DENVER
 Women's Club Soccer
 Player, Oct. 2020 – Oct. 2022

- Helped schedule practices and maintain team goals
- Committed approximately 10 hours per week to training, meetings, and travel while maintaining full course load

Girls Mentorship: Teen Mentorship Program Oct. 2020 – Present

- Aids girls in creating concrete goals in order to achieve future plans
- Strives to provide constructive feedback to teens

"She was a fabulous addition to our team and I am confident that she will succeed in her next pursuit. She was consistently on time and went the extra mile to ensure that all of her work was completed by the end of every shift."
 - Previous Manager

Figure 3. She/Her Condition

Name: [REDACTED] (they/them/theirs)
 Age: 22
 Education Level: Bachelor's Degree
 Applying For: Full-time position

EDUCATION
 University of Denver
 Bachelor of Arts in [REDACTED] Minors in [REDACTED] Denver, CO
 June 2024

- Overall GPA: 3.55
- Accomplishments: Cherrington Global Scholar, Microsoft Office Excel Certified
- Study Abroad: Charles University, Prague, Czech Republic Sept. 2022 – Dec. 2022

PROFESSIONAL EXPERIENCE
 [REDACTED] Organization
 Summer intern, May 2022 – Sept. 2022

- Engaged with customers or clients and provided service and/or sales
- Learned and became proficient with company's internal systems and processes

CAMPUS ENGAGEMENT, UNIVERSITY OF DENVER
 All-Gender Club Soccer
 Player, Oct. 2020 – Oct. 2022

- Helped schedule practices and maintain team goals
- Committed approximately 10 hours per week to training, meetings, and travel while maintaining full course load

LGBTQ+ Mentorship: Teen Mentorship Program Oct. 2020 – Present

- Aids LGBTQ+ youth in creating concrete goals in order to achieve future plans
- Strives to provide constructive feedback to teens

"They were a fabulous addition to our team and I am confident that they will succeed in their next pursuit. They were consistently on time and went the extra mile to ensure that all of their work was completed by the end of every shift."
 - Previous Manager

Figure 4. They/Them Condition

Appendix C

Job Listing Vignettes

Entry-Level Post

ABC Corporation • Denver, CO (On-site) • 3 days ago

Job type: full-time, salaried

Education Requirements: College degree in related field

Preferred Traits: solid business sense; takes initiative; decisive

Figure 5. Masculine-Stereotyped Traits

Entry-Level Post

ABC Corporation • Denver, CO (On-site) • 3 days ago

Job type: full-time, salaried

Education Requirements: College degree in related field

Preferred Traits: interpersonal skills; creativity; skilled communicator

Figure 6. Feminine-Stereotyped Traits



Lion by Parker Crowley

Scratch Board

SHAMING WOMEN TO SHAME MEN: A CASE STUDY OF THE HOUTHIS AND THE RELATIONSHIP BETWEEN HONOR CULTURE IN YEMEN AND SEXUAL VIOLENCE AGAINST WOMEN IN THE YEMENI CIVIL WAR

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Abstract

The factors that influence an armed group's use of sexual violence against women during times of conflict is a much studied area due to the prevalence of the phenomenon, and the significant implications it has for human rights. Studies on the subject have generally contended that cultural attributes and practices present during peacetime play a significant role in determining whether or not an armed group will incorporate sexual violence as a part of their strategy. A relatively under-researched cultural practice that could influence the use of conflict-related sexual violence (CRSV) is the presence and importance of honor culture in a society experiencing conflict. This article seeks to expand on the understanding of its influence by analyzing the relationship between honor culture in a society and how its characteristics influence the groups operating within it to use sexual violence against women as part of their strategy, using examples of female victims of CRSV carried out by the Houthis in Yemen. It concludes that the honor culture of the society the group operates within influenced them to use more CRSV. This understanding has significant implications for policymakers and academics in predicting the severity of sexual violence that might occur in a given conflict happening in an honor-based culture.

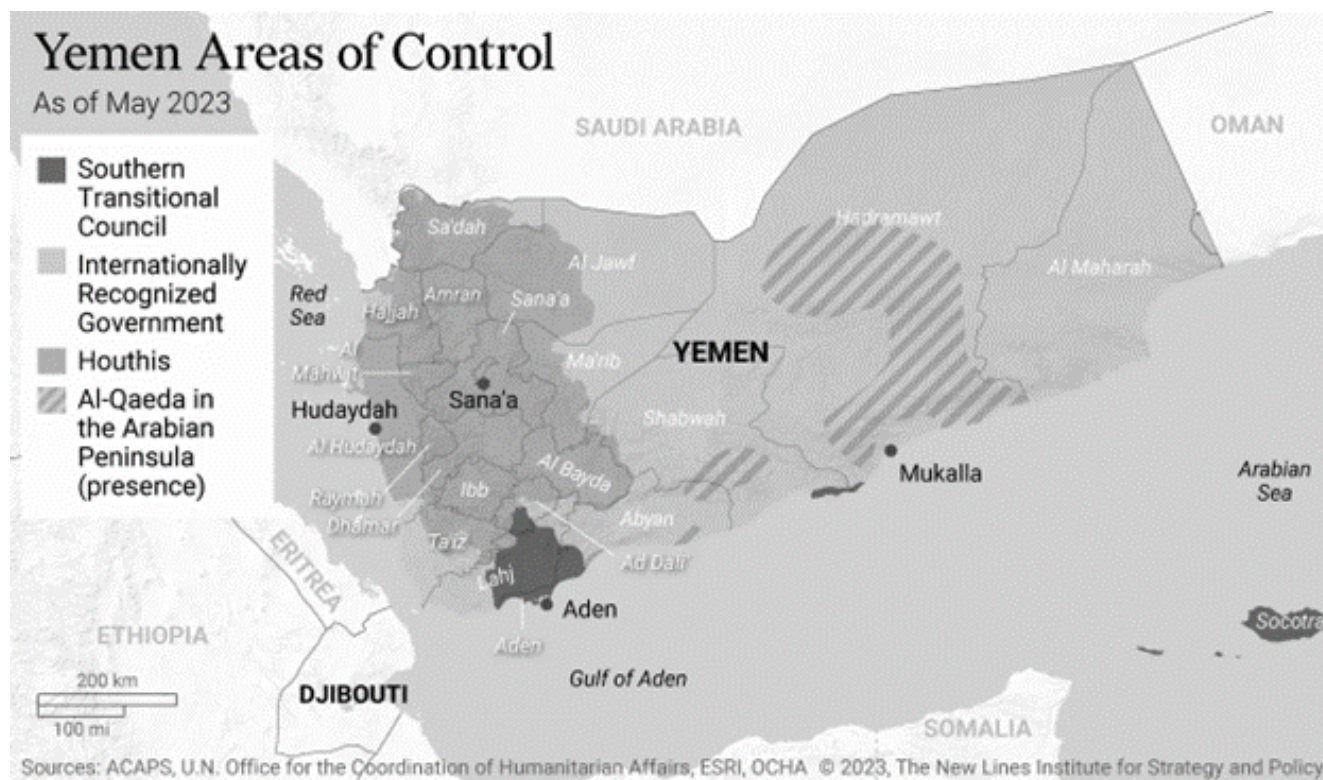
Keywords: *sexual violence, intrastate war, women, Middle East, honor*

1 INTRODUCTION

There have been several civil wars in Yemen's history, but this paper will focus on the most recent one. The current Yemeni Civil War has been ongoing since 2014, with several temporary ceasefires and attempts at peace talks. The major actors in the conflict include the Houthis (the main focus of this paper), a rebel group originating in Yemen and partially supported by Iran; the official government of Yemen, which is supported by Saudi Arabia and formerly the United States; and the Southern Transitional Council (STC), which is supported by the United Arab Emirates (UAE)¹. Other, more minor actors with significantly less influence than the three main groups include several Islamist groups, such as Al-Qaeda in the Arabian Peninsula (AQAP) and the Yemeni branch of the Islamic State (IS, commonly referred to as ISIS). The map of Yemen displays the areas of control of the STC, the official government of Yemen, the Houthis, and AQAP².

The Houthis, whose official name is Ansar Allah, are an Islamist armed group with control over much of Northern Yemen. Their goal is to raise the Houthi clan and its other tribal allies to be the preeminent governmental power in the country and to implement their version of an Islamic state³. This is a way for the Houthis to justify their rule using Islam and to shape the laws of the country to fit their needs. This would likely include the continued use of sexual violence against women by the group in order to maintain power. They currently control Yemen's former capital Sana'a and several important ports⁴. The region under Houthi control is cut off from the international community.

The official government of Yemen is backed by Saudi Arabia, with former support from both the UAE and the United States. The international community is divided on supporting either the official government of Yemen or the STC, although most of the world, including the United Nations⁵, recognizes the official Yemeni government as the legal authority in the country.



The STC has deep roots in Yemen's history. Yemen was previously divided into two countries, North Yemen and South Yemen⁴. The STC, supported by the UAE, is seeking to set up a government in control of South Yemen and separate from North Yemen to once again form two separate states.

Currently, the main conflict is between the Houthis and the two other actors, the STC and the official Yemeni government. The Houthis are also using force against civilians to cement their power over the population within their area of military control in the North. The sexual violence committed by the Houthis against civilians will be the main focus of analysis in this paper.

Since the beginning of the Yemeni Civil War in 2014 thousands of women have been held in Houthi prisons and detention centers without legal justification, and while being detained have experienced numerous forms of violence and violations of their human rights.

Enas Muhammed is a 22-year-old woman from an area of Yemen currently under Houthi control. The daughter of a local tribal leader, she was arrested by the Houthis under the pretext that she had engaged in prostitution and held in one of the group's many political prisons for several months. While detained, she was the victim of rape, beatings, starvation, and other heinous methods of torture, including receiving electric shocks. She was eventually released after the Houthis had accomplished their goal of extorting her father⁶.

Enas's story is devastating, but unfortunately, situa-

tions like it are not uncommon in the Houthi-controlled regions of Yemen. Statistics for the number of women and girls who have been killed or imprisoned by the Houthis are difficult to gather due to the secrecy of Houthi prisons, the routine imprisonment of journalists and activists, and the general instability of the region. However, according to the collective documentation of three Yemen-based human rights organizations, at least 1,181 women were detained by the Houthis in only the three years of the conflict between December 2017 and December 2020, and 293 of them were under the age of 18⁶. However, the actual number of detained women is likely much higher due to a lack of transparent reporting, and even the official number only includes detainees from three years out of the almost nine years of the conflict.

The implications of the Houthis' use of sexual violence against Yemeni women play a vital role in their strategy in the civil war, with the group even having a unit dedicated specifically to targeting women⁷. This opens up the question of why sexual violence against women is so important to the Houthis as a non-state armed group, compared to other similar actors who do not always use such tactics⁸, especially not as frequently as the Houthis do. This question of why a group might or might not choose to use sexual violence against women as a war strategy has become increasingly relevant in the academic literature.

This study brings to light a factor that heavily in-

fluences the Houthis' decision to use sexual violence against women: the fact that the group is operating within an honor-based society. Honor-based societies place extreme importance on the sexual purity and overall honor of females, which determine the reputation and public participation of the entire family⁹. This makes attacks against women's sexual purity extremely effective for armed groups operating within a society that follows such an honor culture, such as the Houthis in Yemen.

The principal finding of this study is that, based on an analysis of the Houthis in Yemen, non-state armed groups that are operating within an honor-based society will incorporate sexual violence against women as a part of their war strategy. Further, this study finds that the reason for this relationship is that in an honor-based society, sexual violence is especially devastating and impacts not just the victims but their families and communities as well, damaging both their economic and social viability.

2 LITERATURE REVIEW

Several academic articles in the realm of gender and conflict studies have focused on the motivations behind non-state groups that commit violence against women. Before considering the contributions of those studies, it is important to first consider the meanings of the terms sexual violence and CRSV within the current literature.

The definition of sexual violence varies significantly from article to article, but in general, the term includes rape, sexual assault, genital mutilation, sexual torture, sexual slavery, forced nudity, and sexual acts under coercion and can include all genders^{8;10}. However, in the context of this study, sexual violence against women is focused on.

CRSV similarly has no single agreed-upon definition and is a much more recently adopted term within gender and conflict studies. The definition accepted by most scholars is that CRSV includes all sexual violence committed by an armed actor during or immediately after a time of conflict¹¹. This includes sexual violence committed against both civilians and combatants.

The consensus is that there is no singular factor that explains whether a group will or will not use sexual violence, either against civilians or combatants. Instead, a multitude of factors influence the presence, prevalence, and types of CRSV that occur in each case⁸. However, some scholars, especially earlier on in the evolution of conflict studies, contended that whether or not a group will use sexual violence is determined primarily by its opportunity to and its ability to use it as a strategic weapon¹¹. This stance ignores the multitude of factors within every conflict that contribute to whether that opportunity and strategic ability are realized. This study seeks to move beyond the assumption that all armed

groups will use violence if they have the ability to and consider an aspect of the specific context that influences an armed group's motivation for the use of sexual violence.

It is generally recognized in the literature that the culture in which the conflict takes place impacts the characteristics (presence, prevalence, and types) of CRSV. Specifically, the cultural attitudes surrounding sexual violence that exist during peacetime don't simply disappear at the outbreak of conflict. They, instead, are intensified and carried out on a larger scale by the actors in the conflict^{12;8}. Depending on the specific cultural attitude towards sexual violence, its use during wartime will be received differently. If a culture has taboos against sexual violence, then it is less likely to be prevalent during conflict⁸. The literature is still exploring how the various cultural attitudes that support sexual violence impact its use during conflict. Several studies have examined specific case studies on culture and CRSV, and some trends have been extrapolated. These include issues of ethnicity¹³, patriarchy¹², and as a part of the intentional genocide of a specific population¹⁴.

Whether due to cultural or other factors, sexual violence has been weaponized for a variety of aims within the context of conflict, including intrastate conflict. As in the trends mentioned above, these include sexual violence as a weapon of ethnic cleansing, such as targeting women of a certain minority group for sexual violence¹⁴ and sexual violence as a reinforcement of the patriarchal structure of a society in order to prevent the full and equal participation of women in a conflict or resistance¹². This weaponization of sexual violence against women makes the study of the motivations behind it, and therefore the likelihood that an armed group will use it, incredibly relevant.

When considering the impacts of culture on the characteristics of CRSV, it is important to keep in mind whether the cultural values being discussed are held by either the leaders of the armed group, the combatants writ large, or both. This is true because combatant beliefs impact their actions and how closely they follow the orders of their leaders based on whether they align with their viewpoints¹⁵. So, if a large proportion of the combatants hold a given cultural value that is affected by sexual violence, then it is more likely to impact the use of sexual violence.

A largely unexplored cultural attitude that involves support for sexual violence is the presence of honor culture in society. The conclusion in the current literature is that in a culture where women are viewed both as in a separate sphere from men and as symbols of their honor, then armed groups acting within that culture are more likely to incorporate sexual violence into their strategy¹⁶. However, prominent gender and conflict studies scholar Wood criticizes this hypothesis as

unconfirmed because the current studies neglect to address whether the cultural belief of women as honor symbols is held by the combatants and the society they operate within and then weaponized or if the sexual violence is purely a strategy formulated by the leaders and then instructed to the combatants⁸. The beliefs of the citizens and local combatants and why they choose to carry out sexual violence and incorporate it into their methods is a critical aspect to consider when confirming the hypothesis that armed groups acting within an honor-based culture are more likely to utilize sexual violence as a part of their war strategy.

This study seeks to use a case study of Yemen, where the cultural view of women is largely influenced by beliefs about honor, to examine how honor culture affects the characteristics of CRSV in the Yemeni Civil War. It will include a qualitative examination of the local combatant beliefs of women within honor culture in order to confirm the hypothesis that combatants view women as honor symbols, and then analyze how this influences their use of sexual violence, along with the types of and prevalence of CRSV, rather than just focusing on the correlation between honor culture and the presence of sexual violence. This will add a new, culturally informed dimension to the broader literature on the use of sexual violence during conflict and, therefore, will assist in predicting whether CRSV will be prevalent in a given case and what the characteristics of that sexual violence might be.

3 METHODOLOGY

This article uses the case study of Yemen as its focus to analyze the impact of honor culture on the weaponization of sexual violence against women as a war strategy for non-state armed groups. Yemen was chosen for several reasons. First, it has an honor-based culture and an ongoing conflict in which a non-state armed group systematically uses violence against women. Second, it has one of the most deeply entrenched and conservative honor cultures in the world^{17;18;19}. As a mostly rural, underdeveloped, and politically unstable country, it has all of the factors that make a society more likely to prioritize honor culture values and norms above government laws^{17;18}. Because the dynamics of honor culture are present in everyday Yemeni actions, the impact of those dynamics on war is extremely evident, making Yemen an excellent focus for this article.

Incidents of actual or perceived sexual violence against women committed by the Houthis were analyzed to consider how occurring within an honor-based society affected the Houthis choice to use that sexual violence as a part of their strategy, and its degree of effectiveness. Perceived incidents of violence were included due to the relevance of instances when the Houthis claimed to have enacted sexual violence

against a woman without actually having done it. The incidents came mainly from the United Nations Human Rights Council reports of violations of human rights in Yemen. Explanations of the several occurrences of violence were listed in the report in a direct, factual manner, with almost all of the citations within the report regarding the details of the violence listed as Confidential Sources on File. This makes the United Nations the nearest known source for most of this study's information regarding examples of sexual violence in Yemen committed by the Houthis. However, it is likely that those sources are derived at least in part from on-the-ground reporting from Yemen.

4 ANALYSIS

4.1 Honor Culture in Yemen

Before analyzing the impact of honor culture on instances of CRSV against women in the Houthi controlled areas of Yemen, it is important to consider the characteristics of those honor-based values in general and in Yemen in particular. Honor culture manifests and is practiced differently depending on the broader culture that it operates within and its specific historical development, but it has a few common characteristics across different societies. These include a patriarchal social structure, an emphasis on reputation, the belief in the importance of women's sexual purity (and the justification of violence or even homicide against women whose sexual purity is believed to have been violated, regardless of whether it actually was), and the connection of individual honor to family honor and often to tribal honor¹⁸. Each of these practices will be elaborated on in the context of how the case study of Yemen experiences them and how those practices manifest in the current Yemeni Civil War.

Yemen has a strong tribal identity²⁰, in which the honor of the families in a tribe determine the honor of that tribe. Within a family, the patriarch ensures the honor of every member, thus the collective family. The women in the family are regarded as property to trade through marriage, and in order for the trade to occur, their virginity and reputation as being sexually pure must be intact. These attributes of women as property based on their sexual purity make them symbols of honor, representing the reputation of the family and the reputation of their tribe⁹.

When a woman's sexual purity is believed to have been violated to the extent that her status as an honor symbol jeopardizes her family, the patriarch of her family is expected to enact violence upon her in order to preserve the family's honor¹⁸. That violence can take the form of genital mutilation, forced early marriage (often to the rapist in the case of rape), forced suicide, or murder, known in this context as an honor killing¹⁷.

These forms of gendered violence are intended to restore the honor of the family, and while almost always illegal, are often overlooked by the societies they occur in frequently⁹, including Yemen because honor culture is so ingrained, and because the punishments often occur in more private settings. In Yemen specifically, even if an honor killing is reported to the authorities (which is already incredibly unlikely due to the reasons mentioned above, the political instability, and lack of governance in the region) and criminal action is taken against the person who committed the murder, Yemen's legal system reduces the sentence if the murder was committed by a man against his female relative and in the name of honor²¹. This means that Yemen's honor culture is a social construct and is also legally cemented in the country's government and legal systems.

When family or tribe honor is considered to have been violated by the larger society (for example, before the honor punishment/crime against a sexually impure woman in the family is enacted, or if another violation of honor has occurred), then their access to participation in the public sphere is diminished⁹. Honor is needed for a group to be recognized in public life and to be able to engage in business and social life. Because of the serious repercussions caused by a violation of honor, families place significant pressure on women to maintain their reputation and sexual purity due to their role as honor symbols and how significantly they can damage the social standing and economic viability of the family.

It is difficult to get an accurate number of honor killings or honor crimes for a given time or region because they often go unreported due to their private nature and because communities tend to hide them from authorities. As a result, reported numbers are considered to be an underestimate. Given that, there are some statistics regarding the prevalence of honor crimes. In 1997, there were 400 honor killings (this does not include nonlethal honor crimes) in Yemen, making the country have one of the highest rates of honor crimes¹⁹. This makes Yemen an excellent case study for researching how the influence and presence of an honor culture results in the use of sexual violence as a war strategy.

4.2 Sexual Violence Committed by the Houthis and the Influence of Honor Culture

The Houthis are well known within the international community for their routine violations of human rights and use of excessive violence, including sexual violence. Houthi forces regularly engage the local civilian populations, especially protestors and human rights activists, and are targeted for kidnapping, violence, coercion, or arrest²¹. In addition to civilians, the Houthis target and label women as enemies and thus subject women to violence. However, the group often uses a specific branch of their military force to enact violence against women,

especially in public areas, like at protests and demonstrations. The entirely female military branch is known as the Zainabiyats. They routinely use severe methods of force against women, including beating, harassing, facilitating rape, kidnapping, and other forms of violence^{7,6}. The group also has roles in guarding female prisoners of the Houthis and ensuring their compliance. Thus, when referring to violence against women, it is likely that the Houthi Zainabiyat were the perpetrators.

Notably, almost all Houthi combatants are from Yemen. Their core goals revolve around the belief that the Houthi tribes are the rightful rulers of their region of Yemen and, as is increasingly becoming the case, the entirety of the country³. Most members are either part of the original Houthi family, Houthi tribes, or other nearby tribes and clans they have created alliances with. Because of their unique makeup, the Houthis hold deeply rooted Yemeni values; thus, they are well aware of the cultural beliefs they are operating within, including the importance placed on values like honor, reputation, family, community, and women's sexual purity, and how their actions and strategies will culturally impact their Yemeni enemies through violations of honor.

These strategies include detaining women to taint their honor, using socially condemned honor violations as excuses to imprison female activists, and targeting specific women for CRSV in order to induce shame and ostracization by their male family members.

4.2.1 Post Detainment and Honor

An analysis of the Houthis' imprisonment of women, along with how and why they release those women from detainment, reveals that honor culture influences the Houthis to arrest more women in order to damage their reputation of honor, which inflicts significant damage to their families and communities.

A major tactic the Houthis use to control the civilian population and allegedly combat enemy infiltration includes detaining protestors and transferring them to prisons, police stations, or other areas for interrogation; this often results in the use of sexual violence, torture, and threats²¹. When women are detained in this manner, the Houthis use Yemen's honor culture to their advantage. The phenomenon is explained by an example of a 2018 protest that resulted in the Houthis detaining female protestors.

On October 6, 2018, a protest at the University of Sana'a, which is under Houthi control, included both male and female protestors and was responded to by a large force of both male Houthi soldiers and female Houthi Zainabiyat soldiers. The soldiers deployed the use of verbal threats and physical violence before forcing between 30 and 50 female protestors to a separate location for interrogation. In this specific case, the authorities released the protestors-turned-prisoners after their interrogation on the condition that they would

cease participation in future protests and be collected by their adult male authority figure²¹. These conditions align with Yemeni society, which legally guarantees that men have guardianship over women²¹. There is evidence that sexual violence occurred against some of the detainees on that day⁶. Given how common the Houthis' use of sexual violence against prisoners is, local civilians likely speculated that it was employed.

The Houthis' requirement for a male relative to pick up their female relative should be especially noted. Requiring the male relative to pick up their female relative, whom they have authority over, ensures that the man is informed of the woman's political actions and knows she was detained and possibly had sexual violence enacted against her. In addition, because the male relative visited the detainment area, his reputation, along with the family and community's reputation, is called into question.

Regardless of whether a woman actually engaged in a sexual act and if it was consensual or not, her family's honor is also called into question; as a result, the family's ability to engage in the public sphere and remain economically stable is at risk⁹. So, by involving a female detainee's male relative, the Houthis are using Yemen's honor culture to punish not just female protesters but their entire families and even communities. This makes sexual violence against women, and even just the threat of it, a viable control strategy for the Houthis or any armed group acting within an honor culture-based society.

A female detainee's actions exemplify the effectiveness of the Houthis' control strategy. Her husband was her male authority figure, so he was expected to pick her up from where she was detained. However, the woman would not contact him to get her because she knew that if he came, his reputation would suffer²¹. The dynamics of Yemen's honor culture clearly play out in this case, with the woman recognizing the threat to her family due to her tarnished reputation from the Houthis' detainment.

This situation was not the only one of its kind. Between December 2017 and December 2020, the Houthis detained at least 292 female activists and 246 female humanitarian workers, but these numbers are likely significant understatements and include documented detainments for only three of the war's nine years⁶. The Houthi practice of imprisoning female protesters and activists is routine⁷. Because the male relative is negatively impacted, she is highly discouraged from future participation in political action due to the danger imprisonment presents as a woman in an honor-based society. This makes Yemen's honor culture and its view on sexual violence a key factor in the Houthis' strategy of controlling civilian women by imprisoning women and tarnishing their reputation or sexual purity. Such a strategy would not be as effective if employed in a

society that does not value the outward perception of sexual purity and its vitality to family honor and social standing. This supports the supposition that the perceptions of sexual violence within honor culture have influenced the Houthis' strategy to include more violence against women due to its unique effectiveness within an honor-based society.

4.2.2 *Honor as a Justification for Imprisonment*

The pattern of Houthi arrests of female activists and their choice to falsely charge them frequently with crimes like prostitution (which are highly stigmatized in honor-based societies) demonstrates that honor culture makes women uniquely vulnerable to armed groups because the culture provides a strategy for the group to illegally hold women who go against them with little to no local pushback.

Houthi violence against people associated with human rights organizations or activism often includes imprisonment and torture, where the detainee is held illegally without any legitimate criminal charges. Detainees have included both men and women, sometimes along with their family members. When women are detained for their political actions or associations, the Houthis often cite charges of prostitution to give the imprisonment a legal basis²¹. However, by charging female prisoners with heavily stigmatized crimes like prostitution, they call her honor into question. Despite the fabricated charges, in Yemen's honor culture, even the perception of having a tainted honor is dangerous for her family¹⁸. Due to the potential backlash to the family of a woman whose sexual purity, and therefore honor, is ruined, the Houthis' charge of prostitution makes it almost impossible for the family or community to come to her assistance in trying to have her released. If they did so, they would violate the societal norm that a woman whose honor is tainted should be punished in order to redeem her family so that they can maintain their social standing.

The Houthis' use of prostitution charges against women, in particular, is an often-used tactic for them. In fact, in 2019 alone, at least 400 women were arrested by the Houthis on charges of prostitution⁶. This number was released by the Houthis as an accomplishment for the group. Like other statistics of violence in Yemen, these numbers are an underestimation of reality. In this case, the numbers only include arrests from one of the nine years of the conflict. Additionally, most of those women who were charged with prostitution were identified by local Yemeni human rights organizations as political activists who took action against the Houthis.

In a non-honor-based society, charges of prostitution against illegally imprisoned women would not hold much weight and could potentially be overturned. But in an honor-based society, prostitution is a very serious crime and is highly unlikely to be disputed by citi-

zens or the detainee's family. Even activists in Yemen face the danger of being imprisoned if they dispute the charges^{7,21}. Illegally holding political prisoners, especially women, is such a viable and frequently used strategy as it offers a way for the Houthis to effectively discourage women from initially getting involved in activism due to the potential damage that would be caused to their families if they were arrested. This reduces the amount of public opposition that the group receives.

4.2.3 Targeting Specific Women to Shame Men

The Houthis' choice to enact sexual violence against specifically chosen women, who had no previous political involvement, demonstrates a specific strategy used to hurt men whom they view as their enemies. This is because by sexually violating the honor of a woman, the Houthis use characteristics of the honor-based society to reinforce shame on the male guardian.

In Yemen and many other countries that consider women to be symbols of family honor, women will always have a male guardian or authority figure in their lives. Whether their father, husband, or brother, this guardian has legal control over the woman and can restrict her ability to travel or leave the house at all, and can potentially enact honor crimes against her if he deems it necessary²¹. As a woman's guardian, a man views it as his duty to protect her from harm. This often manifests as male guardians heavily regulating what women and girls are permitted to do, including where they can go and who they can talk to, in order to prevent her honor from being violated. If her honor is violated by another man (either by an attack against her or of her own volition), then her guardian is considered to have shamefully failed to protect and properly regulate her. Thus it is not only the woman but the guardian and the rest of his family whose honor is diminished²¹. With his diminished honor inherently comes public shame and a reduced ability to engage in his community's business dealings.

Intense pressure is put on men who are the guardians of Yemeni women to prevent these women from being sexually violated. Because of this, when the Houthis need to shame or damage the social standing of a man, targeting one of his female relatives for sexual violence is a viable method to inflict significant harm on him. This makes Yemeni women incredibly vulnerable to CRSV due to the aspects of honor culture that connect their sexual purity to the livelihood of their male relatives. In this way, women merely become objects of a war strategy. They also become ways for the armed group to target specific men whom they view as enemies.

The story of Enas Muhammed in the introduction of this article is an excellent example of this phenomenon. Enas is the daughter of a Sheik (a local tribal leader) liv-

ing in a Houthi-controlled area that resisted the group. Enas had never been involved in politics or actions against the Houthis. In order to target her father, the group kidnapped and then illegally imprisoned, tortured, and raped her⁶. The Houthis employed this strategy because the honor culture they were operating within made it an effective option. Enas's father's honor, and therefore social standing, was connected to her sexual purity because they live in an honor-based society, so targeting her for sexual violence did a significant amount of damage to him. Because his daughter, who is under his guardianship and represents his honor, had her honor tainted by another man, he likely endured shame and ostracization within his community, especially considering that he is a local leader.

Enas' situation demonstrates the effectiveness of the Houthis' strategy of using sexual violence against women to shame and target their male family members, particularly their guardians. Her case is not the only example of the Houthis intentionally targeting a woman for sexual violence to harm her male guardian. Multiple women have been kidnapped and made victims of rape, imprisonment, and torture so that the Houthis could inflict damage on their male relatives²¹. This makes women incredibly vulnerable to violence in the region, even if they are never involved in politics or other aspects of the conflict, such as defying the Houthis.

This strategy would not be nearly as effective in a non-honor-based society and might not even be employed. It also might not be recognized by the combatants as an effective strategy if these combatants did not hold honor-based values. But the Houthis do, which furthers the conclusion that honor culture makes CRSV against women more likely.

The larger goal of the Houthis as a non-state armed group is to gain control of Yemen. As a result, a central part of their strategy must be to reduce opposition to their rule. Employing CRSV accomplishes this by threatening imprisonment to deter opposition from women, actually imprisoning female opposition members under the guise of honor crimes, and targeting specific women for violence in order to damage the reputation of their male relatives who oppose the Houthis.

5 CONCLUSION

When armed groups are acting within an honor-based society, it is highly likely that they will incorporate systematic sexual violence against women as a part of their war strategy. This article has demonstrated this relationship using information from the existing literature on CRSV and armed group motivations, along with a case study of the non-state armed group, the Houthis, acting within Northern Yemen as a part of the Yemeni Civil War. The case study of Yemen demonstrated that within the context of the country's deeply entrenched honor

culture, where the sexual purity of females determines their family's social standing¹⁹, the armed group acting within the honor-based society used this knowledge to target women for sexual violence to inflict damage on her guardian, family, and community. Ultimately, when combatants have honor-based values and operate within an honor culture, it makes sexual violence against women more likely to occur during times of conflict. This conclusion is drawn through the analysis of three examples of the impacts of honor culture on the Houthis' war strategy and systematic use of sexual violence. First, the Houthis detained activist women and then directly involved their male family members in order to shame their families and prevent future political action by the women. Second, the Houthis used highly stigmatized charges, such as prostitution, in order to imprison women for significant lengths of time and prevent their communities or families from coming to their aid. Finally, the Houthis targeted the female family members of their male enemies to inflict harm on them by reducing their access to public and economic participation by diminishing their family's honor.

Understanding that honor culture influences a non-state armed group's decision to incorporate sexual violence against women as a part of their war strategy has several implications for future action. It could help academics, policymakers, non-governmental and inter-governmental organizations, other countries, and other actors in international politics predict if high levels of CRSV will be a concern in potential future global conflicts. This could be done by gaining an on-the-ground understanding of the presence of honor culture in an area experiencing conflicts involving a non-state armed group. If both of those factors are present, then groups can prepare for the high likelihood that any non-state armed groups involved will use sexual violence as a part of their strategy.

This logic could also be applied to present conflicts that have both non-state actors and an honor culture, such as Syria in the Syrian Civil War^{9;19}, Sudan in its current insurgency²², or Palestine in the Israel-Gaza War^{17;18}. Applying this article's results to other societies could further confirm its claims because honor culture manifests many similarities across broader cultures⁹. However, some differences occur, including the different levels of importance placed on women's honor and the ramifications for violations of honor¹⁹. Those differences in other potential case studies could help confirm that this article's conclusion is relevant to Yemen but to honor-based societies in general.

Future research could also examine post-civil war Yemen to determine if the entrenchment of honor culture in Yemeni society was increased or decreased by the Houthis' co-optation as part of their methods of CRSV.

The prevalence of honor cultures in underdeveloped

and politically unstable areas makes studying the impact of honor culture on conflict and CRSV incredibly relevant to the academic literature on conflict studies, as well as for policymakers and other actors^{17;18}.

6 LIMITATIONS

6.1 Research Limitations

Several factors prevent the conclusions of this study from being accepted with complete certainty. These include both limitations to the research process and personal limitations and biases. Beginning with research limitations, the choice of Yemen as the basis of this study introduced some challenges. Yemen was selected in part because it is currently undergoing the Yemeni Civil War, but because it is an active war zone, reporting from the area is spotty and unreliable. This made finding and using local sources difficult. Trusting international sources was also not entirely feasible. Academic articles and United Nations reports were used for the majority of the study's information.

Another factor that makes finding local sources difficult is the Houthis' censoring of media in their areas of control. Journalists who go against the group are often imprisoned or killed²¹, and the average citizen in Yemen only has access to Houthi-sponsored news stations, newspapers, or websites²³. Victims of the Houthis various forms of violence, especially sexual violence, rarely come forward due to the fear of backlash from the group or damage to their honor and reputation²¹. This means that many of the victims' stories are unavailable, so the statistics are likely understatements of the actual number of victims and instances of violence.

The choice to use a case study as the method of analysis also means that the conclusions of this paper can only be applied with certainty to Yemen. However, as explained in the above methodology section, Yemen as a case study has implications that can apply to any honor-based society currently experiencing a conflict. By using other case studies or quantitative rather than qualitative methods, further research can confirm the conclusions and its relevant application. Within potential future studies of honor culture or other case studies of CRSV, another complication arises, which is that there is no single, universally agreed-upon definition of what constitutes sexual violence or CRSV. This means that each contributor to the study of the relationship between honor culture and CRSV will have their own definition of CRSV and could reach a different conclusion depending on the types of violence included in their specific definition. However, this study used broad definitions of the debated terms sexual violence and CRSV. These definitions include types of violence such as rape, sexual assault, genital mutilation, sexual torture, sexual slavery, forced nudity, and sexual acts

under coercion, which are commonly recognized as sexual violence within the current literature.

6.2 Personal Limitations

I could not travel to Yemen to conduct interviews as a part of this study due to safety concerns and financial barriers. A lack of conducted interviews, similar to the lack of local sources, introduces a potential bias towards Western reporting. However, conducting interviews with victims of sexual violence can be harmful and ineffective and introduce other issues to a study²⁴. Therefore, the lack of direct statements by victims of sexual violence is viewed as a major barrier to the analysis and conclusions of this study. In addition, several accounts of victims were reported by relevant agencies such as the United Nations and local Yemeni human rights organizations, so their perspectives were still used for the analysis and played a vital role in it. One important example of this was the account included about the imprisonment and consequent abuses committed by the Houthis against a young Yemeni woman named Enas Muhammed. The information on the incident and the victim's account was from a report on violence against women in Yemen that was written and published as a collaborative work by three human rights organizations founded and operating in Yemen⁶. The published English version was used for research, an exception to the aforementioned issue of being limited to United Nation accounts.

7 EDITOR'S NOTES

This article was peer-reviewed.

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Untitled by Thane Gehring



Carbon Sequestration in Peatlands: Using Environmental Proxies to Understand the Impact of a Changing Climate on Global Carbon Storage

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Abstract

Peatlands are a type of terrestrial wetland ecosystem in which consistently waterlogged conditions prevent the decomposition of organic matter. These conditions allow for sequestered carbon in plant matter to remain stored in the soil to such a great degree that peatlands store more carbon than all other vegetation types in the world combined. By inhibiting decomposition, the composition of water-rich peat soil remains representative of the environmental conditions during the period in which the peat was formed. The collected peat samples can then be utilized as environmental proxies to determine historical temperature, moisture, and carbon content and extrapolated to predict the future capacity of carbon sequestration in the context of a changing climate.

The peat samples in this research were collected during the fall of 2020 in the Echo Lake Fen of Grand Mesa, Colorado, and analyzed using humification analysis to determine changes in organic content over time. This research examines over 200 cm of peat from the Echo Lake Fen, dating back over 8,000 years. Each sample was divided into smaller sections to represent shorter periods of time and tested to determine organic matter content. Results suggest that warmer climates lower the water table of a peatland and expose plant matter to oxygen, allowing plants to decay and release carbon into the atmosphere. This raises concerns about the amount of carbon that could be released into the atmosphere in the future as the climate is predicted to get hotter and drier.

Understanding that carbon, as a greenhouse gas, exacerbates already rising global temperatures and increases the rate of plant decomposition is important in predicting how the loss of peatlands would impact future climate conditions. Peat soils contain more than 600 gigatons of carbon worldwide, which represents up to 44% of all soil carbon. Thus, it is essential that efforts to preserve and restore peatlands are prioritized to minimize the amount of carbon in the atmosphere. This research serves as strong evidence for investing in peatland conservation and restoration.

Keywords: *Peat, proxy, carbon sequestration, humification, greenhouse gas, climate change*

1 INTRODUCTION

Wetland ecosystems are among the most productive ecosystems in the world. They serve as important buffers that filter water, control erosion, and protect against flooding, but their value also lies in their unique ability to preserve historical climate information. The nearly constant state of saturation in peatlands creates an anaerobic environment, meaning that the accumulated organic matter will not decompose and can be analyzed to determine the presence or absence of nutrients over time. Peatlands are a specific type of wetland that is comprised of partially decomposed organic matter and a large percentage of water. The lower layers

of peat lack sufficient dissolved oxygen to fully decompose, meaning that dead plants continue to store carbon in their roots. For this reason, peatlands can be used as environmental proxies to understand the relationship between climate and carbon storage during different historical periods. Radiocarbon dating determines the age of the peat samples, and readily available research into historical temperatures aids in depicting the climate during which peat accumulated. This research adds to that depiction by determining moisture/levels or precipitation, as well as carbon content. Determining how much carbon was stored in the soil during intervals of peat accumulation serves as a prediction for how changing climate conditions may result in net carbon

storage or loss in peatlands.

The peatlands of Grand Mesa, Colorado, are especially effective proxies because of their unique isolation from outside inputs, lacking direct access to navigable bodies of water. These peatlands can then be studied using loss of ignition tests and humification analysis to determine exactly how much carbon was stored during different climate conditions. Loss of ignition (LOI) testing is a process used to measure the weight of a soil sample before and after burning away its organic matter, which determines the carbon content. Humification analysis is a technique that measures the relative degree of decomposition (or humification) of the peat, representing the degree of moisture in a sample. Oxidation accelerates humification of organic matter, so humification analysis provides a method to determine when a section of peat experienced dry/aerobic conditions. Comparing the humification of several sections of the same core, we can measure the fluctuations in the water table of a fen over time. LOI tests and humification analysis can be used to create a timeline of carbon storage as it compares to temperature and precipitation. These results can then be extrapolated to make predictions about the impact of a changing climate on the rate/amount of carbon released into the atmosphere.

The samples in this research were taken from what is considered a “high elevation fen,” a type of peatland at an elevation higher than 3,000 m. Previous research has shown that fens in Colorado situated above 3,000 m preserve a record of Holocene climate fluctuations and responded to changes in past summer temperatures with changes in the rates of peat accumulation. During warmer summers, these fens accumulated peat faster than during cooler intervals, suggesting that these peatlands stored more carbon during these warmer periods. However, humification data in this research indicates that, while the rate of peat accumulation was greater, the peat was also more humified or decomposed. This research expands on current knowledge of peatlands by closely examining carbon sequestration in high elevation peatlands and presents an alternate relationship between peat accumulation and carbon storage.

2 BACKGROUND INFORMATION

2.1 Peatland Formation and Classification

Peat forms through the accumulation of organic matter and is preserved in the anaerobic environment of a consistently high water table, preventing decomposition. In its natural state, peat is 88-97% water, 2-10% dry matter, and 1-7% gas, with 65% of all partially decomposed material being organic matter¹. The botanical composition and state of decomposition are the most important characteristics for categorizing a peatland; particularly, the plant communities dictate the source of decaying

matter in the peat.

There are four broad categories of plants used in peat classification: moss, herbaceous plants, wood, and detrital or humified peat, in which the bulk of the plant is no longer identifiable. Classifying peatlands is important because the rate of growth or decay will be dependent on the plant genera, which can include trees, mosses, heathers, and grasses. Vegetation like *Sphagnum* mosses are more resistant to decomposition than vascular plants are.

Sphagnum mosses are the keystone species in peatland ecosystems and can be credited for many of this ecosystem's unique characteristics². These mosses are made of ordinary cells that photosynthesize and cells whose pores absorb water and can release stored water during times of drought to keep the bog or fen moist. The high water retention capacity of *Sphagnum* mosses allows for the persistence of wet surface conditions, which, among other benefits, prevent deep burning during forest fires and consequently limit the amount of carbon transferred from plant roots to the atmosphere³. *Sphagnum* moss grows at a rate of 2–12 cm each year, and once it dies, it will accumulate at the bottom of a fen or bog, gradually forming peat. As long as the underground dead zone of *sphagnum* remains below the water table, it will continue to hold carbon dioxide (CO₂) and methane (CH₄). Under the general anaerobic conditions of a peatland, peat accumulates through two slightly different processes known as *terrestrialization* or *paludification*. Terrestrialization occurs when peat accumulates over open water systems either at the bottom of the lake from dead biomass or in floating mats on the lake's surface⁴. Paludification is different in that the peat accumulates directly over previously dry mineral soil that has become waterlogged due to changing environmental conditions. Through the process of paludification, the fens of the southern Rocky Mountains accumulate organic matter at a rate of 8-30 cm every 1000 years⁵.

Peatlands are divided into two layers based on the presence or absence of oxygen, but the boundary between the two is more continuous than distinctive. The upper layer is known as the *acrotelm* and is the layer near the surface of the peat in which oxygen is rich, water is absent, and decomposition occurs. Below the *acrotelm* is the *catotelm* which encompasses the deeper, oxygen-poor, and waterlogged layers of peat in which decomposition is halted. Low oxygen content and waterlogging are key factors required for peatlands to form, but the source of that water determines whether the peatland is a fen or a bog.

Bogs are *ombrotrophic*, meaning they receive all their water and nutrients from the atmosphere, creating conditions that are more acidic and lower in plant nutrients. Fens are *minerotrophic*, meaning they receive outside inputs from groundwater or surface runoff. Because of this, fens are more alkaline and nutrient-rich than bogs

and are influenced by the surrounding rocks and soils through which the water flows. A higher pH value corresponds with a greater abundance of plant species that will one day contribute to further peat formation.

Peat soils, also called organic soils, have a number of distinguishing properties that make them different from mineral soils. Organic soils have large organic matter content, low bulk density, large pore density, and large water storage capacity⁴. By definition, such soils contain more than 15% carbon (C), but that number often exceeds 50%. Having such a large organic content means that these soils will have a low bulk density, ranging from 0.01 to 0.2 g/cm³, increasing naturally and in direct correlation with mineral content. Less decomposed organic matter can hold more water because of the larger pore space and greater presence of Sphagnum mosses compared to strongly decomposed organic matter. In peat soils, the water content at saturated conditions can range from 86% to 94%, and undecomposed peat can hold up to 20-30 times its own weight in water⁴. This high water content makes peat soils softer and more susceptible to instability but aids in their ability to store climate data. The presence of water necessarily leads to a loss of oxygen and therefore limits decomposition.

2.2 Where Peatlands are Found

Peatlands are found in every climate zone on the planet and cover about 3% of the Earth's surface⁶. The majority of peatlands are located in Asia and North America, although they are formed under different conditions. In the boreal temperature regions of the northern hemisphere, peatlands are formed under high precipitation and low-temperature conditions, whereas the humid tropics necessitated formation under high precipitation and high-temperature conditions⁶. Regardless of the climate, peatlands serve as major carbon reservoirs and are an important component of the global carbon cycle.

Peat is formed when the rate of biomass accumulation is greater than that of decay, a process that is most conducive to climates that are cold and/or saturated with water⁴. Peatlands are most common in the subarctic and boreal regions of the Great Lakes and Rocky Mountains of North America. In mountain regions, cold temperatures and orographic precipitation lead to increased water availability, subsequently encouraging the formation of organic soils on mountain slopes.

2.3 Benefits of Peatlands

2.3.1 Carbon Storage

Peatlands are uniquely equipped to store carbon in the soil because of their slow rate of decomposition. Peatlands capture CO₂ from the atmosphere through photosynthesis and store it in the soil, but because of the wet

conditions, plants do not decompose and release that carbon in the same way that plants in aerobic environments would. By storing carbon, peatlands provide a net-cooling effect and help to mitigate rising global temperatures. While peatlands comprise only about 3% of global land cover, they store one-third of all soil carbon. It is estimated that, in the Northern Hemisphere, peatlands store between 733 and 1650 billion metric tons of CO₂ and in North America, carbon accumulates in peat at a rate of 7 to 300 g/m² per year⁷.

The capacity for carbon storage in peat deposits has historically been overlooked. When carbon content is measured in forested peatlands, research methods typically focus on understanding aboveground forest components. However, in a study of forested peatlands in the boreal biome of Canada, researchers found that peat carbon stocks were significantly higher than those of aboveground and belowground tree biomass. Even when measured during the short-term historical time-frame of the last ~200 years, peat deposits were shown to contain 4 to 25 times more carbon than the tree components³. These findings are significant because they reframe the potential of an ecosystem that was previously thought to be unproductive. Due to their open canopy structure and low stem density, boreal forests (including forested peatlands) were believed to store low amounts of carbon, impacting their degree of conservation priority. While reforestation is an important practice for restoring habitat and increasing the rate of carbon sequestration, such practices can be expensive, and the impact of rising atmospheric CO₂ concentration has been shown not to affect tree growth³. For this reason, focusing on restoring and protecting existing peatlands will be essential to reaching climate mitigation goals.

2.3.2 Ecosystem Services

In their natural wet state, peatlands are able to provide a number of invaluable services to humans and the surrounding ecosystems. Vegetation filters pollutants and particulate matter, improving water quality and serving as an effective water catchment/retention system. These characteristics make peatlands excellent buffer zones capable of regulating water flows and lowering the risk of early snowmelt flooding or drought. The upper layer of peat, or the "peat blanket" on the surface, protects underlying soils from wind and water erosion and supports soil formation.

Wet peatlands lower ambient temperatures in surrounding areas, making them less likely to burn during wildfires. By offering a refuge from extreme heat, these wetlands provide habitat for unique plants and animals. The biodiversity of a peatland is essential for maintaining a balanced ecosystem and supports all the other services a peatland provides. This includes the cultural services associated with the recreational and aesthetic

use of peatlands and the educational opportunities they provide. Preserved peatlands serve as accurate environmental proxies to learn and teach about historical climate conditions.

2.4 Peatland Destruction

2.4.1 Conversion to Agricultural Land

The use of organic soils varies greatly with their properties, but fens and bogs are most often used for agriculture and forestry. Worldwide, about 25% of all peatlands have been destroyed or degraded anthropogenically, with a rate of further degradation of about 1% annually⁴. Agriculture is responsible for 50% of degradation and use, while 30% of peatlands have been anthropogenically afforested. To be utilized for grazing or crop production, fens must be drained and often fertilized, destroying their ability to capture and store carbon. Instead, they release that carbon into the atmosphere. Drained peat will dry and shrink, promoting oxidative decay of organic material as well as wind and water erosion. Consequently, several meters of peat soil can be lost within a few decades of sustained drainage⁴. Strongly decomposed peat under agricultural use has low available water content, meaning that plant-available water is lower and crops are more susceptible to drought than in less decomposed peat.

2.5 Drainage

Artificial drainage creates an aerobic environment that enhances decomposition and, through a process known as *earthification*, will eventually transform a peatland into a disintegrated, crumbly powder that easily erodes in the wind. This process only occurs through heavy, anthropogenic use with deep drainage⁴. Managed peatlands often have an underdeveloped or missing upper layer due to human alteration, impacting the environmental services offered by healthy peatlands. In a study focusing on fens in Grand Mesa, Colorado, in 2015, 294 ha of the 374 ha studied (79%) had been impacted by human activities that left them with very little restoration potential⁵.

The draining of peatlands using ditches is one of the most common human disturbances to peatlands in the world and has been occurring in the Rocky Mountains for more than a century. Research in the upper 15 cm of peat of four drained Colorado fens indicated losses of 14.7–91.0 tons of organic matter within the last 20 years. The extent of hydrologic impacts on Grand Mesa is considered highly unusual for a high elevation region and has become one of the most impacted high mountain regions in the U.S.⁵.

2.5.1 Greenhouse Gas Emissions/Climate Change

The anthropogenic use of peatlands has a great impact on greenhouse gas (GHG) emissions; once the drained peat is no longer able to store carbon, it must release it into the atmosphere. Degraded peatlands are responsible for 25% of global CO₂ emissions from the land use sector and for 75% of the GHG emissions from agricultural land in the European Union⁸. The rate of GHG emissions depends on the trophic conditions and what the peatland is being used for, including the degree of water saturation, climate, and nutrient status. Croplands, for example, emit 29.0 t CO₂ ha⁻¹ a⁻¹ on average, while afforested peatlands emit between 0.9 and 9.5 t CO₂/ha. And because temperature so strongly influences decomposition, tropical peatlands generally have a higher rate of CO₂ emissions than peatlands in boreal or temperate regions⁴.

There are two general pathways of carbon loss: on-site and off-site emissions. On-site emissions include gaseous fluxes that occur when the water table is lowered, when organic matter is exposed to oxygen, and when CO₂ is released as a byproduct of soil respiration. Off-site emissions involve waterborne fluxes and/or biomass removals that can be converted to gaseous fluxes at a later state⁸. This primarily consists of dissolved organic carbon (DOC) from drainage waters and erosional losses of particulate organic carbon (POC). Healthy peatlands serve as a long-term carbon sink and have had a net cooling effect on the climate for the last 10,000 years⁹. While rewetting peatlands may cause a short-term increase in CH₄ emissions, this does not offset the benefits of reducing oxidative carbon losses and enhanced long-term CO₂ storage. This is especially true if peatland rewetting/restoration encourages the re-establishment of *Sphagnum* moss species, which can reduce CH₄ emissions from waterlogged peat⁸.

The correlation between atmospheric CO₂ concentrations and global temperature is well established, and rising temperatures come with a myriad of effects. Increased atmospheric temperatures lead to increased ocean and freshwater temperatures, fewer frost-free days, sea level rise, shrinking glaciers, and more variable weather patterns⁷. These changing conditions consequently have an impact on human health and safety, water supply, agriculture, energy needs, infrastructure, and recreation.

3 MATERIALS AND METHODS

3.1 Sample Area

Peat cores were collected from the Echo Lake Fen (ELF) located on the east slope of the Colorado Front Range in the fall of 2020. The Colorado Front Range is the easternmost range of mountains within the Southern Rocky Mountains and is marked by steeply dipping

sedimentary layers that mark contact with the Great Plains¹⁰. The Front Range is about 300 km long, extending from the Arkansas River to the south to the Colorado-Wyoming border to the north. Throughout this region, the topography is rugged and steep, with broad glaciated valleys that are most prominent over 2800 feet¹¹.

The Front Range is a faulted anticline that was uplifted during the Laramide Orogeny nearly 70 million years ago. The core is primarily made of metamorphic and granite rocks, with permanent snowfields supplying water to the Colorado, North Platte, South Platte, and Arkansas River systems. The climate on the Front Range is classified as highland continental, meaning there are short, cool summers, long, cold winters, and relatively dry conditions year-round¹². Changes in the average temperature and precipitation occur with increased elevation, in which higher elevations generally correspond with decreased temperatures and increased precipitation. The overall climate is controlled by latitude, elevation, air mass trajectories, and continentality¹⁰.

Echo Lake is located about 15 km south of Idaho Springs, Colorado, at an elevation of 3230 m. The lake itself is within an unglaciated basin about 300 m below the treeline and surrounded by coniferous forest to the north, south, west, and the fen occupying the land east of the lake¹⁰. Echo Lake was formed during the late Pleistocene after a lateral moraine dammed a small side-valley tributary. Radiocarbon dating of the lake sediments indicates that the lake was formed at least 18,500 years ago. This makes Echo Lake the oldest known lake in the Front Range.

The lake level is believed to be maintained by groundwater flow from the meadow east of the lake and by direct inflow of surface runoff and precipitation. The age of the lake and its relative geographic isolation make the ELF an excellent location to reconstruct a paleoenvironmental timeline. As opposed to younger lakes on the Front Range that occupy glacial basins after the ice retreated, Echo Lake offers a continuous climate record that extends back to the Pleistocene.

3.2 Sediment Coring

The cores were taken from the ELF during the fall of 2020. Using a piston-equipped corer, several cores of about 30-40 cm were retrieved from the fen and stored for later analysis. Each core was wrapped in plastic wrap and aluminum foil and placed in a PVC pipe for protection. The cores were briefly described in the field by observing changes in color or the presence of large pieces of organic matter. The cores were labeled to mark the fen they were retrieved from, the year, sample number, and depth of the core. All collected samples were transported back to the University of Denver for

later analysis in a laboratory setting.

3.3 Humification Analysis

3.3.1 Bulk Density

Each core was divided into 1 cm increments by length, and 3 cm³ of each division were collected and placed into a separate crucible to determine bulk density. Bulk density was measured by drying the sample in the oven at 100°C for a minimum of three hours to evaporate water from the samples. The resulting weight was then subtracted from the initial weight of the crucible. This gives the dry weight of the sample. The dry weight (DW) is then divided by the sample volume (V), which gives the bulk density (D_b) of the sample in g/cm³.

$$D_b = \frac{DW}{V} \quad (1)$$

Bulk density is the dry weight of soil per unit volume of soil and is used to determine the amount of mineral material in the peat sample. It is likely that much of the mineral matter in a peat sample was delivered to the fen by eolian processes or large flooding events because of the very slow rate at which water flows through peat¹³. The bulk density is influenced by several factors including temperature/length of the growing season, moisture, nutrients, and rates of decomposition in the soil. This metric can be used to determine the infiltration, water availability, soil porosity, and rooting/depth restriction. A higher bulk density is reflective of a decrease in the ability of soil to shrink and conduct water and indicates that the soil is more rocky or sandy rather than fine-like clay and silt. There is also evidence that decreased organic carbon in the soil increased the bulk density¹⁴.

3.3.2 Organic Content

After finding the dry weight, 0.2 g of dry peat was measured out of each sample and ground into a fine powder using an agate pestle and mortar. Each sample was done separately, using clean and dry equipment to prevent cross-contamination of samples. The new samples were then put into a 200 ml beaker used in later steps to determine humification. The remaining peat samples in each crucible were then placed in the drying oven at 100°C for 1 hour, cooled to room temperature in a desiccator, and weighed to provide "organic content 1" (OC1). This step is necessary because the samples may have absorbed moisture during the previous step and must be re-dried.

After being re-dried and weighed, the samples were placed in a furnace at 550°C for at least 4 hours to combust all organic matter. After at least 4 hours, the crucibles were removed from the furnace and placed in the desiccator to cool to room temperature. Each sample was then weighed again, and the weight is recorded

as “organic content 2” (OC2). The following equations utilize the previous data to determine organic matter content.

$$\frac{OC1 \text{ weight} - OC2 \text{ weight}}{OC1 \text{ weight}} = \text{Organic matter content}(\%)$$

$$\text{Bulk density} \times \text{Organic matter content} = \text{Ash-free bulk density (g/cm}^3\text{)}$$

These steps are used to determine loss of ignition (LOI), which is the weight change of a sample after it has been heated to a high temperature, causing some of its content to burn or to volatilize. This process is used in inorganic analytical chemistry and soil science, particularly in the analysis of minerals and the chemical makeup of soil. LOI tests consist of heating a sample of the material (peat soil) at a specified temperature, allowing volatile substances to escape until its mass ceases to change. LOI can be used as a relative paleotemperature proxy and depending on the temperature at which the sample is heated, this process can measure water, organics, or inorganic degradation.

3.3.3 Humification

Using the 0.2 g of each sample from the previous steps, 100 ml of 8% NaOH solution was added to each labeled sample beaker using a 100 ml graduated cylinder. The beakers were then placed on a hotplate at 100°C and left to simmer for one hour, occasionally topped to 100 ml with deionized water to prevent drying out and to ensure the solutions do not become too concentrated. After one hour, the contents of each beaker were poured into separate 200 ml volumetric flasks, topped to the 200 ml mark with deionized water, and shaken. Each sample was filtered into a 50 ml volumetric flask using a funnel and Whatman No. 1 grade paper. The filtrate from each 50 ml volumetric flasks were then decanted into a 100 ml volumetric flask, topped to the 100 ml mark with deionized water, and shaken. The samples were measured using a spectrophotometer to determine the percentage of transmissivity. Transmissivity measures the amount of light that passes through a sample, with high transmissivity indicating that little to no light was absorbed as it passed through the sample. When the water table in a peatland is high, conditions are wet, and the peat is less humified/better preserved. These conditions support a high percent transmissivity, while a more humified section of peat would have a lower percentage of transmissivity. The spectrophotometer was set to 540 nm and zeroed using a 10 ml cuvette of deionized water before measuring each sample. Using a pipette, 10 ml of each sample is measured into a separate cuvette and placed into the spectrophotometer. The spectrophotometer reading will fluctuate slightly so

three readings from each sample are taken, and two cuvettes are tested for each 200 ml sample of solution. The final data sheet should have six transmissivity readings for each sample. The corrected percent transmissivity is calculated by dividing the average transmissivity by the percent of organic matter for each sample.

3.4 Calculating the Accumulation of Organic Carbon

The rate of peat accumulation has been extrapolated from the radiocarbon chronology of a peat core from the Echo Lake Fen. Ten radiocarbon dates were obtained on the core. These were used to calculate the average accumulation rate through time intervals identified as the Little Ice Age (LIA), 8200-year event (8.2 ka), Holocene Climatic Optimum (HCO), and Medieval Climate Anomaly (MCA). The LIA and 8.2 ka events were periods of cooler temperatures, while the MCA and HCO were periods of warmer temperatures. Multiplying the mean density by the mean % organics for each interval gives the average organic mass per cubic centimeter sample, as shown in Table 1. The average organic mass per cubic centimeter sample is then multiplied by the average peat accumulation rate during that climate event to yield the grams of carbon/cm²/yr for each interval, as shown in Table 2. Organic matter accumulation is representative of temperature conditions, with higher organic matter content correlating to warmer conditions because the growing period is longer and there is more opportunity for organic matter to accumulate.

4 RESULTS

By the end of the study, ~75 cm of peat had been sampled and analyzed to determine the average percent transmissivity and the percent organic matter in the samples. The high elevation Echo Lake Fen shows increased organic content during warm periods. Average percent transmissivity represents the relative degree of precipitation. High transmissivity indicates wet conditions in which the water table is high, and the peat is less humified/better preserved. Used in tandem, transmissivity and organic matter can be used to track changes in climate and carbon sequestration through history.

5 DISCUSSION

Studying peat from the Echo Lake Fen allows us to build a timeline of climate conditions as far back as ~8,000 years. Echo Lake is the oldest known lake in the Rocky Mountains, and the surrounding fen is dominated by wet, anoxic conditions that preserve environmental proxies like pollen and plant matter. These characteristics make the ELF uniquely equipped to store

| Depth | Interval | Mean Density | Mean Percent Organics | Organic Mass |
|------------|----------------|------------------------|-----------------------|-------------------------|
| 14–21 cm | Little Ice Age | 0.45 g/cm ³ | 50% | 0.225 g/cm ³ |
| 186–187 cm | 8.2 ka event | 0.95 g/cm ³ | 35% | 0.33 g/cm ³ |
| 33–39 cm | MCA | 0.32 g/cm ³ | 62% | 0.20 g/cm ³ |
| 196–212 cm | HCO | 0.57 g/cm ³ | 49% | 0.28 g/cm ³ |

Table 1 Four sections of peat coinciding with four major historical climate events and their mean density, mean percent organics, and organic mass.

| Interval | Organic Mass | Average Accumulation Rate | gG/cm ² /yr |
|----------------|-------------------------|---------------------------|-------------------------------|
| Little Ice Age | 0.225 g/cm ³ | 0.033 cm/yr | 0.0074gC/cm ² /yr |
| 8.2 ka event | 0.33 g/cm ³ | 0.02 cm/yr | 0.0066 gC/cm ² /yr |
| MCA | 0.22 g/cm ³ | 0.025 cm/yr | 0.0055 gC/cm ² /yr |
| HCO | 0.28 g/cm ³ | 0.02 cm/yr | 0.0056 gC/cm ² /yr |

Table 2 The average accumulation rates in cm/yr for each interval were multiplied by the organic mass (g/cm³) to yield the grams of carbon/cm²/yr for each interval.

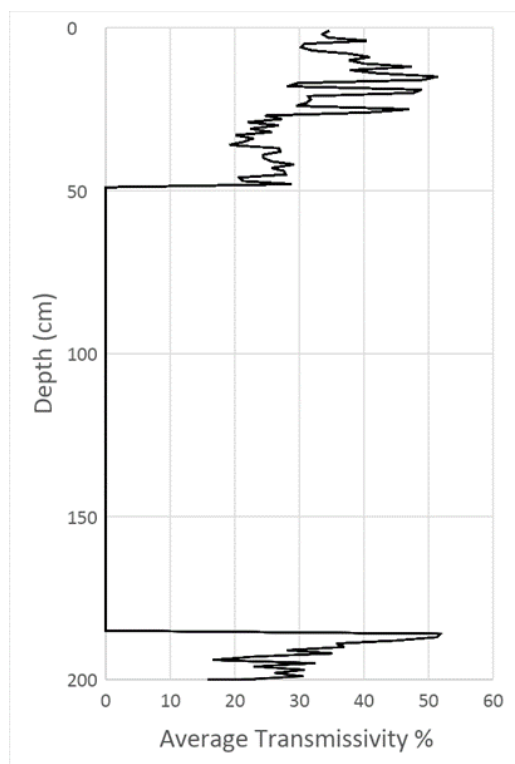


Figure 1. Average transmissivity percentage from 0–50 cm and 186–212 cm depth. The first major increase in transmissivity occurred during the Little Ice Age (1303–1850), followed by a decrease in transmissivity during the medieval climate anomaly (950–1250).

evidence of historical climates and warrant continued investigation. Using the loss of ignition (LOI) data as a proxy for temperature and the humification data as a proxy for paleo-moisture conditions, we can model the relationship between temperature, moisture, peat accumulation, and carbon storage capacity.

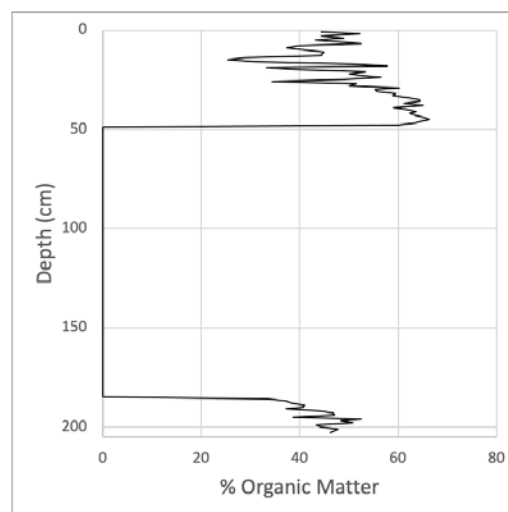


Figure 2. Percent organic matter from 0–50 cm and 186–212 cm depth. The first major decrease in organic matter occurred during the Little Ice Age (1303–1850), followed by an increase in organics during the medieval climate anomaly (950–1250). At 186 cm depth the % organics show a slight decrease, marking what is known as the 8200-year event.

Periods of high transmissivity in Figure 1 indicate wetter conditions or greater precipitation. While Figure 1 accounts for precipitation, Figure 2 serves as a proxy for temperature. When comparing the two graphs, periods of high transmissivity consistently coincide with periods of low organic content. Generally, the combination of high organic matter under wet conditions prevents the decomposition of plant matter and instead sequesters the carbon stored in plant roots into the peat. But to understand how the rate of peat accumulation compares to the amount of organic carbon stored in the soil, calculations relating to bulk density, percent organic content, and peat accumulation rates must be included.

Tables 1 and 2 show that the rate of peat accumulation was greater during periods of warm and dry conditions, but the peat was also more humified or decomposed. This is likely due to the greater amount of evaporation occurring during the warm intervals, which lowered the water table, increasing the exposure of peat in the *acrotelm* to oxidation.

These results suggest that more carbon is stored per cm^2/yr during cooler intervals than during warmer intervals, as much as 30% more. In other words, while rates of peat accumulation are greater during warmer summers, there is less carbon stored per cm^2 due to increased humification of the peat during these times.

When the climate is dry, peatland water tables are lowered and dead organic matter is exposed to oxygen, undergoing decomposition. Through this process, carbon previously sequestered in plant roots is released into the atmosphere as CO_2 . The rate at which partially decomposed matter in the *acrotelm* is deposited into the *catotelm* is a large determining factor in how much carbon is stored at a given site¹⁵. While warmer conditions may encourage plant growth in some instances, these results suggest that high peat accumulation should not automatically be associated with greater organic carbon storage.

These results must be viewed as preliminary. While the data are compelling, more sampling and better chronological control are needed. However, if these results are supported by future work, the implications are great. With continued warming forecast by nearly all Global Climate Models for the western U.S., these results suggest that peatlands will become less efficient as carbon sinks in the future.

5.1 Peatland Degradation and Climate Change in the Future

These results have important consequences as the climate is predicted to become warmer and drier, and the increase of CO_2 in the atmosphere will compound the effects of climate change. For example, recent warming at high latitudes has accelerated permafrost thaw in northern peatlands. The presence of permafrost has been instrumental in the long-term accumulation of carbon in northern peatlands by slowing rates of microbial decomposition. In a study looking at peatland permafrost thawing in western Alaska, researchers found that, upon thaw, carbon loss in the peatlands was equivalent to ~30% of the initial forest carbon stock¹⁶. Their models indicate that permafrost thaw shifted these peatlands from a carbon sink to a carbon source for a decade after the thaw. At this point, carbon was again stored as more peat accumulated. Still, this process of regaining pre-thaw levels of carbon storage can take multiple centuries to reach (depending on the amount of carbon accumulated prior to the thaw). These researchers

concluded that the loss of sporadic and discontinuous permafrost by 2100 could result in a loss of 24 Pg of carbon.

The positive feedback loop of released carbon, resulting in more warming, changes the wildfire regimes, and low precipitation/drought conditions make peatlands more susceptible to burning. In an undisturbed peatland, most of the stored carbon is protected by waterlogged, anoxic conditions, which cannot be burned by fire. However, drying as a result of climate change and human activity lowers the water table of peatlands, exposing partially decayed plant matter to oxygen and initiating decomposition¹⁷. Having greater quantities of dried peat in the *acrotelm* increases the presence of fuel for wildfires, which come with their own collection of ecosystem impacts. Specifically, fire in boreal peatlands initiates plant successional change, increases soil temperature, and increases nutrient availability.

Researchers have found that from an atmospheric point of view, low-intensity fires in an undisturbed peatland are likely to be CO_2 -neutral because the released carbon will quickly be sequestered by recovering vegetation¹⁷. However, a longer, smoldering fire will transfer heat deep into the soil and increase the intensity of the burn. Fires like this increase damage to sensitive plant roots and microorganisms like ectomycorrhizal fungi or bacteria and release carbon that may have been stored in the soil for centuries. At this point, the peatland would no longer be CO_2 -neutral but a source of atmospheric CO_2 .

5.2 Rewetting and Restoration

Because drained peatlands are a significant source of greenhouse gas emissions, rewetting and restoring these soils is considered a critical climate change mitigation strategy. Researchers in Northeast Germany studied the long-term presence of greenhouse gases in drained versus rewetted peatlands and found that rewetting reduced CO_2 emissions in unvegetated areas by 50%¹⁸. Rewetting is defined by the International Panel on Climate Change as “the deliberate action of raising the water table on drained soils to re-establish water saturated conditions¹⁹”. This can include a wide variety of management strategies that are highly site-specific such as drain-blocking, bund construction, and peatland landscaping.

There is a large amount of variability in the impact of rewetting on peatlands that depends on factors like climate, peat type, nutrient availability, hydrology, vegetation, and human interaction. Variation in and exposure to weather inputs directly affect internal peatland functioning, and in some circumstances, drained peatlands have been so impaired that their original properties cannot be restored. Researchers suggest that restoration efforts should focus primarily on reestablishing hydro-

logical conditions and vegetation similar to an intact system to have the best chance at rebuilding the carbon sink. While rewetting sites have been more sensitive to interannual changes in weather conditions than their undisturbed counterparts, rewetting is currently the most effective peatland restoration effort with regard to increasing carbon sequestration¹⁸.

One way to encourage rewetting while still allowing for land use of peatlands is through paludiculture. Paludiculture is the practice of wet agriculture and forestry on peatlands, primarily crop production. Rather than draining wetlands as conventional farming would do, paludiculture focuses on preserving and/or restoring peatlands while simultaneously utilizing the produced biomass. The goal of paludiculture is minimal peat disturbance, meaning that the water table needs to remain near surface level to keep the peat saturated, and ploughing or harvesting below-ground biomass is prohibited²⁰.

6 CONCLUSION

Peatlands function as excellent environmental proxies and can be used to determine historical climate information. When compared to their known radiocarbon dates, the data collected from the Echo Lake Fen samples are able to track historical climate events as far back as ~8200 years ago. Aside from holding historical data that serves as an important educational resource, peatlands provide invaluable environmental services. Vegetation filters pollutants, improves water quality, and provides a buffer zone capable of regulating water flow and lowering the risk of snowmelt flooding or drought. Wet peatlands lower the ambient temperatures and provide habitat for many endangered plants and animals; also, they function as one of the most productive ecosystems in the world in terms of carbon sequestration.

Changing climate conditions at the Echo Lake Fen are predicted to have negative impacts on the ability to store carbon, especially with the newest findings in our data. The data suggests that warmer temperatures (despite accumulating more peat) lose more carbon than during cold conditions. Looking to the future, this means that predicted rising temperatures will result in a greater loss of stored carbon. Further research of high elevation fens and the changing carbon levels in peatlands will be necessary for understanding how rising temperatures will impact the global balance of CO₂ in the atmosphere.

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I recognize that the University of Denver resides on lands that are held in stewardship by the Cheyenne and Arapaho tribes. It is with much gratitude that we recognize the descendant communities of the Northern Cheyenne Tribe of Montana,

the Northern Arapahoe Tribe of Wyoming, and the Southern Cheyenne and Arapaho Tribes of Oklahoma and remember that it is through their sacrifices that we are able to engage in learning and collaboration to further the study of higher education.

These samples were collected on the traditional land of the Southern Ute Tribe, whose continued stewardship of the land made this research possible.

8 EDITOR'S NOTES

This article was peer-reviewed.

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The Rocky Road to Statehood: Colorado Statehood and the Contested Election of 1876

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Abstract

This thesis will explore Colorado's path to statehood. It begins with a summary of the election of 1876 to set up the research question: why did Colorado, a Republican-territory, become a state in a critical election year when the Democrats controlled the House of Representatives? Next, it covers the historiography to gain insight into how scholars view Colorado statehood and its relationship to the election of 1876 given that both happened in the same year and that coincidences in politics are rare. A follow up will occur with an explanation of the differences between a state and a territory to demonstrate the importance of statehood alongside a discussion of the unsuccessful attempts to make Colorado a state that came from both within the territory and in Congress. Then, events inside the territory leading up to the successful bid for statehood will be discussed to gain an understanding into the origins of that effort. Afterwards, national events will be covered to narrate a familiar experience for Colorado statehood – that various occurrences at different moments appeared to halt statehood for the time being. Finally, this thesis ends with a discussion of the final statehood bill in Congress to explain how it finally passed. The major argument will be that political developments inside Colorado territory promulgated the successful statehood effort while the inability of the Congressional Democratic leadership to hold the party together in opposition to Colorado statehood allowed it to pass and in time to participate in the election.

1 THE PRESIDENTIAL ELECTION OF 1876

On the morning of Wednesday, November 8, 1876, the day after the last polls closed, the *Chicago Daily News* declared that the Democratic former governor of New York, Samuel Jones Tilden had been elected President by “a very considerable majority of the electoral vote.” The nation's press was almost unanimous in its agreement with the *Daily News*¹. The Republican-affiliated *Indianapolis Journal* agreed that the Republican candidate, Rutherford Birchard Hayes had been defeated. “Tilden is elected. The announcement will carry pain to every loyal heart in the nation, but the inevitable truth may as well be stated,” the journal lamented².

On the night of Tuesday, November 7, the disappointed manager of the Hayes campaign, William Chandler, was certain of Tilden's victory and retired to bed in low spirits¹. The candidate himself accepted his loss and planned to draft his concession speech the next morning². However, at 10:00 on Sunday morning, March 4, 1877, the heavily bearded former governor of Ohio, Rutherford Birchard Hayes, was sworn-in as the nineteenth President of the United States in secret². Two days prior, the American public did not know who their next President would be².

The controversy that resulted in the election of Hayes, as historian, Keith Ian Polakoff writes, “was potentially as grave as the crisis that ensued after the election of Lincoln in 1860”¹. The nation was on edge following the first election where the president elect was the loser of the popular vote, a condition made possible by a controversial clause in the Constitution that critics charge limits accountability and the determination of voters of who represents them¹. As the procedure is laid out, the real power for electing presidents rests with a body of officials called Electors, who may vote however they choose, irrespective of the result of ballots cast in the state they represent. States are assigned a number of Electors derived from the sum of a state's Congressional districts and its two Senators as an effort to balance the electoral influence of highly populated states. Even though Electors nearly always confirm the popular votes of their states, the fact that the number of Electors is smaller than the population of their states allows for the possibility that the winner of a presidential election lost the popular vote³. To this point, however, such a condition had never appeared, creating the appearance that the popular vote affected the result of presidential elections. The inconsistency between the Electoral College and the popular vote in the 1876 pres-

idential election brazenly exposed the limitations of the choice of eligible voters in presidential elections, and was the driving force behind the dispute in the election.

Without the Electoral College, Samuel Tilden would have been elected president because the number of votes cast for him by eligible voters outnumbered those cast for Hayes, and there was no uncertainty about it. The nature of the dispute lay in questions of how the Electors voted in 4 undetermined states (Florida, Oregon, South Carolina, and Louisiana) and which returns from those states were legitimate, as conflicting Electoral vote returns had been submitted to Congress from those states. The fact that the loser of the popular vote, Hayes, was still elected president provoked an outcry from Democrats and was a source of their insistence that President Hayes was an illegitimate president—after all the majority of American voters chose Tilden¹.

After a commission appointed by Congress to settle controversy awarded all twenty of the disputed electoral votes from the four states to Hayes, the former Ohio governor was given a total of 185 electoral votes—one more than his Democratic rival⁴. When Congressional Republicans struck a deal with their Democratic counterparts who were filibustering the count of the Electoral votes after the commission released its decision, the Democrats halted their filibuster, and Hayes' victory was confirmed².

2 INTRODUCTION

A variety of factors contributed to making the election of 1876 memorable, but one often overlooked factor ensured that the election would be disputed. When Colorado entered the Union as the thirty-eighth state, known as the Centennial State in reference to the one-hundredth anniversary of the Declaration of Independence, the balance of electoral votes increased from 366 total votes to 369. This meant that the necessary total for election rose from 182 to 185 votes^{2,5}. Although three electoral votes may seem trivial, in 1876 it was crucial. While Samuel Tilden had secured 184 votes to Rutherford Birchard Hayes' 162, without Colorado's admission, Tilden would have won with no contest, and the twenty disputed electoral votes would have made no difference in the outcome. However, when Colorado became a state on August 1, 1876, and gave its 3 electoral votes to Hayes, every vote mattered. With 165 votes, should all 20 disputed votes go to Hayes, he would be elected. Unfortunately for Tilden, that is what happened.

Colorado—although a Republican stronghold, like most far-western territories—joined the Union while the Democrats controlled the House of Representatives^{6,2}. Moreover, as Keith Ian Polakoff points out in his book, *The Politics of Inertia*, “The election of 1876 was universally expected to be the most closely con-

tested election in more than a generation, even before the candidates had been chosen”¹. For the first time in twenty years, the Democrats had a real chance of winning the presidential election¹. This raises an important question: why did Colorado, a Republican-territory, become a state in an important election year while the Democrats controlled at least one house of Congress, especially considering that the last time the Democratic candidate was elected president was a full two decades ago? Further, Colorado statehood was not new; in fact, it had been attempted both from within Colorado and in Congress five times before 1876. This raises an additional question: why did Colorado not become a state earlier?

This thesis will seek to explain how and why Colorado became a state in a critical election year. It will begin with a synopsis of the historiography to understand the debate amongst historians over the importance of Colorado statehood to the election, then follow up with a brief explanation of the differences between a territory and a state to demonstrate the significance of Colorado statehood. After that, it will explore Colorado's path to statehood through a summary of previous attempts to make it a state to understand why Colorado did not become a state earlier and what the consistent arguments for and against Colorado's admission were. Next, it will consider events inside Colorado between 1869 and 1876 to gain insight into why the statehood movement was revived in 1873. Afterwards, it will explore the national context between 1872 and 1876 to understand why the national setting was finally favorable to Colorado statehood. Unlike the last two efforts to make Colorado a state (1865 and 1867), this attempt was met with a more supportive president and fractured opposition in Congress coupled with stronger support for statehood amongst the territory's voters. Although the Congressional Democratic leadership did not support Colorado's admission during the territory's final effort to become a state, their ultimate inability to hold the party together in opposition to the admission of the Republican-territory was a decisive factor contributing to Colorado's achievement of statehood in 1876, thus paving the way for the dispute that would define the election. This thesis will argue that the defeat of Colorado statehood in its five unsuccessful attempts were affected partly by internal opposition but mostly by an unconvinced president and weak Congressional support. Contrarily, the reasons for statehood in 1876 were largely internal and unrelated to the election of 1876.

3 HISTORIOGRAPHY

The 1876 electoral controversy was set up after Colorado became a state on August 1—just in time to participate in the election. Most scholars agree that Colorado statehood was a critical factor in the election, but

they disagree on its importance. As far as Colorado statehood and the election of 1876 are concerned, two sets of scholars have emerged.

3.1 Group 1

The first group focuses mostly on the election. These scholars largely agree that Colorado statehood guaranteed that the election would be disputed, but they argue that other factors resulted in the seating of Hayes over Tilden. To them, Colorado statehood is important but not central. Rather, it is relevant background information necessary to complete a narrative discussion of what happened in 1876 while they ultimately argue that there were other reasons for why Hayes won.

This group includes Michael Holt, who dedicates half of chapter two of his 2008 book, *By One Vote: The Disputed Presidential Election of 1876* to a discussion of Colorado statehood. However, he does not consider it a central feature in the election. Holt bluntly writes, "This book is supposed to be about the presidential election of 1876, not what Congress did in the winter of 1874-1875 with regard to Colorado or anything else"⁵. Clearly to Holt, Colorado statehood was important enough to merit half a chapter, but to him it was a separate event that, though important, was not a central factor of the election.

Like Holt, Keith Ian Polakoff, in his 1973 book on the election, *The Politics of Inertia: The Election of 1876 and the End of Reconstruction*, also thinks of Colorado statehood as an important event affecting the election. However, unlike Holt, Polakoff only dedicates two pages and one paragraph to the topic. The author ends his discussion of Colorado after mentioning its electoral votes¹. It is evident that he considers Colorado statehood relevant but still not directly related to the election. For Polakoff, Colorado statehood had an important consequence for the election, but it was not a central factor.

Unlike Holt and Polakoff, not all scholars writing about the election of 1876 even view Colorado statehood to be noteworthy. These authors include William Rehnquist, the former Chief Justice of the Supreme Court. In his vivid retelling of the election, *Centennial Crisis: The Disputed Election of 1876*, Rehnquist describes the details about national developments surrounding the election. However, all he said about Colorado statehood was that it happened. The only time Rehnquist mentions Colorado statehood in his 248-page account of the election, he writes, "Colorado was admitted to the Union in 1876 as the thirty-eighth state; it would be known as the Centennial State"². The Chief Justice does not even discuss the significance of the new state's electoral votes for the dispute. Clearly, Rehnquist regarded Colorado statehood as no more than background information unconnected to the election.

3.2 Group 2

The second group of scholars, much smaller than the first, largely takes the reverse perspective of Colorado statehood and the election of 1876. These scholars focus on how Colorado became a state, and unlike their counterparts in the first group, they mention the election as relevant background information. They mostly agree that while Colorado statehood was influenced by and in-turn influenced the election, they argue that other factors led to Colorado's successful bid for statehood in 1876 not entirely related to the election. This group includes Eugene Berwanger. Although his 2007 book, *The Rise of the Centennial State: Colorado Territory, 1861-76*, presents an overview of Colorado history from the Pikes Peak Gold Rush to statehood, Berwanger dedicates all of chapter eight of his book to a discussion of national developments around the successful bid for Colorado statehood and the election. Unlike Holt who dismisses Colorado statehood by stating the purpose of his book was not to summarize the actions of Congress in 1874 and 1875, Berwanger makes no such comment about the election. He certainly considers the achievement of Colorado statehood in 1876 as related to the election and the impact that the new state had on the election⁶. Evidently to Berwanger, the election was an integral factor affecting Colorado's successful statehood effort. Nevertheless, his book is about Colorado history—not the connection between statehood and the election.

Unlike Berwanger, Sybil Downing and Robert Smith, in their biography of Thomas Patterson, Colorado's territorial delegate to Congress in the formative years of 1875-76, dedicate only three pages to the election. However, this is not due to the authors' apathy for the election; rather because their book is a biography, it must stay focused on the life-story of its subject⁴.

Dissimilar to Berwanger, in his 1943 master's dissertation on Colorado statehood, "Early Colorado Statehood Movements and National Politics," Gerhart John Decker only remarks on the election as an afterthought. He writes, "Colorado lost her first fight for statehood but when she did reach the goal of statehood, she was destined to play a part of far-reaching importance in 1876"⁷. However, this is not because he disregarded the importance of the election for statehood; it is because his paper was about unsuccessful Colorado statehood movements. For sure, the purpose of his research was to understand the origins of the statehood movement through previous failed attempts and to gain insight into why Colorado did not become a state earlier, not the ultimate accomplishment of statehood in 1876.

In this thesis, Berwanger's approach of considering Colorado statehood in relation to the election is followed. That said, Berwanger will be departed from, as neither he nor any other scholars have specifically followed Colorado's path to statehood. The purpose of

this thesis is particularly to trace Colorado's advancement to statehood from its inception as a territory to its ultimate achievement of statehood parallel to the election of 1876.

4 TERRITORY VS. STATE

To understand the significance of statehood to newly admitted states and the nation, it is necessary to understand what a state is and how it is different from a territory. The admission of new states marks an important point in American history. It captures great attention from the public and signals a progression in the country's development. This was especially salient in the nineteenth century when at least one new state was added every decade. The nineteenth century was largely a century of expansion for the young republic. Following independence in the late eighteenth century, the country's borders spread westward, increasing the borders of the republic, with each new state signaling the power and potential of the United States and highlighting what many contemporaries asserted was the nation's destiny to greatness, which they understood to be the amount of land controlled by the government and established under Congressional authorization⁸. Sybil Downing and Robert Smith offer perhaps one of the clearest explanations of the differences between a territory and a state.

A territory was like a poor relative. With no direct voice in Congress (territorial delegates had no vote and could only serve on the Territorial Committee in the House), Colorado was dependent on patronage and friends in high political places to secure aid for its railroads or helpful mining laws⁴.

Furthermore, territories do not have representation in the Senate and lack electoral votes⁶. Lastly, in the nineteenth century, top territorial government officials, including the governor, treasurer, secretary of state, chief auditor, and attorney general were appointed by the president, and subject to confirmation by the Senate⁶. Governed by Washington with no direct influence in Congress, Colorado was completely reliant on the Federal government for support with infrastructure, construction of schools, and aid resolving conflicts with Native Americans among other issues⁶.

On the other hand, states had everything that territories lacked – direct influence in Congress with two Senators, at least one voting member of the House of Representatives (dependent on a state's population), electoral votes for president, and self-government. Unlike territories, states do not need support from allies in the nation's capital to address internal concerns. Despite the benefits of statehood, though, the citizens of

states, who must pay state and federal taxes, face more and higher taxes than do the citizens of territories, who only owe territorial taxes which are smaller⁶.

5 UNSUCCESSFUL STATEHOOD ATTEMPTS

Colorado statehood would be attempted five times from both inside and in Congress before it eventually reached the milestone in 1876. The first official effort came in the spring of 1859 when a group of overzealous Pikes Peak gold prospectors organized a meeting to draft a constitution for their proposed State of Jefferson, in reference to the late president, Thomas Jefferson, perhaps as a gesture to Zebulon Pike mission to the region of Pikes Peak in 1806 which had been ordered by President Jefferson. However, when the proposal to create the state government for the region encompassing the Front Range of the Rockies and the surrounding area was presented on the ballot, the voters saw no logical reason to skip the territorial phase and had no desire to pay higher taxes, and so they overwhelmingly rejected it.

Considering the instability of a population founded on gold prospecting and the raging debate over slavery back east, it is unlikely that this proposal would have led to the creation of a state had it passed the referendum. Despite the rejection of the statehood offer, though, the voters approved a subsequent proposal to organize the Territory of Jefferson. They went on to elect a legislature, a governor, a territorial delegate, and other executive officials. Congress never recognized the Territory of Jefferson or its delegate, and so the Territory of Jefferson operated as an extra-legal body presiding over an area that included parts of the Kansas, Nebraska, and even Washington territories. Nevertheless, the referendum on the State of Jefferson and Jefferson Territory formed the basis of the movement that led to the formal establishment of a territory in early 1861⁹. To make the territory, Congress drew lines at the 40th and 42nd parallels from the Nebraska Territory and east of the Continental Divide and the 37th parallel from the New Mexico Territory⁶. However, Congress rejected the name of "Jefferson" for the new territory, as lawmakers balked at naming a territory after an individual. In the end, Congress agreed to name the territory Colorado in reference to the Colorado River which originated within the boundaries of the territory⁶.

In early 1864, statehood would be attempted again (despite the national focus on the Civil War in the East—known at the time as the rebellion), when Congressional Republicans, uncertain of President Abraham Lincoln's reelection chances, hustled through enabling acts for three Republican-oriented territories in the far west: Colorado, Nebraska, and Nevada, hoping to give the incumbent wartime president a boost in the Electoral College. New Mexico, not surprisingly,

was not included as it was controlled by the Democrats. Utah, similarly, was excluded because Congressmen bristled at the widespread and legal polygamy practiced there⁶. Ultimately, Congressional Republicans had no reason to worry about Lincoln's reelection as the former Illinois Congressman won in a rout¹⁰.

As for Colorado statehood, when the issue was presented on the ballot in the territory, the voters heavily refused statehood for the same reasons they voted against the State of Jefferson proposal six years before. Added to opposition based on taxation, the widespread apprehension of the territory's voters that statehood would enable them for the Civil War draft convinced many to vote against statehood. This effort for statehood also faced formidable opposition from the rural communities whose voters dismissed statehood as a disingenuous attempt by urban politicians to increase their power and the strongly Democratic southern counties, whose voters resented their removal from the New Mexico territory⁷. In the end, only Nevada achieved statehood in 1864⁶.

However, the movement for Colorado statehood would not be silent for long. As the transcontinental railroad began to expand west of Omaha in the summer of 1865, statehood advocates insisted that the direct voice in Congress that would come with statehood would guarantee Colorado a connection to the rail, which they asserted would bring greater prosperity and a higher population more capable to meet the demands of statehood. Denver leaders drew up a new state constitution, and this time, with the Civil War over, the territory's voters approved statehood by a vote of 3,025 to 2,870⁶.

In early 1866, though, Colorado statehood met defeat in the Senate, by a vote of 21 to 14 with 15 Senators absent⁷. As Congressmen were distracted with the considerable task of Reconstruction following the conclusion of the Civil War, statehood for a far-western territory with a sparse population of mostly miners and former gold-prospectors was not of critical necessity to the nation. Along with that, the fact that the proposed state's constitution denied Black men the right to vote exasperated Radical Republicans (Colorado women would not have access to the ballot until 1893). Most of all, the fact that the territory had such a small population composed mostly of miners convinced many Senators that Colorado was not able to be a state as mining was far less stable and permanent than agriculture or industry, and it was widely expected that miners would move as soon as the circumstances proved propitious. The small turnout of Colorado voters in the referendum for statehood likely demonstrated that the citizens of the territory were not ready to support a state government. Lastly, the fact that the vote in Colorado was not done under legal protection against fraudulent voting with no organized opposition persuaded opponents in the Senate that it was not clear if the citizens of Colorado

really did desire statehood^{7,9}.

Nonetheless, on Wednesday, April 25, Henry Wilson, a Radical Republican Senator from Massachusetts would reintroduce the bill. Wilson convinced his colleagues that Colorado held staggering natural wealth that would be realized much easier with statehood and that with so many Senators absent during the vote, the issue did not get an accurate assessment. The bill then quickly passed both houses of Congress⁷. However, when it reached President Andrew Johnson's desk on Tuesday May 15, the Tennessee Democrat was not impressed, and he vetoed the bill. This was the closest Colorado had come to becoming a state before it eventually did in 1876. All it needed was the president's signature, but for now it was not to be⁷.

To Johnson, all former Confederate States had to be reintegrated to the Union before the admission any new states could be considered, and Colorado was no exception. As far as Johnson was concerned, Colorado was doing just fine as a territory, and did not need statehood to be prosperous. For him, a mining population was unstable - there was no certainty, he insisted, that such a population would exist long enough to justify statehood for an area that could realistically be completely void of American citizens in the not too distant future. Additionally, for the president, the prosperity of the region existed in its natural wealth and the ability of the population to access it, and thus needed no formal authorization to realize its potential. Most vehement were Johnson's objections based on the small size of the population (and not just what he argued was a non-permanent one) and the legality of the bill presented before him. For Johnson, it made no sense to give a population roughly four times less than the minimum population to determine Congressional districts, an at-large district and two Senators. As far as the president was concerned, a territorial delegate was adequate for the representation of the population of miners and former prospectors in the region of Pikes Peak and the eastern slope of the Rocky Mountains⁷.

Because the voters of Colorado rejected statehood after Congress authorized an enabling act in 1864, Johnson was determined that the act had expired. For Johnson, Congress had the power to grant a territory admission if its citizens desired it, but Congress could not make states. For Johnson to be satisfied on that end, Congress would need to draft a new enabling act for Colorado for 1865. Because that did not happen, Johnson insisted that the Colorado bill of 1865 was illegal, and therefore, he could not sign it. Even if a new enabling act had been drafted and the citizens approved statehood on the ballot, to Johnson, 30,000 of mostly miners and former prospectors was a nomadic population that was far too small to require a state and too unstable to believe that there would consistently be enough citizens in it to justify a state government.

Lastly, it is hard to imagine why Johnson, as a Democrat, would be eager to assist a Republican-oriented territory into the Union⁷.

Ultimately, Congress failed to act to override the president's veto, and yet again, Colorado statehood was done for the time being. Once again, it would not be tabled for long⁷. The next year, in defiance of the president, Congress shoved the Colorado bill right back at him. As was probably expected, Johnson was not of a different mind than he was the previous spring and vetoed the bill for a second time on Monday, January 28, 1867. On Friday, March 1, Congress attempted to override the veto, but fell short of the necessary two-thirds in the Senate by 3 votes (the total vote count in the override attempt was 29-19)⁷.

Colorado statehood was one of several areas Johnson and Congress would clash over, and the next year the president would survive an impeachment trial by one vote over an incident unrelated to Colorado after Johnson discharged Secretary of War, Edwin Stanton in contempt of a new bill passed in Congress that required the Senate's approval for the president's dismissal of Cabinet officers¹¹. As far as the territory was concerned, this time, the question of statehood was finally buried for the time being. The advocates for statehood inside the territory and in Congress finally accepted the fact that with Johnson in the White House and no urgent need for the territory or the nation to rush Colorado's admission, continuing their efforts was futile. Ultimately, the defeat of statehood meant that it would come up later, and the next time Colorado statehood would pop up, the nation would be in crisis, just as it had when Colorado became a territory in early 1861.

6 STATEHOOD RESURRECTED

6.1 Controversy in Colorado

With the election of the Republican, Ulysses S Grant in 1868, the chances for Colorado statehood might have seemed better. On Wednesday, March 3, the day before Grant took the oath of office as the eighteenth president of the United States, *The Boulder County Pioneer* rejoiced, "... (T)omorrow brings the inauguration of President Grant and the retirement of AJ. Let us have peace"¹². However, the forty-seven-year-old former General of the Union Army did more harm to the territory than good at the beginning of his tenure in office. Within his first four months as president, Grant capriciously removed Colorado's territorial governor, Alexander Cameron Hunt, an appointee of Andrew Johnson, who was generally well liked, and by all accounts, performing competently in his office and without scandals⁶. In 1873, the suffragette and writer, Sara Jane Lippincott, known by her pen name, Grace Greenwood, wrote, "the general favorite (among the governors) in Colorado is

Governor Hunt"⁶.

In a gross display of patronage, the president replaced Hunt with Grant's Civil War comrade, Edward Moody McCook, who, despite having lived in the region that would become Colorado Territory from 1859 to 1861 and having served on the Jefferson Territory legislature in 1860, was at this moment, a resident of Ohio^{6,13}. There was great resentment amongst the residents of territories to outsiders being appointed to high offices of the territorial government, and Colorado was no exception⁶. "Eastern men..." the *Colorado Tribune* huffed, "who have no claim to govern us, are given preferences over their own citizens, as though we had no rights which the Administration was bound to respect"⁶. Worse yet, Hunt's successor quickly developed a reputation for corruption, dishonesty, poor integrity, and plain incompetence.

McCook, who sported a receding hairline, distinguishable by his bushy, protruding mustache that drooped over his lips, set the tone for his governance after he immediately appointed his brother-in-law, James B Thompson, as his private secretary, auditor of public accounts, and special agent to the Ute Nation at the same time. Although patronage and nepotism were common in nineteenth-century American politics, Thompson's many simultaneous offices gave him seemingly significant influence over the governor and territorial affairs⁶. Before these questionable appointments, McCook split public opinion right away after allying himself with Henry Teller, the long-time opponent of statehood and leader of the mountain communities which challenged Denver for the location of the site for the capital and infrastructure projects⁶.

McCook went on to engage in a series of scandals wherein he embezzled approximately \$30,000 dollars (in 1869 value—adjusted value of \$615,000 in 2022 currency) from the territorial and Federal governments⁴. McCook's debauchery did not end there. As governor, he was mandated by law to adhere to the terms of treaties with indigenous tribes and to preside over negotiations between the territorial government and Colorado's indigenous nations. The governor quickly discovered that he could serve this function and profit significantly from it⁶.

In one instance, McCook requested \$5,000 from the Federal government to cover the cost of supplies to satisfy the terms of an 1868 treaty between the Ute Nation and the territory. Upon receipt of the funds, though, instead of paying the distributor, the governor deposited \$3,000 of the loan in his personal account while claiming that the Federal government had only supplied him with \$2,000. Another condition of the treaty stated that the tribe were to receive occasional shipments of superior American cattle and sheep. To fulfill this condition of the treaty, McCook placed an order for 750 head of cattle, but instead of the high-quality animals

the treaty promised the Utes, McCook purchased unhealthy and emaciated animals which he bought for \$7.50 each—more than four times less than the price of the healthy animals. Afterwards, in yet another attempt to enrich himself, the governor requested payments from Washington for the price of the healthy cows the treaty promised (\$45.75 per head of cattle). The animals that McCook presented to the Native Americans were in such poor condition that the Utes refused to accept them.

Along with his criminal activity as governor, McCook displayed shocking incompetence. In a moment of appalling carelessness, the governor failed to sign a divorce decree between a couple until seven months after receiving the request, as divorce decrees by-law required the governor's signature within 10 days of receipt to be completed. Because the husband married another woman while the divorce decree sat untouched on the governor's desk, the man was legally married to two women at the same time, making him a polygamist, which was illegal under Colorado law. When the governor finally did sign the decree, in an additional blunder, he placed the wrong date on the form⁶.

6.2 The Final Push for Statehood Inside the Territory

By December 1872, Denver Republicans, led by Colorado Territorial Delegate to Congress, Jerome Chaffee—a close friend of Grant's, wrote a series of telegrams and letters to the president beseeching him to remove the unpopular, corrupt, and inept governor from office. As more and more reports of McCook's crimes were released and the allegations and investigations against him piled up, Grant discharged the embattled governor on Monday, January 27, 1873, and replaced him with the longtime resident of the territory and Chaffee ally, the long-bearded Samuel Hitt Elbert, who had previously served as Territorial Secretary before being elected to the Territorial General Assembly in 1868^{6,14}. The *Golden Weekly Globe* praised the president's decision to fire McCook and outlined the common wish of Coloradans that no corrupt carpetbaggers would rule their territory again:

... (I)ndications are that Hon S. H. Elbert, of Denver, is to be his (McCook's) successor. Mr. Elbert is an old Coloradan, and his hearty acceptance by the people is predicted by our exchanges. The folly of sending a man to the territory to act as chief executive, without knowing what our wants and necessities are, and no practical knowledge of the country, is becoming evident to others besides ourselves, and if Mr. Elbert is a man of right principles, we bespeak for him a successful jurisdiction¹⁵.

Meanwhile, in Washington, Chaffee, determined to keep another unscrupulous and clumsy carpetbagger from ruling the citizens of Colorado again, introduced a new enabling act for the territory in December 1873, almost a year after McCook lost his post as Territorial Governor⁵. For Chaffee, the only way out of the McCook mess would be for Colorado to choose its own top officials, which it could only do as a state. On Thursday, May 28, 1874, Chaffee submitted the following report from the House Committee on the Territories:

Population alone is not the proper or sole test for the admission of new States. The character of the people and the prospects for immediate growth and development of the proposed State should be controlling factors. There can be no doubt of the future growth and prosperity of Colorado. Few states had the population when admitted or possessed the wealth Colorado now has. The Committee can see no sound reason why a new or different rule should be applied to the territories now or hereafter seeking admission¹⁶.

The new governor shared Chaffee's perspective that it was time for Colorado to become a state, but rather than arguing against objections based on a small population, Elbert claimed Colorado had a population of roughly 125,000, in sharp contrast to the 1870 census report, which credited the territory with a population of around 40,000^{17,18}. In the State of the Territory address, on Tuesday, January 6, 1874, the governor made the following remarks on the prospect of statehood for Colorado:

Self-government is the highest aspiration of a free and intelligent people. It is the surest guaranty of inestimable rights, the most trustworthy guardian of material interests. The time has come when, under the spirit of our institutions and the practice of our government, we can properly apply for admission as a State into the Federal Union. . .

While I see in State government an additional burden, I also see represented in these facts and figures the strength that will support it. That Colorado has all the elements of a great and prosperous State, is not the language of exaggeration, but the clear and distinct utterance of statistics; the unequivocal testimony of achieved results. . .¹⁸

For Elbert, the objections to Colorado statehood based on the territory's population were no longer relevant. The construction of the railroad through Denver in 1868 and the expansion of rail lines throughout the territory in the following years meant that more people

could move to Colorado more easily⁹. Although it is hard to predict what the population of Colorado was in 1874, it was probably growing at a higher rate than it was when Andrew Johnson vetoed the last Colorado statehood bill in 1867. Like Chaffee, the governor insisted that the wealth of the territory demonstrated that Colorado was able to sustain a state government.

6.3 The Final Straw

Along with Chaffee's new bill and the governor's support for admission, new developments would convince many in the territory that statehood was imperative and that now was the time. After reports of various scandals involving Elbert's subordinates, the governor's rivals began petitioning the president to take action, and McCook began to demand his job back⁶.

Following a spat between Grant and Chaffee in January 1874, supposedly over a poker game, the president finally responded to the calls for Elbert's dismissal. The president recalled Elbert along with all of Chaffee's friends in top places in the territorial government, including territorial marshal, Frank Hall, who would later publish a multi-volume history of Colorado, and WS Lessig, the surveyor general, among others⁶. In a final blow to Chaffee, Grant nominated Elbert's controversial predecessor, Edward McCook, who Chaffee had worked so hard to get rid of ten months earlier. On Friday, June 19, 1874, McCook was confirmed by one vote in the Senate, and the divisive former governor was back⁶.

Disheartened by McCook's return, Chaffee declined his nomination from the territorial Republican Party to run for reelection as territorial delegate. In Chaffee's place, H.P.H. Bromwell took the nomination⁴.

The return of McCook to Colorado was met with such outrage in the territory that his reinstatement caught national attention. The *New York Times* concluded that Colorado politics were among the most corrupt in the country⁶. As a result of their large anger about McCook's reinstallation, many citizens of the territory began more than ever before to demand self-determination⁶. This time, public indignation over the McCook affair outweighed previous resistance to the higher taxes that statehood would bring. On Wednesday, August 19, 1874, the *Fort Collins Standard* published the following excerpt from the *Denver News*, highlighting the widespread discontent amongst the Colorado public with McCook's reinstatement as governor:

One mission of the Republican party has been to purify the public service and to expose and punish fraud whenever found. The so-called republican convention which met in this city seems to have taken a widely different view of things, and to have thought

that all charges of fraud should be hushed up, and all corruption buried beneath the mantle of party welfare... (that) it ought to be overlooked... McCook did swindle the government... It is just this moral cowardice, exhibited by the convention, that is destined to cause... Bromell's defeat by the largest majority ever given against any candidate for congress in this territory. A defeat upon a bold, square, honest enunciation of principles would have been honorable, and given strength and vigor to the party; but defeat, caused by such a platform as was adopted by the administration convention, can be construed only as a rebuke to the managers, who were willing to barter principle, reputation, honesty, everything, for a delusive harmony¹⁹.

The common outrage over McCook's reinstatement as governor prompted Grant to remove him from this post once and for all after eight months. McCook then left public life never to return. The former governor would never be prosecuted for his misdeeds as governor and he would eventually leave Colorado for good²⁰. However, the damage had been done, and as *The Fort Collins Standard* had predicted, Bromwell lost to his Democratic challenger, the 35-year-old Irish born lawyer, Thomas MacDonald Patterson, who would be the only Democrat Colorado would ever elect as territorial delegate. The president replaced McCook with yet another non-resident of the territory, John Routt, who hailed from Kentucky⁶. The widespread revulsion to McCook's corruption described in this editorial and a fervent desire to prevent another scandalous carpet-bagger like McCook from leading the territory again fomented strong support for statehood throughout the territory. *The Rocky Mountain News*, the mouthpiece of the pro-statehood faction asserted:

It seems that the people of Colorado Springs, or at least a portion of them, are opposed to the admission of Colorado as a state... We learn from a private source that the under current reasons for the opposition at Colorado Springs are purely local and personal... The News fails to see how admission can benefit Denver more than other portions of the territory... We believe that (statehood) would greatly promote and hasten the settlement and development of all parts of Colorado²¹.

For the editors of the *News*, statehood was in the best interest of all counties of Colorado, and they predicted a weak and disjointed opposition inside the territory. The *Trinidad Enterprise*, speaking for the southern counties, however, disagreed:

In Southern Colorado, that question (state-

hood) will be treated as only as an immaterial issue. Statehood would be not particularly desirable to us, as our present condition is not such as to create a wish for a change²².

Despite large opposition to statehood from the southern counties and the mountain communities, support for statehood at this point was stronger, more widespread, and more united than it had been in previous attempts.

Not seeming to sense that Chaffee's statehood bill was a rebuke to his appointees or his leadership, Grant, unlike Johnson before him, backed the effort to make Colorado a state⁶. The president's interest in the issue reportedly predated his presidency, going back at least as far as 1868, and Grant remained firm in his commitment to Colorado statehood, despite his recent falling-out with its territorial delegate. In a letter to Chaffee dated March 13, 1875, the president wrote:

From the date of my first visit to Colorado to the present I have believed that Territory had the Mineral and Agricultural resources to make it a populous and prosperous state, and an intelligent and energetic population calculated to develop these resources and to maintain republican government. I sincerely hope that all strife in the embryo state may cease, and I confidently believe it will²³.

Grant's reasoning was similar to that of Colorado statehood advocates in the past—that Colorado's natural wealth justified its admission. The president shared Samuel Elbert's belief that the wealth of the territory meant that Colorado was capable of supporting a state government, and on that subject alone, it did not need to remain a territory. Despite the president's support for statehood, though, national events appeared to spell doom for this effort to make Colorado a state as it had previous attempts.

7 A NATION IN CRISIS

Before Chaffee drafted his bill, throughout 1872 a series of reports were released documenting several scandals involving Republican members of Congress and the Grant administration². On Thursday, September 18, 1873, a final blow would be dealt to the Republicans who controlled both houses of the legislative branch when one of the nation's largest banks, Jay Cooke & Company announced that it had gone bankrupt. The announcement spread panic throughout the country and sent shockwaves throughout the world. The ensuing depression would be the nation's worst before 1929, and it would last for over two decades²⁴. Not surprisingly, as the ruling party, the Republicans took the blame for the bad economy. Frustrated by economic

hardship and disenchanted with Republican corruption, the nation's voters turned on the party.

The Congressional midterms of 1874 would be a nightmare for the Republicans. The Democrats flipped a 100-member Republican majority in the House to a two-thirds Democratic majority while nearly flipping the Senate². This would be the first time the Democrats controlled the House since the middle of the 1850s. The party went on to win a series of key gubernatorial races throughout the country and switch a number of state legislatures⁵. The huge success for the Democrats in 1874 came just two years after the Republicans dominated the 1872 midterms. The Democrats' turnaround in 1874 marked, "one of the most stunning reversals in American political history," and their great triumph convinced many members of the Democratic establishment that anything was now possible for the party⁵. The new split Congress might have marked the end of the most recent attempt to make Colorado a state. However, like in the past when the issue appeared to be a dead letter, Colorado statehood would not be stopped.

8 THE FINAL PUSH

8.1 Initial Passage in the House

When Chaffee's bill reached the floor of the House of Representatives in June 1874, it faced a ferociously hostile eastern press who largely scorned far western territories as backward, and, not surprisingly, great antagonism from the mountain communities and the southern counties of the territory whose voters held the same attitudes towards statehood as they did in 1864 and the other previous efforts to make Colorado a state⁶. With the Congressional midterms that would flip the House still around 4 months away, the Republicans still controlled the House. However, the bill was presented under a rule that required a two-thirds vote in the affirmative to pass. The Republicans, lacking a two-thirds majority, needed some help from the Democrats for Colorado statehood to progress to the Senate. Surprisingly, no Democrats raised any objections to statehood for the Republican territory that had far fewer American citizens in it than the minimum population to determine Congressional districts⁵. Although the Democratic leadership did not support the bill, no fewer than 32 Democrats joined 139 Republicans in the yes column. Twenty-three Republicans and 69 Democrats voted against it. Had the 32 Democrats who voted yes stayed in line with the party leadership or abstained from the vote, they could have killed the bill⁵. Regardless, the 32 Democratic votes gave the bill a two-thirds majority, and Chaffee's bill passed the House on Monday, June 8⁵.

No Democrats spoke in favor of Colorado statehood, so it is not clear why 32 Democrats voted for it²⁵. In-

terestingly, the House Democrats who voted for initial passage of Colorado statehood came from all regions of the country, so the bill was not passed simply because of regional biases by far-western Democrats²⁶. Interviews with politicians were less common in the 19th century than they are now, so the reasons for why those Democrats supported the passage of the enabling act for the Republican-oriented territory to become a state are difficult to determine. Surely, even had those Democrats spoken in favor of Colorado statehood, it is hard to imagine that they would have discussed partisan motives. With the presidential election still more than two years away and Thomas Patterson's election as Colorado's territorial delegate still 4 months away, the possibility that the 32 Democratic votes were motivated by the upcoming presidential election and their expectations for how Colorado might vote seems unlikely.

8.2 The Senate Battle

When the Senate took up the bill in February 1875, the partisan implications for Colorado statehood were evident⁵. The Democrats had stunned the nation in the Congressional midterms in the fall while Colorado had elected Thomas Patterson as its territorial delegate to Congress. Patterson supported statehood, and he tried to convince his fellow partisans in Congress to vote for it, claiming that his election was part of a national shift towards his party and that his victory signaled a partisan realignment in Colorado from the Republicans towards the Democrats⁴. With the upcoming presidential election in mind, Patterson all but promised that if admitted, Colorado would vote Democratic in 1876⁶. Amidst Patterson's pledges to the Democrats, Jerome Chaffee stayed in Washington to reassure his Republican colleagues that Colorado would be a Republican state if admitted and reminded them of the likely conditions for Patterson's election – that the Irishman had been elected probably because of widespread anger over the McCook affair and not because of any change in the voters' partisan interests⁴. In a September 2, 1874 editorial, *The Fort Collins Standard* confirmed Chaffee's beliefs that Patterson's election was the product of public frustration over the McCook episode and not a partisan realignment in Colorado:

...(I)t becomes clearer every day that Mr. Bromwell is a McCook carpet-bag candidate, and by his election the people will endorse the President's action in the removal of all the old officials of the territory and substituting carpetbaggers in their stead²⁷.

By rejecting Bromwell and electing the Democrat, Patterson, Colorado voters sent a powerful message of

their disapproval of the president's meddling in their affairs.

Irony abounded when George Edmunds, a Vermont Republican, known by his Senate colleagues for having a cantankerous and crotchety disposition, did not trust Chaffee's reassurances and sought to delay statehood by offering an amendment stating that Colorado could not hold a popular referendum on statehood until July 1876⁵. Consternated by Edmunds' unexpected and possibly hostile amendment, Patterson confided in a letter to his wife Katherine, "If the state bill should fail, it will be from the treachery of its professed friends in the Republican party"⁴. When Edmunds' fellow Republican, Phineas Hitchcock of Nebraska, who served as the bill manager, suggested in the Senate debate that Edmunds was trying to stall Colorado statehood, Edmunds tersely retorted, "The Senator is right"²⁸.

The Vermont Senator maintained that he still supported Colorado statehood but insisted that the citizens of the territory should have proper time to consider the issue before having the question suddenly thrust upon them—just as Andrew Johnson had reasoned in his statement following his first veto of Colorado statehood back in 1866 that the lack of an organized opposition rendered the true interests of the citizens of Colorado uncertain⁵. Ultimately, Edmunds' amendment passed⁵. The bill then went on to pass the Senate with just two Democrats, both from states west of the Mississippi River (James Kelly of Oregon and Lewis Bogy of Missouri) joining 26 Republicans in the affirmative. Eight Republicans, including Edmunds, and 14 Democrats voted against the bill^{5;28}.

The fact that any Senate amendments would require approval in the Democratic House for it to progress to Grant's desk and Edmunds' vote on the bill contradicted the Senator's pledges of support for statehood. Edmunds knew that if the House failed to accept amendments added in the Senate, the bill would fail. With the possible implications for the upcoming presidential election clear, Edmunds could have expected that the Democratic House would reject the amendments or fail to put the bill on the agenda to let it die on the Speaker's desk when the Congressional session ended. Either way would obviate the risk to Republicans that a new Democratic state would be admitted in a critical election year should Patterson's professions prove true. By voting no on Colorado statehood after adding an amendment to delay the popular vote, it demonstrates that Edmunds had likely sought to kill the bill.

Ultimately, Edmunds' motivations are hard to discern. The Vermont Republican did not speak against Colorado statehood in the Senate debate, nor could any record be found wherein Edmunds presented a reason for his opposition to Colorado's final attempt to become a state. It is possible that he was motivated by

concerns about the upcoming presidential election and an apprehension that the attitude of Colorado voters was shifting from the Republicans to the Democrats following Patterson's election—at least for 1876 following the huge success of the party in the 1874 midterms and their unexpected triumph in state and gubernatorial races across the country.

8.3 Statehood At Last

Regardless of Edmunds' intentions, the Democratic House Speaker, Michael Kerr of Indiana, allowed the bill to have a vote to consider the amended version passed in the Senate, and the House adopted the Senate's amendments, though with diminished support from the Democrats. This time around, only 15 Democrats voted for the bill as opposed to the 32 in June 1874⁵. Whether those 15 Democrats were influenced by Patterson's pledges is hard to know. What can be known is had those few Democrats abstained or voted in the negative, as in 1874, Colorado statehood would have lost. Colorado voters approved statehood on Saturday, July 1, 1876, and President Grant signed it into law on Tuesday, August 1. In the end, Edmunds' amendment only delayed the entrance of Colorado's Senators and its Representative until March the next year^{5,4}.

In a classic moment of Gilded Age corruption, pro-statehood voters reportedly voted several times over in the July 1 referendum. However, the vote was never formally challenged, and Colorado entered the Union as the 38th state⁴. After Republicans swept the new state's elections on Tuesday, October 3, the new legislature added a provision to the state constitution that provided that the legislature would choose the state's electors in its first presidential election year, and afterwards the voters would. Not surprisingly, the Republican legislature chose Republican electors who inevitably voted for the Republican presidential nominee, Rutherford B. Hayes. Colorado's votes were not challenged in Congress, and when the electoral dispute was settled, Hayes was counted in as the nineteenth president of the United States¹. Whether Patterson's promises to his party were correct cannot be known—in 1876 there was no popular vote for president in Colorado. Considering the outcome in the election for the state legislators, though, it seems unlikely that the popular vote would have confirmed Patterson's claims. What can be known, though, is that the new Republican legislature was not willing to take any chances. With the electoral votes of four states undetermined and the balance of votes required for election thrown off, the stage was set for conflict.

9 CONCLUSION

In summary, few states have faced as much resistance to admission as Colorado did. It could have become a state any time before 1876, with its best opportunities coming in 1866 and again the next year. All it needed was the president's signature. Had Johnson signed the bill, Colorado probably still would have voted Republican in the critical election year of 1876. The McCook affair would not have happened and probably neither would Patterson be elected to represent Colorado in Congress. Nonetheless, Johnson vetoed it twice, setting the stage for Colorado statehood to reappear at some time in the future. Indeed, it was widely understood that all of the Western territories would eventually become states. The fact that Colorado became a state in a crucial election year might make it appear that there was a link between Colorado statehood and the election. However, that link is debatable. The final effort to make Colorado a state was the product of events inside the territory, particularly public opprobrium over the McCook affair.

When the bill first passed the House, with the Congressional midterms that led to the Democratic flip of the House and the election of Thomas Patterson as Colorado's territorial delegate still months away and the presidential election more than two years away, it is not likely that the bill's success in the House was tied to the election. Rather, it appears that the Democratic leadership did not consider blocking the admission of the Republican territory a priority, and the 32 Democrats who voted for it probably voted for it for reasons unrelated to the election. However, the battle in the Senate was strongly related to the election as some Republicans, like Vermont's George Edmunds, worried that Colorado was shifting to the Democrats. When the bill reached the House for final approval of Senate amendments, it is possible that House Democrats were influenced by Thomas Patterson's vows that Colorado would vote Democratic. However, that is hard to know. The Democratic leadership did not support the bill this time around just as they did not support it in 1874. However, the Democratic House Speaker, Michael Kerr of Indiana, considering the possibility that Patterson's statements might have been true, put the bill on agenda and allowed it to have a vote.

The reasons why 15 House Democrats voted for it in 1876 could have been the belief of those Democrats that Patterson's promises were true—that Colorado was indeed becoming Democratic. However, that is hard to know. No written record of the discussions between Thomas Patterson and his fellow Democrats could be found. Moreover, more than fifty percent fewer Democrats voted for the bill in 1876 than initially in 1874. Therefore, to connect the achievement of statehood for Colorado to Thomas Patterson's election and

his dialogue with Congressional Democrats seems inaccurate. Even had those House Democrats based their votes on their belief of Patterson's claims, the fact is hard to prove. What is certain, though, is had the Democratic leadership been more effective at holding the party together or if Kerr had not granted the bill a vote, Colorado statehood would not have happened in time for the election, and the electoral dispute would not have taken place.

Ultimately, the weak control of the Democratic leadership over the party would be a recurring theme in the election and subsequent dispute. Had the Democrats rejected every Republican proposal to determine which candidate had won the electoral votes of four states in question and had they not come up with their own proposals, no candidate would have secured a majority in the Electoral College, and as stipulated in Article II, Section I, Clause IV of the Constitution, the House would determine the next president³. The House, controlled by the Democrats, would inevitably choose Samuel Tilden. However, because the Democratic leadership was unable to hold the party together and because Democrats in Colorado did not consider statehood a significant enough defeat to appeal the result and Democrats in the nation's capital did not regard Colorado as worthy of review by the electoral commission, Colorado became a state, the election became disputed, and against all odds, Hayes was elected.

Surely, Colorado statehood would have taken a much different path had Grant never removed Alexander Hunt as territorial governor and installed Edward McCook. Had Grant left the territory alone, Colorado statehood may very well not have come up in the years leading up to the election, and it might have happened in later years. The history of the state and the nation would have taken a much different path in the Gilded Age, and Samuel Tilden would have been president. Perhaps then, the election of 1876 would not be so memorable, and it would have disappeared from public memory just as many nineteenth century elections have. Because Colorado became a state in 1876 and in time to participate in the presidential election, the election of 1876 has not been forgotten and the specter of 1876 lives on.

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11 EDITOR'S NOTES

This article was peer-reviewed.

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Butterfleye by Natalie Crowley
Acrylic Paint on Canvas

Caprin1 and Fmr1 Genetically Interact to Regulate the Development of the Larval *Drosophila* Neuromuscular Junction

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Abstract

Fragile X Syndrome (FXS) is the most prevalent inherited neurodevelopmental disorder and the most common single-gene cause of autism¹. FXS occurs due to the loss of the *Fmr1* gene and its protein product, the Fragile X Messenger Ribonucleoprotein (FMRP). FMRP is an RNA-binding protein (RBP) with notable functions in synaptic development. Given that cellular processes often entail the collaborative actions of multiple proteins acting as binding partners to regulate mRNA metabolism, identifying FMRP's associates is essential for comprehending FXS mechanisms. Caprin1 was identified as a high-confidence interactor via its co-immunoprecipitation with FMRP in an IP/LC experiment done in the Barbee laboratory, among others^{2,3}. The objective was to determine if *Caprin1* and *Fmr1* genetically interact to regulate synaptic development of the neuromuscular junction (NMJ) in *Drosophila melanogaster* (fruit flies). *D. melanogaster* is a well-understood model organism for studying FXS because it shares many similarities with human FXS⁴. To determine if a molecular interaction between the RBPs existed, a genetic cross of *D. melanogaster* with mutated copies of *Fmr1* and *Caprin1* was created. The analyzed synapses were analogous to the overgrowth seen in the FXS brain. *Fmr1* and *Caprin1* were determined to be genetic interactors in the regulation of synaptic development in the *D. melanogaster* NMJ. These findings offer a glimpse into the intricate molecular processes governing neurodevelopment in the presence of mutated *Fmr1* and *Caprin1* genes, providing valuable insights into their contributions to the molecular pathology of FXS. Future experiments should aim to determine the function of Caprin1 within neurons and examine the biochemical interaction between FMRP and Caprin1 proteins.

Keywords: *Fragile X Syndrome, Caprin1, FMRP, neuromuscular junction, synaptic development*

1 INTRODUCTION

1.1 Fragile X Syndrome

Fragile X Syndrome (FXS) is the most prevalent inherited cause of mild to severe intellectual disability. It is the leading single-gene cause of autism¹. The syndrome results in lifelong neurological and behavioral impairment, affecting approximately 1 in 4,000 males and 1 in 7,000 females¹. About one-half of X-linked intellectual disability cases are the result of FXS. FXS is associated with features such as intellectual disability, social and communication difficulties, hyperactivity, repetitive behaviors, and physical characteristics like an elongated face and large ears. FXS is caused by a mutation in the *Fmr1* gene. The mutation consists of a trinucleotide repeat expansion, CGG, which elicits epigenetic silencing. The expanded repeats cause hypermethylation extend-

ing from the 5' untranslated region (UTR) of the *Fmr1* gene into the promoter region. This loss-of-function mutation prevents the production of Fragile X Messenger Ribonucleoprotein (FMRP), the protein product of *Fmr1*. The full mutation occurs when there are over 200 CGG repeats. A premutation carrier will have between 55-200 CGG repeat expansion and be at risk of developing fragile X tremor-ataxia syndrome (FXTAS) if male and fragile X-associated primary ovarian insufficiency (FXPOI) if female.

1.2 Function of FMRP

FMRP serves functions in mRNA regulation and metabolism, translation and ribosome stalling, RNA editing and modifications, regulated transport, and DNA damage response¹. FMRP is classified as an RNA-

binding protein (RBP). RBPs regulate all aspects of gene expression including mRNA trafficking, splicing, stability, and translation⁵. While FMRP plays diverse roles, it is best characterized as a translational repressor⁵. FMRP possesses conserved RNA binding motifs that can directly interact with mRNA and physically obstruct ribosomes from accessing it⁵. Conversely, FMRP can also interact with various proteins involved in different stages of translation. FMRP can also sequester mRNA and ribosomal components thereby spatially repressing translation by removing the necessary constituents out of the available pool⁶. Adding an additional layer of control, FMRP can either enhance or suppress the silencing effects of miRNA⁷. FMRP is implicated in synaptic plasticity, dendritic spine development, and overall neuronal maturation. The constant formation and elimination of synapses during development requires thousands of proteins to cooperate to achieve proper neuronal communication and functional neural networks. Thus, FMRP's modulatory action on protein synthesis (and its potential interactors) is important for the pruning of synapses during development and for alterations via synaptic plasticity later in life. Its dysfunction in FXS can lead to impaired synaptic plasticity and contribute to the neurological and cognitive deficits associated with the disorder.

1.3 Structure of FMRP

FMRP contains several functional domains, consisting of two K homology domains (KH) and one arginine glycine-rich region (RGG) box⁸. These domains are involved in RNA binding and interactions with other RBPs. Through these interactions, FMRP plays a critical role in the localization of mRNAs within neurons, especially in dendritic spines, contributing to the regulation of local translation and synaptic plasticity. FMRP is known to engage in various RBP interactions, including associations with both nucleolar proteins FXR1P and FXR2P. FMRP also interacts with cytoplasmic proteins outside of the nucleus like CYFIP1 and CYFIP2⁹. The resulting complexes form heterodimers indicating a direct protein-protein interaction¹⁰. Forming larger functional complexes is typical of most RNA-binding proteins, such as FMRP, as they tend not to operate in isolation. Functional complexes are involved in various cellular processes, including mRNA translation and synaptic function¹¹. The absence or malfunction of FMRP, along with altered interactions with its binding partners, can lead to synaptic and neuronal dysregulation contributing to the characteristics of FXS.

1.4 Localization of FMRP

The precise localization of FMRP plays a pivotal role in its ability to interact with RNA molecules, other pro-

teins, and cellular structures. FMRP is known to exhibit a dynamic pattern of localization, reflecting its diverse functions in cellular processes. Predominantly, FMRP localizes in the cytoplasm, but also is detectable in the nucleolus¹². The binding of specific mRNAs by FMRP can direct its transport to designated subcellular compartments along with activity dependent mechanisms. It is abundantly found in dendritic spines, the small protrusions on neurons where synaptic connections occur¹². The precise positioning of FMRP at synapses is critical to its role of regulating translation, synaptic plasticity, and overall neuronal function.

1.5 Liquid-liquid Phase Separation Properties of FMRP and other RBPs

Recent studies have established that FMRP regulates the formation of several types of RNA/protein granules, including messenger ribonucleoprotein particles (mRNPs) transport granules, fragile X granules (FXG), P-bodies, and stress granules⁷. The ability of FMRP to undergo liquid-liquid phase separation (LLPS) may contribute to the formation and dynamics of stress granules, which are transient aggregates of mRNA, RBPs, and initiation factors that form in response to cellular stress⁷. The phosphorylation state of FMRP influences both stability and binding affinity, dictating associations with various RBPs and mRNA. Phosphorylated FMRP more readily phase separates with mRNA into the liquid droplets' characteristic of LLPS. LLPS is crucial for targeted delivery and localized translation of mRNAs. Within the neuron this is particularly important because specific proteins, like FMRP, need to be brought to specific locations, like dendrites and axons, to perform specific processes required for proper neuronal function. Thus, FMRP associates with mRNA and other RBPs inside of LLPS particles for trafficking to the synapse. The phase separation capability may enhance spatial and temporal control of FMRP's interactions with mRNA molecules, ribosomal components, and other binding partners ultimately influencing cellular processes such as translation and synaptic plasticity.

1.6 FMRP and Synaptic Plasticity

FMRP reportedly binds to approximately 4% of all mRNAs in neuronal tissue¹³. Thus, a lack of FMRP's repressive action leads to the enhanced translation of many messages in the central nervous system. One of these systems is the metabotropic glutamate receptor 5 (mGluR5), a Type 1 mGluR. An enhanced mGluR5 pathway contributes to long-term depression (LTD). Specifically, FMRP acts as a translational repressor of mRNA downstream of Type 1 mGluR activation. In its absence, there is excessive mGluR-dependent protein synthesis¹⁴. LTD causes weak and immature synaptic connec-

tions hindering synaptic plasticity, synaptogenesis, and pruning¹³. Synapses are the basis for neural circuitry and are essential to neuronal function, communication, and enabling of complex behaviors. Without FMRP regulating synaptic development, especially in the post-natal period, synapses become overgrown due to the lack of “connection pruning”¹⁵. Likewise, long-term plasticity (LTP) requires activation of Type 1 mGluRs and is dependent on protein synthesis under the control of FMRP just like LTD¹¹. Thus, FMRP is known as a “master regulator” and “molecular switch”¹⁶ as its regulatory activity is necessary for the processes of synaptic development and maintenance both early on and later in life. At its core, FMRP acts as a versatile regulator, exerting its influence at multiple levels of gene expression control, including RNA binding, translation regulation, mRNA transport, and synaptic plasticity.

1.7 Regulatory Control of FMRP

Another feature of FMRP and its regulatory control is its heavy influence on dendritic spine development via FMRP-mediated mRNA transport. Consequently, the deficiency of FMRP in individuals with FXS results in abnormal synaptic morphology¹⁷. A distinctive pattern of immature synapses manifests at the dendritic spine, marked by increased density, abnormal morphology, altered synaptic plasticity, and impaired synaptic maturation. The FXS synapse appears longer, thinner, and more filopodia-like compared to mature, mushroom shaped spines observed in typical development. These structural changes are thought to be related to impaired synaptic pruning, a process crucial for the refining and optimizing of neuronal circuits during development¹⁷. In FXS, this process is disrupted, and synapses remain in a more immature state impacting the overall functioning of neurons. Increased synaptic terminal bouton count and extensive branching occur within the overgrown, immature synapses compared to the pruned and distinctly mature synapses of a healthy wildtype. These features contribute to the neurobiological basis of the cognitive and behavioral challenges observed in individuals with FXS. Understanding the specific characteristics of immature synapses is crucial for developing targeted interventions that address synaptic abnormalities.

1.8 Determining RBP Interactors of FMRP

The function of FMRP can be determined by its interactions with other RBPs. However, most of these other interacting RBPs are not known. It is important to understand the associations of proteins because it provides insights into their specific cellular functions. Immunoprecipitation is a widely used laboratory technique that allows for selective precipitation of a specific

protein or protein complex from a mixture. This technique is the standard for studying protein-protein interactions and identifying possible binding partners. After the proteins are eluted by immunoprecipitation and found to be bound together, they are then identified using techniques such as mass spectrometry. The Barbee laboratory at the University of Denver performed an FMRP-co-immunoprecipitation experiment of the adult *D. melanogaster* head, enriched for neuronal tissue. The precipitated proteins bound to FMRP were identified by liquid chromatography-mass spectrometry (LC/MS). Caprin1 was identified as a high-confidence interactor.

1.9 Caprin1

Caprin1 is an evolutionary-conserved, ubiquitously expressed cytoplasmic phosphoprotein. It is classified as an RBP indicating its role in binding and is characterized by different domains including an RNA binding domain and a coiled-coil domain. These domains suggest its involvement in RNA metabolism and protein-protein interactions. Importantly, Caprin1 has been implicated in several cellular processes including the regulation of mRNA translation and stress granule formation like FMRP⁷. It is thought that the Caprin1/G3BP1 complex regulates the transport and translation of mRNAs. These mRNAs encode proteins involved in synaptic plasticity, as well as cellular migration and proliferation across several cell types¹⁸. Caprin1 is specifically found packaged with other RBPs in postsynaptic granules located at neuronal dendrites¹⁸. As such, Caprin1-mediated dendritic localization of mRNAs has been suggested as an underlying mechanism for AMPA receptor scaling that occurs in response to varying increases and decreases in neuronal activity¹⁹. Altering the density of AMPA receptors contributes to overall synaptic strength, plasticity, and proper function. In essence, Caprin1 serves as a key player in the orchestra of synaptic plasticity, shaping the brain's ability to learn, adapt, and remember by acting as a central regulator and molecular taxi.

1.10 FXS Modeling

D. melanogaster, commonly known as the fruit fly, is a well-established model organism for the study of neurodevelopmental disorders including FXS. Many fundamental genetic pathways and molecular processes are conserved between *D. melanogaster* and humans. The *Fmr1* gene and its protein product FMRP have functional equivalents in *D. melanogaster*. When the *D. melanogaster* ortholog of FMRP is lost it exhibits many shared cellular and behavioral phenotypes with human patients⁴. One of these shared phenotypes is significant overgrowth of the larval NMJ, a phenotype characteristic of hippocampal synapses in human FXS patients¹⁷.

Since synaptic dysfunction is a hallmark of FXS, the *D. melanogaster* NMJ proves useful for investigating altered synaptic structure and function in a non-human model⁴. Henceforth, this phenotypic trait allows insights into precisely how FMRP may influence synaptic plasticity at the molecular level. Zooming in, the A3 segment NMJ along muscle 6 and 7 is a well-studied model system for investigating the development and function of synapses in the *D. melanogaster* nervous system. It is easily accessible for experimental manipulation due to its positioning on the ventral side of larvae. The transparency of *D. melanogaster* larvae allows for visualization of NMJ structures using light microscopy and fluorescent staining.

1.11 FMRP and Caprin1 as Potential Interactors

A plethora of literature has established that Caprin1 and FMRP colocalize and directly interact in non-neuronal tissue^{20,21,22,23}. Caprin1 and FMRP interact in systems such as the *D. melanogaster* ovary, mammalian embryo, and in vitro. Namely, the analysis of Caprin1 and FMRP crystal structures shows that they have a direct protein-protein interaction that is not RNA-dependent. It appears they bind to RG-rich sequences in the RGG box located on both proteins²². Equally important, Caprin1 was co-immunoprecipitated with FMRP in multiple laboratories beyond the Barbee laboratory^{2,3}. It is believed that the interaction between Caprin1 and FMRP is important in the control of mRNA metabolism, particularly its translation into proteins³. Defects in these processes are directly linked to FXS. However, there is a gap in knowledge of how precisely the dysregulation of translation causes the neurodevelopmental defects that are characteristic of FXS. Thus, Caprin1 is an RBP of interest as it may have important interactions with FMRP at the genetic level in *D. melanogaster* neurons.

Here we ask if a genetic interaction between *Caprin1* and *Fmr1* exists. Secondly, if an interaction does exist, is it of biological relevance within the *D. melanogaster* neuron? Lastly, does their combined genetic interaction control for FXS phenotypes such as synaptic overgrowth. These experiments are based on the prediction that no effect on NMJ development will be observed when a single copy of *either* gene *Fmr1* or *Caprin1* is lost within a single mutant, as the remaining copy will be enough to rescue the phenotype, as is typically observed. Therefore, to determine if there is a genetic interaction, a double mutant cross that has lost *both* a copy of *Fmr1* and *Caprin1* will be reared and examined for genetic interplay predicted to result in immature, overgrown synapses. Thus, it is hypothesized that *Fmr1* will genetically interact with *Caprin1* to regulate synaptic development of the larval NMJ. This interaction will be discerned by observable altered morphology in comparison to both wildtype and single mutant lines.

2 METHODOLOGY

2.1 *D. melanogaster* Stocks and Crosses

Fly lines and genetic crosses were maintained at 25°C on standard Bloomington media. Genetic lines used included *Iso31,w^{*}Sb/Tm³SerGFP*, *FRT80B,capr²/Tm²*, *Fmr1^{Δ50}/Tm⁶TbSb*, *FRT80B,capr²/Tm³SerGFP*. The *Caprin1* line was created by crossing *w^{*}Sb/Tm³SerGFP* and *FRT80B,capr²/Tm²*. A male and virgin female with the genotype *FRT80B,capr²/Tm³SerGFP* were selected and crossed from the F1 generation to establish the *Caprin1* line. The double mutant was selected from virgin *Caprin1* females with the genotype *FRT80B,capr²/Tm³SerGFP*, and males from the *Fmr1* line with the genotype *Fmr1^{Δ50}/Tm⁶TbSb*. The denoted double mutant genotype is *FRT80B,capr²/Fmr1^{Δ50}*. All crosses contained 15 virgin females and 5 males. There were three negative controls used: a wildtype, a single *Caprin1* mutant over wildtype, and a single *Fmr1* mutant over wildtype. They are denoted as follows *Iso31 (+/+)*, *FRT80B,capr²/Iso31 (Caprin1/+)*, and *Fmr1^{Δ50}/Iso31 (Fmr1^{Δ50}/+)*.

2.2 Neuromuscular Junction Microdissections and Immunofluorescent Staining

Larvae of *D. melanogaster* at the wandering third instar stage were dissected in Jan and Jan buffer, a calcium-free saline solution. The larval body wall preps were fixed with 3.5% paraformaldehyde (PF) and then washed in 1x-phosphate buffered saline (PBS). The preps were incubated overnight with mouse -DLG, the primary antibody, for immunofluorescent tag attachment. The 1° antibody to block dilution was 1:100. The next day the preps were washed in PBS containing 10% Triton X-100 (PBS-T) and incubated for 1 hour with the secondary antibodies anti-mouse IgG Alexa488, a green-fluorescent tag, and anti-HRP Alexa633, a blue-fluorescent tag. The 2° antibodies to block dilution was 1:500. Antibodies were sourced from Developmental Studies Hybridoma Bank, anti-discs large. Lastly, preps were mounted in DAPI Fluoromount-G (Southern Biotech) and stored at -20°C until imaged.

2.3 Imaging and Statistical Analysis

Images of the NMJ at segment A3 m 6/7 were obtained from scanning confocal microscopy using the Olympus Fluoview FV3000 with 60x objectives (N.A. = 1.42). Using the Olympus FV software, the entire NMJ was imaged using 0.4-micron optical sections. All channels were manually adjusted to the threshold prior to imaging. A Z-projection was assembled from all optical sections in ImageJ. Analysis was performed using Image J software with the cell counting plugin. Type 1s glutamatergic boutons and type 1b glutamatergic bou-

tons were manually counted and differentiated based on size and intensity of DLG staining. Type 1b (big) boutons are distinguished from type 1s (small) boutons due solely to their difference in size. Additionally, their respective branch tips were quantified. The immature phenotype associated with FXS, characterized by overgrown synapses with extended branching and increased bouton count, is expected to be observed in the double mutant. The bouton analysis was blinded. All data were first recorded in Microsoft Excel. Statistical analysis was performed in GraphPad Prism. Because there was a significant difference in standard deviation between groups, the statistical test used was the non-parametric Kruskal-Wallis ANOVA. Secondly, Dunn's multiple comparisons test was performed. Such tests were necessary to delineate a true relationship between variables since the collected data is not of normal distribution. Results were considered significant at $p < 0.05$. The results shown are mean \pm SEM. n.s. = not significant, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$. Fifteen NMJs ($n=15$) were analyzed in each set for a total of 60 NMJs.

3 RESULTS

3.1 *Caprin1* Genetically Interacts with *dFmr1* to Regulate Development of the Larval NMJ

The dysregulation of FMRP-mediated mRNA translation is a prominent feature in fragile X syndrome. However, the detailed mechanistic understanding of how this dysregulation occurs remains incomplete. FMRP is known to engage in documented interactions with other RNA-binding proteins (RBPs) and general cytoplasmic proteins, yet not all its interactors have been determined⁹. *Caprin1* was identified as a possible binding partner of FMRP during their combined immunoprecipitation. Since they precipitated together and FMRP has notable roles in synaptic plasticity, the objective became to determine if *Caprin1* and *Fmr1* interact genetically to regulate the typical FXS *D. melanogaster* NMJ phenotype. The *D. melanogaster* FXS model uses loss-of-function mutants²⁴. *Fmr1* nulls commonly exhibit enlarged synaptic terminals and increased frequency, indicating structural abnormalities associated with altered synaptic transmission²⁴. To investigate this in the case of *Caprin1* and *Fmr1* genetic interactions, a double mutant animal was reared. The double mutant is defined by single deficient copies of both *Fmr1* and *Caprin1* within the same animal, a trans-heterozygote. The procedure began with NMJ dissections, immunofluorescent staining, then imaging by scanning confocal microscopy. The double mutant of interest was compared to three negative control lines: solely single mutant *Fmr1* and *Caprin1* sets and a wild-type set. Completely deficient *Caprin1* and *Fmr1* homozygotes were found to be lethal before the 3rd in-

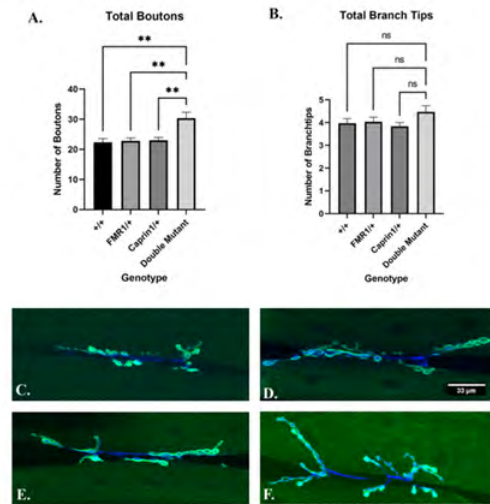


Figure 1. Post-synaptic glutamatergic boutons stained with α DLG appear green. The intensity of the green anti-mouse IgG Alexa488 staining is dependent on bouton type; Type 1b versus Type 1s. Type 1b appears more intense and Type 1s appears less intense. Blue stain represents anti-HRP Alexa633 pre-synaptic terminal staining. Fifteen NMJs ($n = 15$) were analyzed in each of the four sets, total ($n = 60$). The scale bar denotes 33 microns. (A) Graphical representation of total glutamatergic boutons present, Type 1b and 1s. The double mutant was significantly overgrown with a higher total count of both types of synaptic boutons, ** $p = 0.0004$. (B) Graphical representation of total branching quantified by branch tip count. There was no significant difference found in branch tip complexity. (C) Wildtype, $+/+$ (D) *Fmr1* heterozygote, *Fmr1*/ $+$ (E) *Caprin1* heterozygote, *Caprin1*/ $+$ (F) Double mutant, trans-heterozygote, *Fmr1*/*Caprin1*.

star larval stage and could not be dissected nor used as positive controls. A Kruskal-Wallis non-parametric ANOVA test and Dunn's multiple comparison test were performed for both total synaptic bouton and branch tip count. Fifteen NMJs were imaged in each set $n = 15$; $+/+$, *Caprin1*/ $+$, *Fmr1*/ $+$, and the double mutant. A total of 60 NMJs were analyzed. The difference between total synaptic boutons, indicative of synaptic overgrowth, of the negative controls and double mutant was found to be significant with ** $p < 0.0004$ (Panel 1A). The images produced showed a distinct morphological difference between the double mutant and single mutant controls (Panel 1C-F). Including increased synaptic bouton frequency and overall shrunken size. Both Type 1b and 1s boutons were visibly smaller in the double mutant compared to controls (Figure 2). Increased branching of the NMJ is another phenotype observed in *Fmr1* homozygotes²⁴. Although, branch tip complexity was not found to be significantly different between the double mutant and single mutants of this experiment (Panel 1B).

4 DISCUSSION

Fragile X Syndrome is a well-characterized disease; however, its underlying molecular mechanism remains

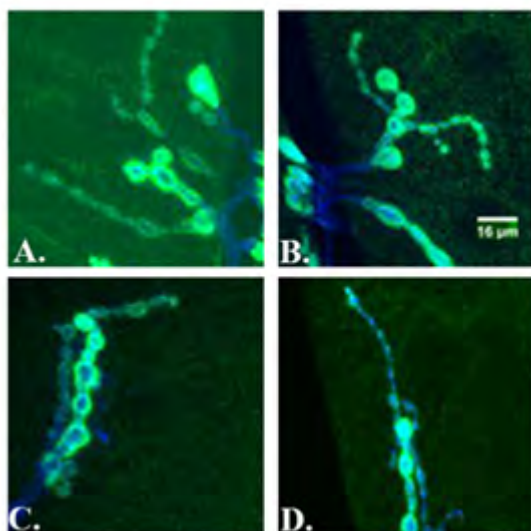


Figure 2. Above displays both Type 1b and 1s boutons located on the terminal branches of each genotype. The double mutant had visibly smaller Type 1b and 1s boutons, a distinct morphological difference. All images are zoomed to 16 microns in scale. (A) Wildtype, +/+ (B) *Fmr1* heterozygote, *Fmr1*/+ (C) *Caprin1* heterozygote, *Caprin1*/+ (D) Double mutant, trans-heterozygote, *Fmr1*/*Caprin1*.

largely unknown. There is still a lack of knowledge surrounding the relationship between genes that control synaptic development in *D. melanogaster* neurons. The study at hand aimed to reveal a possible genetic interaction between RBPs and their role in FXS within *D. melanogaster* neurons. The majority of *Caprin1* research has been studied in mammalian models. Prior to the results presented in this thesis, it was unknown whether *Caprin1* served a function in *D. melanogaster* neurons. The current study has established *Fmr1* and *Caprin1* as genetic interactors that co-regulate the neurodevelopment of synapses at the neuromuscular junction in *D. melanogaster* neurons. Changes in bouton size and frequency are common morphological differences observed in FXS. On the genetic level, the pathology of FXS is caused by two mutant copies of *Fmr1* and the subsequent inability to produce FMRP. When FMRP is not produced alterations in synaptic morphology are observed. However, the double mutant in this experiment was only given one deficient copy of each of the *Caprin1* and *Fmr1* genes. Therefore, under typical circumstances, the offspring would not be considered to have FXS because it does not have two deficient copies of *Fmr1*. Nevertheless, if there is a genetic interaction between *Caprin1* and *Fmr1*, one deficient copy of each should be sufficient to induce a phenotype characteristic of abnormalities witnessed in FXS. Since there was synaptic overgrowth (Panel 1E), measured by the increased number of synaptic boutons compared to negative controls (Panel 1A), a genetic interaction be-

tween *Caprin1* and *Fmr1* must be occurring. Differences in bouton size were also noted within the double mutant displaying smaller type 1b and 1s boutons (Figure 2). The overall increase in bouton number may suggest a compensatory response or regulatory mechanism aimed at maintaining synaptic connectivity despite the reduction in size. This phenomenon could be indicative of various processes occurring at the synaptic level, such as synaptic pruning, changes in plasticity, or alterations in neurotransmitter release and reception. It was possible that branching would be affected as it is typically increased in FXS, but that was not observed as an overall trend here (Panel 1B). Therefore, by quantification of boutons it was determined that the synapses were overgrown, as is expected in FXS. The overgrown synapses observed suggest alterations in synaptic development and impaired neuronal functioning characteristic of FXS. In conclusion, *Caprin1* and *Fmr1* genetically interact to regulate synaptic development of the *D. melanogaster* NMJ. This finding is in line with other research showing *Fmr1*'s and *Caprin1*'s interaction and co-regulation of different processes in other cell types and systems^{20;21;22;23}.

Many *Caprin1* and FMRP immunoprecipitation experiments have already strongly supported a genetic interaction between these genes and their products^{2;3}. Subsequently, it has been consistently proposed that protein interactors modulate FMRP functions²². Since both FMRP and *Caprin1* have previously been implicated in synaptic plasticity separately, their combined role specifically in *D. melanogaster* synaptic growth is within reason and would describe the interaction observed here^{18;7;19;21}. Understanding the interactions between *Caprin1* and *Fmr1* in the regulation of larval *D. melanogaster* NMJ development can provide insights into the molecular mechanisms governing synaptic connectivity and plasticity. This research may contribute to our understanding of neurodevelopmental processes and potentially bring clarity to conditions linked with synaptic dysfunction, such as fragile X syndrome.

The literature provides further intriguing insights into the potential interaction between *Caprin1* and FMRP, as revealed by nuclear magnetic resonance spectroscopy (NMR) studies. These investigations indicate that phase-separated condensates containing FMRP and *Caprin1* proteins interact via the arginine-rich and aromatic-rich regions of both proteins²². *Caprin1*'s structure includes two HR-2 binding domains and three arginine-rich (RGG) boxes¹⁸. Upon binding FMRP, an integral α -helix is formed. In the context of the research at hand, these structural alterations highlight the dynamic nature of *Caprin1* and FMRP interaction, suggesting a potential regulatory role in the cellular processes under investigation. The synergy observed between FMRP, *Caprin1*, and G3BP1 forming a functional complex that is evolutionary conserved, underscores

the complexity of their interplay²¹. Moreover, the observed phase separation of phosphorylated FMRP with Caprin1 into neuronal stress granules adds a layer of complexity to their interaction dynamics, which may be pertinent to the stress response in the context of this paper⁷. These findings contribute to a deeper understanding of the molecular intricacies that underlie the functions of and connections between Caprin1 and FMRP in cellular processes.

Studies have revealed a collaborative relationship between FMRP and Caprin1 in the regulation of the mid-blastula transition (MBT). Both were found to associate with *CycB* and *frs* mRNAs and function as activators of their translation, while at the same time repressing the translation of other cell cycle modulators. The cooperative interaction of FMRP and Caprin1 ensured the correct timing of the MBT²⁰. Caprin1's role in controlling follicle stem cell fate in the *D. melanogaster* ovary, where it acts as a positive translational regulator, further underscores its significance. A one-copy reduction of *Fmr1* exacerbated the Caprin1 encapsulation phenotype suggesting that *Caprin1* and *Fmr1* regulate a common process^{23,20}. In the context of this study, a one-copy reduction of Caprin1 and FMRP also appears to be regulating a common process, synaptic growth at the *D. melanogaster* NMJ. Caprin1 has been identified in other immunoprecipitation experiments whose primary focus was to investigate FMRP associations with messenger-RNA-containing ribonucleoprotein (mRNPs) complexes.² Within that experiment at least two RNA targets were found to be shared by Caprin1 and FMRP. These mRNAs were identified as *CaMKII-alpha* and *Map1b*, both have established functions in the control of synaptic plasticity.

Limitations of this study include the inability to produce both *Fmr1* and *Caprin1* homozygous mutants even though they have been shown to be producible in some cases before. The use of these homozygous mutants as positive controls would have been preferred. The production of homozygotes was attempted but ultimately failed. *D. melanogaster* crosses were placed in a lower temperature environment to slow the lifecycle so that larvae could be obtained before lethality occurred; this was not successful. There are further limitations to consider when translating findings from *D. melanogaster* to humans. These include evolutionary differences, central nervous system complexity, lack of brain structures comparable to mammals, behavioral differences, absence of splice variants, drug metabolism differences, disease complexity, and limited modeling of synaptic plasticity. Despite these limitations, *D. melanogaster* remains a powerful tool for investigating the basic cellular and molecular mechanisms of disease before translation to mammalian models and eventually human clinical studies.

Understanding the interplay between FMRP and

Caprin1 is essential for unraveling the complexities of mRNA regulation in neuronal cells and its implications in neurological disorders. The dynamic nature of their interactions provides insights into the molecular mechanisms underlying synaptic plasticity and in the pathogenesis of FXS. Here, *Fmr1* and *Caprin1* have been shown to genetically interact and work in tandem to co-regulate synaptic growth at the *D. melanogaster* neuromuscular junction. The intricate processes of mRNA transport and translation are fundamental for maintaining synaptic plasticity and functional neural circuitry. Both Caprin1 and FMRP are implicated in the dysregulation of mRNA transport and translation in various diseases and are likely at play here. A genetic interaction is evident as a double mutant containing one deficient copy each of *Fmr1* and *Caprin1* caused synaptic overgrowth and altered dendritic morphology. These structural alterations are in line with the synaptic phenotype observed in full mutation FXS caused via two copies of deficient *Fmr1*, strongly suggesting a genetic interaction.

5 FUTURE DIRECTIONS

The present study has established a biologically relevant interaction between *dFmr1* and *Caprin1* at the genetic level within *D. melanogaster*. To substantiate these findings, future experiments should focus on validating a physical interaction of their gene products via biochemical methods. Potential experiments could involve investigating whether these proteins colocalize within the same neuronal structures and assessing their role in regulating neurite morphogenesis in other neuron types affected by *dFmr1*: larval sensory neurons, mushroom body neurons, and so forth. Expanding the scope of investigation to include diverse neuronal populations affected by *dFmr1* will provide a comprehensive understanding of their role in neuronal function. Exploring their combined impact on FXS behaviors would also prove beneficial. This includes observing the behavior of larvae via crawling assays and examining various behaviors in adults, such as circadian rhythms, grooming, climbing, flight, and other relevant patterns. These proposed experiments will not only validate the observed genetic interaction but also shed light on the broader implications of *Fmr1* and *Caprin1* in neuronal function and behavior regulation. Such endeavors pave the way for a more comprehensive understanding of their roles in neurobiology and potential therapeutic avenues for FXS.

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7 ABBREVIATIONS

1. FXS: Fragile X Syndrome
2. FMRP: Fragile X Messenger Ribonucleoprotein
3. RBP: RNA-binding protein
4. NMJ: Neuromuscular Junction
5. UTR: Untranslated region
6. CGG: Cytosine-guanine-guanine
7. mRNA: Messenger RNA
8. KH: K homology
9. RGG: Arginine glycine-rich
10. LC/MS: Liquid chromatography-mass spectrometry
11. mGluR5: Metabotropic glutamate receptor 5
12. LTD: Long-term depression
13. LTP: Long-term plasticity
14. NMR: Nuclear magnetic resonance spectroscopy
15. MBT: Mid-blastula transition
16. CaMKII: Calcium/calmodulin-dependent protein kinase II
17. Map1b: Microtubule-associated protein 1B
18. IP/LC-M: Immunoprecipitation-mass spectrometry
19. α DLG: Drosophila discs large homolog
20. LLPS: Liquid-liquid phase separation
21. RISC: RNA-induced silencing complex
22. miRNA: micro-RNA
23. FXTAS: Fragile X tremor-ataxia syndrome
24. FXPOI: Fragile X-associated primary ovarian insufficiency
25. PBS-T: Phosphate-buffered saline containing 10% Triton X-100
26. PBS: Phosphate-buffered saline
27. PF: Paraformaldehyde

8 EDITOR'S NOTES

This article was peer-reviewed.

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Revelation Altarpiece by Alex Blom

Studies of Identity in Modernity: Literary, Phenomenological, and Psychoanalytic Approaches

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Abstract

This paper analyzes challenges to conventional notions of identity in Pirandello's novel *One, No One, and One Hundred Thousand*, towards understanding new conceptions of meaning and identity in the early 20th century. The aim is to provide a multi-plural study in the Italian modernist tradition (1890-1945), with the goal of understanding how technological, industrial, and socio-geographical changes of the period were felt across a range of fields, and centered on new ideas of the self in society. A study of how Pirandello's literary style addresses the complex socio-geographical climate of Italy and Europe in the early 20th century is put in conversation with Martin Heidegger's phenomenological approach to being, and the alterations of personality and cohabiting identities charted by psychologist Alfred Binet. The complementary and conflicting accounts of selfhood taken from these thinkers and their work is used to understand prevailing notions of identity during the period, what might be responsible for these shifts, and their representation in literature. A synthesis and concluding section is used to assess the takeaways from the study, and what can be broadly understood about identity in Pirandello's fiction and the period of literary modernism.

1 INTRODUCTION

Unprecedented social, technological, and political shifts in the early 20th century posed new challenges to conventional notions of the identity and role of the individual in society, and elicited a resounding response from literature and art. Literary modernism was a movement in art, literature, and the broader humanities that began in the late 19th century and continued until the mid-twentieth century. It addressed the challenges of technological innovation and socio-political changes, among others, and sought experimentation in artistic and literary forms. Individuals closely associated with the movement include Picasso, Pound, Joyce, Hemingway, Woolf, Eliot, and Beckett. The Italian literary tradition dealt acutely with these challenges; and *One, No One, and One Hundred Thousand*; a novel by Luigi Pirandello, intersects with the fields of psychoanalysis, philosophy, and literary theory in its conversations around identity. The protagonist of the novel, Vitangelo Moscarda, has a revelation that no one around him, not even himself, truly knows who he is. So begins a destructive and cynical investigation into modernist notions of selfhood set against the socio-geographical and technological shifts of the early 20th century. The thesis uses literary, psychoanalytic, and philosophical critique, beginning with Alfred Binet (1857-1911), a psychologist

which paved the way for discussion about alterations in personalities, and helped normalize discussions of flux in identity as opposed to a rigid psyche. Newfound ideas of selfhood are also found in the work of Martin Heidegger (1889-1976), in his writings on being, and later essays touching on the role of art and challenges of a technological world. *One, No One, and One Hundred Thousand* interrogates the function of narrative, the nature of the relationship between a narrator and his audience, and challenges the reader at every step. Mass migration from rural to urban areas and changing ideas of work, family, and gender roles required that artistic mediums adopt new approaches to an entirely new subject matter. Rapid technological innovation, a more connected world, and modern warfare challenged previous views of the world and the individual's place in it. Selfhood and identity would come to be thought of as more fluid, complex, and nuanced than before. This offered new challenges to the placement of the individual in society and potential for greater freedom and self-expression.

In *One, No One, and One Hundred Thousand*, Luigi Pirandello challenges conventional notions of identity through his innovative narrative style, drawing on modernist literary techniques like stream of consciousness narration and experimental usages of time and space. This changing idea of selfhood addressed by the novel

is a response to broader societal shifts at the turn of the 20th century, which are echoed in psychoanalysis and philosophy in the works of Alfred Binet and Martin Heidegger respectively. Studying these fields and thinkers in synergy offers the chance to understand how changing political and socio-geographical conditions led to new, innovative notions of identity in the modernist period, and how these changes were reflected in literature and art.

2 METHODS

This paper first uses extratextual perspectives, with a focus on Pirandello's biography and the circumstances surrounding literary modernism, in addition to the aforementioned psychoanalytic and philosophical analysis. Intratextual analysis of the protagonist, method of narration, and layout of the novel is then used to better engage with the text itself, with less usage of outside perspectives. This textual literary analysis considers the novel on the basis of its own literary value and its qualities as art and fiction that affect the reader. The intratextual analysis in this paper rests on the scholarship on the novel from within the Italian academic canon as well as original insights, while discussions of authorial context come from the articles and significant body of work written on Luigi Pirandello's life. Discussions of Binet and Heidegger come primarily from the original texts, with fewer secondary sources. These methods are used to better understand the literary qualities of *One, No One, and One Hundred Thousand*; Pirandello's intent; and the impact of the work continuing to present studies of identity. Extra-textual analysis allows an understanding of the text's broader impact and its placement within important movements and innovations of the modernist period. Though this is a broad focus, the use of a diverse range of critique is necessary to do justice to a work as multifaceted as *One, No One, and One Hundred Thousand* and the question of the self in modernity.

The industrial, urban, and socio-political shifts in Europe at the start of the 20th century created a unique atmosphere of uncertainty, change, and experimentation that drew responses from the arts, humanities, and sciences. *One, No One, and One Hundred Thousand* could not take place in a different historical moment, and the novel is a reflection and product of literary modernism and the period in which it was written. As scholar of Italian literature Mimmo Cangiano notes in his analysis, "The new existential situation thus becomes a space of individual freedom, a space of a subject who, rejecting the presumed 'cages' of Being, modifies alienation into independence and mystifies the structure of domination (that created by society) in the domain of the metaphysical concept"¹. This quote offers a solid starting point for discussion. The excerpt illustrates the challenges and innovations of modernity in understanding new ideas

of identity, and the role of broader socio-political structures in the formation of selfhood. This paper aims to illustrate how Pirandello explores identity in the novel, and its relation to the work of Alfred Binet and Martin Heidegger.

3 LUIGI PIRANDELLO: SOCIAL & HISTORICAL CONTEXT

The novel begins when the protagonist's wife makes a seemingly innocuous comment about his nose. From this point, Moscarda understands that every person who knows him or who has known him has a different image of him. This causes a crisis of the self, and he decides in a fit of cynicism and anger to erase himself entirely from his own gaze and that of others. To do this, he begins a systematic destruction of his personal and professional relationships. He lashes out at his wife, Dida, and their dog. He behaves erratically at the bank, a former property of his father. Moscarda then threatens to evict a poor couple, Marco di Dio and his wife Diamante, before having a rapid change of heart, and giving them wealth and housing. This, among other interactions marked by sudden changes in mood and aggression, alienates him from the townsfolk. Interspersed between his erratic outbursts are fleeting reflections on his fragile selfhood and what dictates a coherent identity. Towards the end of the novel he is wounded by gunfire after an encounter with one of his wife's friends. At the court hearing he refuses to commit to, or be defined by, a single sense of self. This frustrates the magistrate, and the judicial system's necessity of treating him as a coherent, single subject elicits his irritated cynicism. As he recovers, he reflects on the environment around him, saying "I am reborn new and without memories: alive and whole, no longer in myself, but in everything outside"². This is an uncertain conclusion. Contrary to his previous outbursts and aggression, he is now far more pacified. Pirandello's intention is open to interpretation, and difficult to pin down. Moscarda seems calmer and at peace, though there is also a sense of resignation in this conclusion, as he finds himself physically and emotionally distant from himself and others.

It is necessary to first understand Pirandello's own biography and the novel's socio-historical context. Luigi Pirandello's life was fundamentally tied to the history of Italy and Sicily in the early 20th century. He was born shortly after the unification of Italy, and he saw a profound sense of disappointment and tragedy with the promises of unification and the overall improvement of the nation³. He would observe the prominent divide on the basis of both culture and industry between North and South⁴. This national tension and uncertainty features heavily in his work. Throughout his fiction he talks about technology and industrialization, but in *One,*

No One, and One Hundred Thousand this sense of irreverence can be seen more poignantly through Moscarda himself. Pirandello's attitude can be characterized as an intelligent cynicism, an interrogation of society but also of the self. This perspective probably comes from an atmosphere of uncertainty and change during this industrial period of a young Italy. The specter of unification and modernism haunts his fiction, with complex and diverse manifestations throughout his career. Pirandello's relationship with his father was complex, and the author felt closer to his mother in childhood⁵. Stefano Pirandello is thought to have presented a masculine, overly-intimidating, and forceful demeanor. The figure of the father poses an interesting challenge in analysis of the novel and ties into Pirandello's broader body of work. Pirandello and his father came into conflict over the former's area of study and career, as well as their profound differences in personality. Later, the collapse of the sulfur mines would drive Pirandello's wife, Maria Antonietta Portulano (1871-1959), to a mental breakdown from which she would never recover. They had enjoyed several years of peaceful marriage, but after the accident she would become unpredictable and at times violent towards the children and Pirandello. For some years he was unable to pay for her treatment, which caused persistent conflict in their home⁶.

Still, Luigi Pirandello and his family depended on his father's sulfur mines for financial support, which led to dual senses of resentment and obligation. This dissonance with the paternal role is found throughout Pirandello's works. Pirandello's father continued to influence his son even after his death, and the specter of this paternal figure can be seen throughout the latter's fiction. In *One, No One, and One Hundred Thousand* there is Moscarda's literal late father, as well as Moscarda's view of him, and his influence diffused across their town. The protagonist's father exercised significant financial influence over the entire area, not unlike Pirandello's father, and as such, Moscarda encounters specters and reminiscences of him throughout his interactions and excursions into the village. His father has a strong influence over him, yet is not literally present. There is 'hauntology' here, a causative factor that is neither here nor there, neither present nor absent⁷. Moscarda's father owned the town bank, and he continues to live with his wife in his father's home, facing those who were impacted by or did business with his father's bank. Thus, his father's power and image remains perhaps more forceful than his son's even after his demise. This legacy is entrenched within the town itself, and an effort to escape it may be responsible for Moscarda's efforts against a coherent selfhood. The protagonist lashes out against the presence of the paternal as a disciplinary and guiding force within the institutions of the village, and as a specter he cannot escape. Moscarda is neither willing nor reluctant. He is

implied to have led a passive and compliant life before the events of the novel. He is instead rendered as the object of these paternal forces and the specter of the father. He reflects on the role of the city in identity:

Let us say, then, that what we call peace is to be found within ourselves. Does it not seem so to you? And do you know where it comes from? From the very simple fact that we have just now left the town, that is, a world that is built — houses, streets, churches, squares — not for this reason alone, however, because it is built, but also because we no longer live for the sake of living, like these plants, without knowing how to live, but rather for something that is not and which we put there, for something that gives meaning and value to life, a meaning, a value which here, at least in part, we succeed in losing, or of which we recognize the grievous vanity. Hence comes your languor and your melancholy. I understand, I understand. Let-down of nerves. Afflicting need of self-abandonment. You feel yourself relaxing, you abandon yourself².

And so, when he not only subverts, but ends up discarding and mocking these conventions of self and country, these acts are distinctly anti-paternal. Considering how the desires of the father have influenced him, and continue to shape his life, when Moscarda begins to destroy his sense of self this is mostly a rejection of internalized filiation, and this "given" sense of self. In a sense, the thrust of the novel centers on matters of paternalism. Moscarda's father is never alive in the novel's diegesis¹, but is ever-present in his son's ego. And given the period of the novel's publication, and Pirandello's own biography, there are parallels with discussions of Fascism as well. Pirandello's relationship to the Italian Fascists was complex⁸. Though he joined the party, he continued to be considered under suspicion, and his work offered implicit subversions of Fascist ideology. The Fascist leader embodies a hyper-masculinity, a disciplinary paternalism, tying into the discussions above. There is certainly room for further scholarship on this point. Questions of the role of the father abound in *One, No One, and One-Hundred Thousand*, and speak to Pirandello and Moscarda alike. This advances the hypothesis that these difficulties underlying the conception of the family entered Pirandello's works as a constant and malevolent specter. In contending with the influence of his father, Moscarda raises the question of the capacity to forge a new identity beyond formative circumstances. Many of his sharpest criticisms are towards the remnants of his father's influence, and the

¹The diegesis is the internal universe, logic, and narrative in a story.

aspects of himself in which his father remains, as well as his inability to escape his shadow. As Moscarda notes, in this process of destruction he sees his father in a new sense:

I saw then my father for the first time, as I had never seen him before, externalized in his own life, but not as he had been to himself, not as he had felt himself to be, which was something I could never know; but rather, as a being that was wholly strange to me, in that reality which, as I now beheld him, I might suppose that others had imposed upon him².

As Moscarda undergoes the disintegration of his identity he gains a sense of clarity, though it doesn't last. He begins to understand how his father has impacted his life in ways he hadn't understood before. For the first time, he sees his father in a more vulnerable light, understanding that even a somewhat antagonistic figure faced similar struggles around others forcing a sense of identity upon him.

Pirandello is well-known for his plays and fiction, though he also wrote on philosophy, notably putting forward the idea of "umorismo"⁹. It is based on a meshing of tragedy and comedy, what seems initially ridiculous or comical is in fact profoundly tragic. It is a play on expectations, is paradoxical, and is present in much of his work. There is humor here, but also a sense of tragedy. And though this tragedy comes from contradiction, it cannot exist in this sense without humor. The human experience is fundamentally one of complexity and is not easily classifiable. The contradiction of human experience and the reflection on opposites is a principle of Pirandello's work. There are two things at the same time, with a moment of realization. There are already parallels here between Pirandello and Heidegger's work². Yet it is in the modernist rejection of dichotomy that these irreconcilable parallels can achieve a newfound identity. This is also present in Pirandello's famous play, *Six Characters in Search of an Author*, which deals explicitly with the limits of fiction and diegesis¹¹. Here, six characters meet a director in the process of directing a show. The divide between fiction and reality is blurry for characters and viewers. There is an absurdity here, a strange ridiculousness, but also a sense of unease. While the situation might be funny or absurd at first, it becomes shocking, as many of the characters suffer tragic fates. The ease with which Pirandello's drama switches between the darkly comical and human tragedy is jarring at times, but reflects an incredulity towards an either/or perspective, with both made possible by the other, or co-dependent.

²The idea of "being-as-paradox/undefinability," or something along these lines is key to both Pirandello and Heidegger's work. Present in "L'Umorismo"⁹ and *Being and Time*¹⁰ as well as *The Basic Writings*¹⁰

Pirandello's final novel is profoundly autobiographical, assuming a fragmented, diary-like approach⁶. This makes the thematic project of *One, Nobody, and One Hundred Thousand* more difficult to define. Some of Moscarda's reflections are perhaps repackagings of Pirandello's own thoughts or contemplations, the protagonist's actions perhaps the exercise of his author's curiosity. The character of Moscarda can be thought of as Pirandello's literary rebellion against precedent and the systematic, both in social conditions and notions of identity. Moscarda's internal destruction, a contempt aimed at both the self and the world, suggests an alternative interpretation. It is possible that the protagonist embodies an internal conflict for the author during these difficult times. In a more optimistic reading, Moscarda could be taken as a vehicle for Pirandello to explore and work his own discontents and troubled identity. The work may be a destructive effort for the protagonist and a reconstructive one for the author.

4 LITERARY CRITIQUE OF *ONE, NO ONE, AND ONE HUNDRED THOUSAND*

One, No One, and One Hundred Thousand is likely the most modernist of Luigi Pirandello's works. Pirandello's liberal treatment of space and time is not unlike Joyce and Woolf's narrative styles in *Ulysses* and *Mrs. Dalloway* respectively, and his work is at home in the broader modernist canon. Pirandello's fiction deals intimately with problems of identity and historical and geographical contexts. *The Late Mattia Pascal*, one of Pirandello's other novels, also describes an individual's struggles with selfhood as they attempt to adopt a new identity. Some of Pirandello's writings, such as his short story "The Train Whistled," touch on an unstable protagonist, rebellion against convention, and the intersection of real and fantastic¹². Though the struggles of Pirandello's protagonists certainly speak to the broad human experience, they are also tied to the challenges of the period acutely felt in Italy. The economic, cultural, and social disparity between Northern and Southern Italy has played a major role in the nation's history and remains a topic of contention⁴. Pirandello, hailing from Sicily, would have felt the impact of this divide, and the prolonged underdevelopment of the South was in many ways only accentuated by industrialization.

The method of narration is unusual in that the focus is on Moscarda's perspective itself, instead of giving a clear account of events. Moreover, rupture of the everyday is a theme of Pirandello's work, and a rupture of sanity is the central conflict of the novel. Pirandello writes of ego-as-fiction, always under threat of madness, of disorder as the undoing of coherence.³ Moscarda's

³The method of analysis stems from Jacques Derrida's *Resistances of Psychoanalysis*¹³

selfhood is written as profoundly unstable, and with a tenuous connection to reality. In discussing the divide between the metaphysical and the psychoanalytic and Moscarda as concept and character, it is also necessary to frame these concepts around narrative and technique. Pirandello's literary style is key here.

Moscarda is an unreliable narrator in the conventional sense. Yet, if his view of the diegesis is the only one the reader receives, how can truth and untruth be separated on the novel's own terms? Is there a 'real' diegesis beyond his narration? Moscarda must be considered an unreliable narrator in the sense that his philosophy and recollection is incompatible with our expectations of coherence in narrative. If he does not remain with a degree of stability, or with a cohesive perspective, can he be considered a single narrator? Can a narrator be an individual, but in fact, be a multiplicity? What makes him an unreliable narrator is that he is not thought of as a single person, and therefore cannot give insight in relation to a single ego as reference to the reader. Perhaps nowhere is this clearer than in his reflections at the beginning of the work, where he consolidates his notions of self we have just discussed.

4.1 Reflections

1. That I was not to others what up to then I had believed that I was to myself;
2. That I could not see myself living;
3. That, not being able to see myself living, I remained a stranger to myself, that is, one whom others believed they saw and knew, each after his own fashion, but not I;
4. That it was impossible to stand this stranger up in front of me, in order to see and know him. I could see myself, but could no longer see him⁶.

The points are useful in understanding the state of his identity at this point in the novel. These reflections are a far cry from the chaos that might be associated with the disintegration of ego. Rather, Moscarda's reflections are methodical, regimented. These reflections establish where Moscarda's project stands at this point in the novel. In contrast to the more chaotic second-half of *One, No One, and One Hundred Thousand*, these reflections are more ordered, and demonstrate the extent to which Moscarda's identity has remained intact at this point, and how much further it is to slip. They allude to a reflective, but profoundly cynical sense of self, and the idea that knowing or seeing oneself truly is impossible.

Moscarda doubts even his own beliefs and ego, which problematizes the world of the story relayed through his hesitant narration. He is forced to balance narration with his aim of self-effacement. The shifts and

stumbles in Moscarda's narration are indicative of his own selfhood(s) and this retelling can be read as breaks in his own ego. The world of *One, No One, and One Hundred Thousand* is his world. It is *only* a reflection of Moscarda's inner state. He goes so far as to mock the reader in his narration. The reader is addressed directly, inquired as to how they know themselves, or if the features of their identity are as certain as they seem. Moreover, Moscarda's narration distorts a clear chronology, at least in terms of how the reader should view casualty. He discusses past recollections, current plans, musings, and speculations within his narration, which is complicated by his own radical self-doubt. It is therefore difficult to ascertain how he views the bearing of the past on his present situation, and if he can guess at any kind of future for himself at all, given that Moscarda hopes to erase his own ego. Similarly, the reader is given no broad sketch of town at the novel's onset, but rather Moscarda discusses or visits locations as they gain some importance in his broader project. Each location he visits or describes is steeped in his own past and memories, and bears further significance to his own project. There is a profound dualism or multiplicity to Moscarda's narration, and studying it as conflict and confluence of different selfhoods is promising. The creation and disintegration of selfhood in relation to internal and external factors features throughout Pirandello's work¹⁴.

The registers of philosophy and psychoanalysis are useful as a means of tackling the question of Moscarda's ego, and how Pirandello's presentation of the self speaks to real shifting social views of meaning and identity. The nihilistic and existentialist aspects of the period in which the novel was written are something that Mimmo Cangiano takes up. "Those aspects have begun to be exalted which, pertinent to the sphere of existentialism, nihilism and the philosophy of life, refer to the entry in crisis of metaphysics, of logos, of systematizing reason and of the very idea of objectivity"¹. Cangiano notes the shifts in philosophy at the turn of the 20th century, and the open question of "being" at this time. Changes in philosophical notions of being around the turn of the 20th century are woven into the novel, with Moscarda's implicit interrogation of previous philosophical notions of being that offered a greater sense of stability, like those found in the German Idealist tradition, while Moscarda's project instead reflects a sense of "becoming" or a process ontology⁴.

⁴German Idealism was a 17th-18th century movement in philosophy driven by figures like G.W.F. Hegel, Immanuel Kant, Johann Gottlieb Fichte, and Friedrich W.J. Schelling. It worked extensively in aesthetics, epistemology, and metaphysics, while those that came after Kant attempted to derive a unified or absolute philosophical system (roughly) based on his work¹⁵. Process ontology is a view of "being" that focuses on becoming, emergence, and the idea that being is a process instead of a static state. It is associated with Phenomenology in the early 20th century, and figures like Edmund Husserl, Martin Heidegger, and Maurice Merleau-Ponty

This offers insight into changing notions of being in the philosophical tradition, and the influence of modernity on understandings of the self. The later section, “Martin Heidegger,” will explore this in greater depth.

The next section places the literary interpretation of the protagonist alongside prevailing psychoanalytic theories of the period, towards understanding the true nature of human personality.

5 ALFRED BINET

Alfred Binet is well-known for the intelligence test he developed alongside one of his colleagues, and he is considered a pioneering figure in education and psychology. Alfred Binet’s work draws heavily on his prolonged case studies on patients with personality disorders. He accounted for their periods of expected behavior as well as any lapses into differing states. As a clinician, his aim was to help his patients achieve a greater sense of stability in their lives. His work *Alterations of Personality*¹⁶ is notable in its exploration of studies involving shifts in identity and personality over the course of an individual’s life. In the preface he aligned his own studies with those of others in the field, and alludes to broader shifts within physiology and philosophy. Binet spoke of different fragmented “consciousness” that can appear in the individual, each with distinct identities and interior systems¹⁶. He presented various studies, including a discourse on somnambulism, as he attempted to provide a survey of various personalities existing in one individual, alterations, and the emergence of these changes. Part II, Chapter IX, “Plurality of Consciousness in Healthy Subjects” is Binet’s approach to what he views as actions of the unconscious, and understanding underlying mental factors. This section is notable in that Binet applies similar ideas to healthy individuals, and tries to understand the extent to which these alterations and fluctuations in personality can appear outside of a strictly clinical setting. However, it should be noted that Binet does maintain a division of “hysterical” and healthy individuals, though his analysis does explore how underlying psychic phenomena are present in both groups. One of Alfred Binet’s greatest contributions is a new way of interpreting the self and mental disorders. Crucial here is that he did not view disruptions as coming from the outside, but rather as emergent from within the self. He believed that human subjectivity and psychology are vulnerable to changes in personality and disposition to varying degrees. Binet adopted a more analytical mode, instead of an outrightly discriminatory one.

Alfred Binet worked on a more specific level in determining how different personalities or aspects of the individual emerge, and the line between the ordinary and unusual manifestation of personality and the self. His work concerns what constitutes these abnormal per-

sonalities, and what causes their emergence implicit in the discussions of abnormal personalities and “normal” ones from the perspective of the observer and broader society. According to Binet, personality alterations can happen at any time in life, and do not appear to be something that marks an individual at birth. This focus on the range of known and unknown determinative factors of identity ties into the work of Sigmund Freud, often considered the father of psychoanalysis, and an early innovator in both psychoanalysis and psychology. Freud’s case studies (The Rat Man, Little Hans, The Wolf Man, etc.¹⁷) address the systems and structures that influence identity, both based on childhood experiences and reinforcement/emergence in adulthood. This continues in his studies on the interpretation of dreams and emphasis on childhood development and identity formation¹⁸. Freud’s work aligns well with Binet’s and the broader movements in psychoanalysis at the turn of the 20th century, and these questions of identity are clearly present in Pirandello’s work as well. It is a comment from his wife that triggers Moscarda’s efforts. This could be considered an environmental stimulus, but it is unlikely in an external setting that this alone would cause such changes. This is a literary choice. However, it is possible that unacknowledged stressors had remained dormant in Moscarda’s mind, and thus his wife’s comment was the breaking point that brought all his conflicts of identity to the forefront. When discussing his relationships, his family, and his finances, it seems that these issues existed before, and he was not as acutely aware of them. These alterations can come and go in someone’s life, problematizing a static sanity or insanity.

6 MARTIN HEIDEGGER

Moving from narratology and psychoanalysis to phenomenology, there is a transition from discussions of mind and ego to “being”⁵. Phenomenology is centered on tangible, lived experience, and the world as it is encountered through consciousness. It is more grounded in the individual’s encounters with the world rather than abstracted analysis. This ties into Moscarda’s process of exploring his identity in the novel. He posits claims or ideas about himself and the world around him before testing these ideas through deliberate actions or encounters with others. His narration is speculative, but thoroughly grounded in his experiences and interactions throughout *One, No One, and One Hundred Thousand*. Moscarda’s approach to selfhood is not overtly phenomenological, but both Heidegger and Pirandello interrogated views of identity that centered on a constant or rigid structure, while exploring how individual identity is affected by relationships, environ-

⁵Metaphysics focuses on being, existence, reality, and the principles that underpin or precede these concepts

mental factors, and modern technology.

Martin Heidegger is one of the most famous phenomenological philosophers, and his attention to the search for meaning and identity, and what it means to live and dwell, situate him well for analysis of the novel. Heidegger's unique approach to "being" is most evident in the term he used to fundamentally describe the human condition, *Dasein*. *Dasein* is a complex, sometimes paradoxical casting of the human condition, that is meant to describe how human beings uniquely interact with the world and themselves through an emergence or process. Heidegger saw the process of revelation or "coming into presence," a key term in his later works, often in a paradoxical light. With the idea of a "rediscovery" of "being," there is a certain theological or primordial slant to his thought. This kind of engagement with the self and the world is uncertain, and Heidegger saw this journey to authenticity as a process of "becoming." Like his teacher Edmund Husserl, Heidegger placed great emphasis on how humans engage with others, act, and express themselves. Many previous views of "being" considered it as static or ontologically consistent. Heidegger's thought interrogates living and engaging in modernity. One of his foremost aims was learning how to *dwell*. As he explained, "the proper dwelling plight lies in this, that mortals search anew for the essence of dwelling, that *they must ever learn to dwell*"¹⁹. Heidegger felt that societies had, in the course of human events, lost a manner of dwelling or thinking that allowed us to meaningfully engage with ourselves and others. Individuals live, but they do not dwell, or inhabit spaces as consciously as they could. It is a rediscovery of this character of life that is the objective of Heidegger's phenomenology. But for Heidegger, "being" is a process without completion. There is no "being," rather *dasein* is constantly becoming. Individuals define and redefine themselves in their engagements with their surroundings and the other people, as well as with the knowledge of their own death. Put forward in *Being and Time* is being-towards-death, as one's death is wholly one's own and something that cannot be experienced in their stead. "Being" is being-towards-death, marked by the knowledge of *dasein*, and being defined by its conclusion. Death is constitutive of *dasein*, as one's own death cannot be taken away or known prior to its event. The death of others can be experienced, or one's own death can be contemplated, but each individual's own death cannot be taken away or experienced in place of the self, and is wholly unique. How this knowledge trickles into decisions influences the life one leads, and death is thus a defining characteristic of each individual's life. Heidegger's work is difficult because this rediscovery or return is almost more of a state than a clear objective. It is an awareness and appreciation of death as one's ownmost, and an understanding of the flux of selfhood. This self is

paradoxically not necessarily within the self. Heidegger gave the example of a trucker who feels at home on the road, though he does not literally live there, or how in dedicated carpentry the hammer almost becomes one with the self in performance of an action¹⁰.

Central to both Heidegger's and Pirandello's thought is a transgression of precedent. Pirandello's fiction critiques both the Italian literary tradition preceding it, and static ontologies and presentations of identity²⁰. Heidegger felt that philosophy could not proceed without dealing with "being." He started with some studies of Aristotle and his conception of "being," but for the most part he felt "being" itself had been neglected. Heidegger's work transgresses several philosophical boundaries. The first is the weight of previous philosophical traditions. While it is legitimate to argue that his work draws from a tradition of late 19th century thinkers, his main conception of "being" has its main connection in classical thought. Thus, his work almost subverts predecessors in philosophical traditions, choosing instead to revise and rethink Aristotle. Then there is his most direct attack on Cartesian metaphysics. Descartes's work postulates a clear separation between the self-conscious observer and the external world, a mind-body dualism²¹. Descartes argued that the only thing he could be certain of was his own doubt—"I think therefore I am." But for Heidegger and subsequent metaphysical thinkers, any separation between self and the broader world is problematized. "Being" is inextricably linked to the presence of the world and people's relationships with entities and equipment that cannot be completely separated from the individual. Linked to this is the idea of "thrownness," which describes how humans engage with the world. Heidegger observed that individuals are 'thrown' into a pre-existing state of affairs, and must learn to live in and alongside it. These connections and entities do not begin with birth, but are precedent. People face a world and system that is not designed for one specifically, and does not always make it easy to acclimate. He later wrote more specifically on art and poetry, after what is called "the turn" in his thought. The "*Kehre*" or "turn" in Heidegger's thought represents a shift in the focus or subject of his work. His project in *Being and Time* deals more with his re-conception of "being" using an immanent phenomenology, and the role of time as the horizon of "being" and death as its defining quality.

Heidegger wrote of art that "the artist is the origin of the work. The work is the origin of the artist. Neither is without the other"¹⁹. For him, these entities existed together in the construction and perception of an artistic work. This ties into Heidegger's broader view of "being" as well. Moscarda can be seen as a means of "revealing," but this ontological journey is too "certain," not "open" in the Heideggerian sense, and decidedly destructive and distancing in practice. Heidegger did not advocate

isolation. While it is true that he wrote much about *Being and Time* in isolation in the city of Todtnauberg, the philosophy he created and supported does not encourage this destruction of connection. Indeed, this is almost impossible in Heidegger's understanding of "being." This total isolation from the outside to find a sense of self is impossible in light of the German philosopher's transgression of object-subject. The protagonist and Heidegger share a desire for authenticity, but their starting points are different. The biggest problem that stands in the way of reading Moscarda's in-depth study through Heidegger is the protagonist's desired abstraction of himself. If Moscarda takes these other interpretations of himself to be false, implicit in this is that a self must be true, or that it is engagement with others that leads to falsehood. While Heidegger felt that *Dasein* finds its meaning in death, Moscarda's vision in the novel instead places the search for meaning against exteriority. This conception of "they" plays a role in Heidegger's philosophy, but it does not grant *Dasein* its meaning. The protagonist's project works better in a Cartesian framework, which is precisely what Heidegger argued against. Moscarda believes that the external representations of him are false, that there is a deception in our relations with others and how they influence us. Heidegger advocated for an awareness of these attachments. A complete separation is nearly impossible in his view, and detrimental to the self. A goal of Heidegger's philosophy is living and guarding a sense of wonder or appreciation, a way of interacting with the world, objects, and entities, in-of-themselves. Against this effort he placed *das mahm*, or a great social plurality. This pre-existing entity threatens the goal of true self-engagement and authenticity. "Fallenness" is the state of having forgone one's own relationships, to embrace a pre-set means of interaction instead of discovering these relationships for oneself.

To conclude, it is necessary to address Heidegger's antisemitism, and open support for the Nazi regime and values. He personally and professionally endorsed Nazi views, and enacted their decrees in his academic position. In terms of his philosophy, in the process of this "rediscovery" of "being," there can be read an implicit longing for a thing before that never existed, a discovery of the ideal or the "before." This has unpleasant connections to the Nazi mythos of rediscovery or return to a previous state of affairs. Still, his warnings against falling into social pluralities and losing the self run contrary to Fascist ideology. To a certain extent, Heidegger's philosophy can rebuke his personal views. Heidegger's thought has more nuance that requires discussion, but this abhorrent aspect of his thought must be noted.

7 CONCLUSION AND FURTHER STUDY

One, No One, and One Hundred Thousand uses a unique narrative style interspersed with self-aware, poignant reflections on the nature of "being" to interrogate how individuals know themselves and how others perceive them. Pirandello does not offer a simple solution, but instead chronicles the draw of truly knowing oneself as well as the dangers that come with such an attempt. This intersects with the case studies of Freud and Binet into determinative factors of personality, how individuals can change and shift selfhood over their lives, and the extent to which aspects of identity remain unknown even to the individual. Heidegger takes a metaphysical approach, and amid what he views as the encroaching threat of modernity, prescribes an individual project of awareness. This is an awareness towards the social pluralities we engage with, social constructs, norms, and conventional ways of thinking and acting. He also advocates for an increased sense of 'intention' with how we live and work, appreciating actions and relationships in of themselves, as opposed to a means to an end.

Binet and Pirandello explore similar concepts through different means. Both thinkers discuss shifts in a sense of identity, though Binet's aims are more clinical whereas Pirandello's are literary. Still, this is emblematic of broader shifts in modern notions of identity towards an acceptance of the mutability of selfhood based on both interior and exterior factors, and the difficulties that can result. Both thinkers foreground the awareness of this change and flux as necessary in understanding subjectivity. Binet does not cast these alterations as abnormalities, but present to varying degrees in the psyche.

Pirandello aptly diagnoses a kind of numb cynicism towards oneself and others which has only grown more pronounced. It is difficult to say if Pirandello had an answer to this question of meaning in the industrialized/modern world, as Moscarda scoffs at every institution the other villagers hold dear. Though Heidegger's work can be difficult, it acknowledges Moscarda's struggles in knowing himself, and to engage in such an effort is commendable. But, Heidegger offers awareness and appreciation where Moscarda searches for destruction. Phenomenology is a philosophy of immediacy, of that which appears to us, not of an abstract, ever-elusive selfhood. This is paradoxical, in that identity is not immediately apparent, but ever-present. It is a network of connections to work, relationships, and how people relate to the world they encounter everyday.

Binet's work is oriented towards the pathological, the clinical, and diagnosis and treatment. While there are implications for perceptions of the self from a social perspective in his work, he is not intended to diagnose an entire era. His concern was with the individual in a medical sense, whereas Heidegger saw people from a

phenomenological perspective, as an unfolding of “being.” There is also the question of Moscarda. For Binet, the resolution is ambiguous. Moscarda resigns himself to an institution in the countryside, where he spends his days with superficial reflections on nature, himself, and what is far away from him now. There is a sense of peace and solitude here, but still no cohesion of self. At the end of *One, No One, and One Hundred Thousand*, Moscarda ceases his investigations. And for Binet this is not ideal, because he still does not have a stable sense of identity, or a means of interacting meaningfully with the world. There is a sense of passivity here, a calmer life, but without real commitment. And for Heidegger, the verdict is similar, but with a more metaphysical accusation. In Heidegger’s phenomenology a true sense of authenticity is ideal, but to literally distance oneself is futile. With this renunciation of his relationships Moscarda becomes undefined in the ontological sense, without the determinations of others but also with the definitive decisions of the self.

This research is situated not as a final statement, but hopefully as a contribution to further study in Italian literature and the unique conversations around identity in the tradition. Modernist literature has a wealth of scholarship behind it, but there remains work to be done in the Italian tradition and its ties to other fields and movements of the period. It would be interesting to study the novel using later metaphysical conversations around language. An analysis of the novel, or Pirandello’s broader work, using Derrida’s metaphysics of text would be fascinating, and there are parallels between Derrida and Moscarda’s projects. Derrida explores the dyadic (two-part) view of language as signifier/signified, questioning the connection between the two terms, and if either can ever fully be present or absent. Here, meaning can only be found in reference to other connotations, leading to an infinite chain of meanings. In Derrida’s metaphysics, meaning is always deferred to the next term, and never static or fully at-present. This has loose ties to the Pirandello’s “l’umorismo” and the central conflict of *One, No One, and One Hundred Thousand*, and a study of the author’s broader body of work in conversation with Jacques Derrida’s thought would be fascinating. While Heidegger looks at phenomenology for “being,” Derrida looks at language and texts. Pirandello interrogates selfhood from a more ontological or psychoanalytic perspective. But it would be worthwhile to undertake similar investigations of identity in modernist texts with a focus on gender roles or economic conditions. But there is room for scholarship on the representation of women or gender dynamics in Italian literature, and understanding how Italian modernism compares/contrasts with broader European modernism in this regard would be an interesting investigation.

Moscarda’s crisis speaks to questions of selfhood in

the modern era. For Moscarda, existence is an open question, one to which he finds no meaningful answers. The tragedy of his life is that he finds no answers, but perhaps encourages readers to question how they view their own sense of self. The modernist literary canon maintains a strong resonance with contemporary readership, and the struggle to find meaning remains a pertinent one. Binet and Heidegger are instrumental figures in their respective fields, and their insights contributed greatly to contemporary discussions of the self. These thinkers tackled issues of alienation, authenticity, and identity in literary modernism. It is an incomplete, ongoing process, but a valuable one nonetheless. Heidegger, Binet, and Pirandello opened new avenues of thought in their fields of study, and raised interdisciplinary questions that are still discussed today. It’s important to remember that with these thinkers there is a shared sense of “discovering,” of a process not towards defining authenticity, but of a continual search. These thinkers, and the period of literary modernism in general, leave a difficult legacy. To live and work in an effort towards an equitable and authentic selfhood is one of the toughest tasks one can face, but perhaps, it is also one of the most important.

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9 EDITOR’S NOTES

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Strategies in Time-Based Media Conservation: An Evaluation of Three Institutional Approaches

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1 INTRODUCTION

Time-based media (TBM) is a category of art in which the works rely on the passage of time and often the integration of technology to convey their artistic concepts and narratives¹. It encompasses various artistic expressions, including video installations, sound art, performance, and interactive digital works. This diverse array of mediums present distinct challenges to institutions responsible for their storage, preservation, and accessibility. The rapid evolution of technology and the inherent fragility of the media formats make the proper management of time-based media art equipment a critical concern. This paper examines three case studies of time-based media artworks from the Guggenheim, Museum of Modern Art, and Smithsonian American Art Museum, evaluating the approaches employed by each institution to address the unique challenges of conserving display equipment for exhibition. By analyzing the outcomes and implications of these approaches, this study aims to contribute to a comprehensive understanding of effective strategies for preserving and presenting time-based media artworks in museum settings.

Many of these time-based media works consist of three essential technical elements: the information carrier, the playback equipment, and the display equipment. For example, a VHS tape—the carrier—is responsible for storing the data, a VHS player—the playback equipment—reads the data, and a CRT video monitor—the display equipment—renders the data in a consumable format for the viewer². In this constructed “dynamic system,” each of the components is vulnerable to degradation and technological obsolescence, so parts must eventually be repaired or replaced³. While regularly exercising a time-based media work is vital to keeping it and the institutional knowledge of its installation alive, it also introduces loss to the dynamic system by gradually degrading the equipment with each use⁴. Consequently, two fundamental tenets of the museum—preservation and exhibition—are at odds with one another⁵.

The active role of a TBM conservator is to strike a

delicate balance between these two institutional missions, and to do so they must make decisions that require a certain degree of nuanced, conceptual interpretation. If a piece of equipment fails, should it be replaced with the exact same model as the original or can modern technology be used in its place? If the equipment is updated, what aesthetic or auditory qualities—if any—inherent to the original technology should try to be emulated? If the original hardware is considered invariable—meaning the work’s authenticity is reliant on that specific equipment—how does the institution source and preserve the backup equipment that may have become scarce since the artwork’s inception? There are never perfect or one-size-fits-all answers to these questions. Technological obsolescence is a common hurdle, and the work becomes more vulnerable to loss as the equipment becomes more invariable and specialized⁶. A conservator must work with other stakeholders such as the artist, curators, collections managers, and fabricators to determine the best strategy for each specific TBM artwork.

Pip Laurenson—the first TBM conservator to be appointed to any institution worldwide in 1996—posits that there are three main strategies to address equipment failure of media artworks⁷ (see Appendix A). The first entails replacing technical components with spare parts of the same equipment as it was originally installed. While this strategy preserves the work’s conceptual and physical integrity the most, it may not be the most sustainable option due to the necessary stockpiling and upkeep of obsolete, often rare technology. The next strategy involves swapping out failing components with new or modified technologies while maintaining what is considered to be significant to those pieces—like integrating modern components within an original casing or updating the information carrier and playback equipment while preserving the original display equipment. Lastly, a TBM work’s significant features can be recreated by substituting the equipment with an inexact alternative that uses the same technology or by emulating quantifiable outputs like dynamic range, resolution, audio levels, and rhythm with mod-

ern technologies, reproducing functionality and behavior through imitation⁶.

As Laurenson states in her seminal work, “Authenticity, Change and Loss in the Conservation of Time-Based Media Installations,” even identifying a piece’s “significant features” or “work-defining properties” is a complicated endeavor, especially when the artist has not provided detailed installation instructions, is not available for interview, or is no longer a reliable source of information and decision-making³. The statement of an artist must be contextualized by conservation expertise and the conservation treatments should also consult the artist’s original vision². The care of a TBM work is a constant, cyclical, collaborative process that varies based on the piece’s unique dynamic system, available technologies, and institutional context. Different institutions may use different conservation approaches based on their resources and needs. Although TBM conservation treatments are complex and nuanced, individual case studies can be evaluated based on the same criteria to determine their efficacy.

2 CASE STUDY I: THE GUGGENHEIM’S CONSERVATION OF *RANDOM ACCESS* BY NAM JUNE PAIK

2.1 Description of Conservation Treatments

As recounted in Joanna Phillips’ 2010 article, “Shifting Equipment Significance in Time-Based Media Art,” Nam June Paik’s original 1963 interactive artwork, *Random Access*, included a cable-extended open-reel audio deck with which visitors were encouraged to trace over an arrangement of ½ in audio tapes—giving them the opportunity to “randomly access” the recorded content of the tape (see Appendix B). This work has three authorized versions, but the Guggenheim’s conservation strategies for their version Paik’s *Random Access* differs from those done to other iterations.

The first installation of this piece—labeled the Daniels version after the private collection in which it currently resides—values the portable cassette player as a unique object. Although still in working order, it has been suspended from interactive use since 1998 due to its fragility. Displayed out of the reach of visitors, it has become a non-functioning museum object, emphasizing preservation over interactivity. The second—named the Paik and Saueracker version for the artist and his former assistant who still presents it today—is treated as a conceptual artwork not tied to any specific technical component of significance. In this version, the analog media work is newly fabricated for each installation using different audio decks bought second-hand. This approach emphasizes the flexibility and variability of the artwork, with the devices modified in the name of interactive exhibition.

In contrast to these two previous iterations, the conservation strategy for the Guggenheim Museum’s version of *Random Access* focused on retaining the original equipment and preserving its interactive functionality. This approach was decided based on answers to the Variable Media Questionnaire—a tool to record the artist’s preservation preferences for mediums facing obsolescence—from Paik’s studio representative at the time of the work’s acquisition⁸. When the audio deck and extended audio head fell into disrepair, a crucial decision had to be made regarding whether to repair or replace the equipment. The significance of the original equipment was paramount in this conservation approach. The Guggenheim conservation team recognized the importance of maintaining the authenticity and integrity of the artwork, considering both the artist’s intentions and the historical context.

The equipment—including the modified 1970s RCA open-reel audio deck and the extended audio head—played a vital role in the artwork’s concept and interactivity. By the time the artwork required conservation, however, this period hardware was no longer in production and there were no modern, digital alternatives with the same functionality and tactility available. Consequently, although this technical component began as a variable piece of equipment, it had acquired unique value over time, becoming a precious and integral part of the artwork itself. In the end, repairing the equipment was deemed feasible and desirable to preserve the artwork’s interactive nature. However, this decision was not without its difficulties. Finding replacement parts became challenging due to the obsolescence of analog technology. While functioning analog equipment was more readily available a decade before the conservation began, it had become increasingly scarce, making repair and maintenance more complex and time-consuming.

Additionally, the physical dimensions of the equipment were considered essential for the artwork’s presentation. The custom-fit acrylic housing, bearing Paik’s signature, was specifically designed to accommodate the 1970s audio deck and the 1990s amplifier. Any replacement equipment with different dimensions would have been incompatible with the acrylic construction, potentially compromising the artwork’s authenticity and authorship².

2.2 Evaluation of Conservation Strategies

Based on Laurenson’s three strategies for addressing equipment in TBM artworks, the conservation strategy employed by the Guggenheim Museum for Nam June Paik’s *Random Access* aligns closely with Strategy 1: Repairing the original unit or replacing the failed unit with the same kind⁶. The Guggenheim’s chosen approach focused on repairing the original equipment and preserving its interactive functionality. This approach

maintained the integrity of the work by preserving the identity of the physical components and ensuring a link to the original meaning of the artwork. By repairing the same equipment or substituting it with the same make or model, this strategy aimed to prevent any loss of the artwork's technical components, intended concept, and functionality.

The case study provides evidence of the original equipment's significance through documentation, including the Variable Media Questionnaire and the artist's studio representative's stipulation for the use of "period equipment" for future recreations². While Phillips admits there are gaps in this original documentation, the conservation treatments were documented to aid with future treatment plans and maintenance.

While the chosen strategy emphasizes the importance of the original equipment, challenges arise in terms of equipment availability and long-term sustainability. The obsolescence of analog technology poses difficulties in finding functioning replacement parts for repair or substitution. With a strong link between the specific equipment and the authenticity of the work, more loss is inevitable than if the hardware was variable⁶. Although the conservators were able to repair the piece with minimal substitutions during this treatment, the same may not be true in the future, leaving potential limitations in ensuring the artwork's preservation.

In terms of compatibility and functionality, the conservators stabilized the piece and returned functionality to it through their treatments. In comparison to the Daniels version, which preserved historicity over functionality by removing its interactive element, the Guggenheim's *Random Access* maintains functionality and the original display set-up. However, long-term interactive exhibition may degrade the work-defining equipment and therefore its authenticity.

The approach of repairing the technical components allows for potential reversibility or modification if future technologies or preservation methods become available and the previous repairs are no longer viable. Retaining the original equipment introduces minimal risk to the physical authenticity of the work because it is not a complete re-fabrication that may undermine the properties deemed significant in this work. However, as analog technology becomes increasingly obsolete, it may be challenging to adapt the artwork to emerging standards or formats in the future. Still, the chosen strategy does not result in any significant loss or degradation of the original work. By retaining the original equipment and its modifications made by the artist's hands, the unique authorship, authenticity, and functionality of the artwork are preserved. The visual aesthetics, interactive quality, and audio of the time-based media are maintained as intended by Paik.

3 CAST STUDY II: SAAM'S CONSERVATION OF *FOR SAAM* BY JENNY HOLZER

3.1 Description of Conservation Treatments

The conservation of *For SAAM* by Jenny Holzer—chronicled in depth in Dan Finn's "Museum Authorship and the Conservation of Media Installations: Two Case Studies from the Smithsonian American Art Museum," from 2021—is unique in that it addressed a large-scale, site-specific work commissioned in 2007 specifically for the Smithsonian American Art Museum's lobby (see Appendix B). The cylindrical LED sculpture stands 28 feet tall and features a series of the artist's texts animated by individually programmable LEDs. After approximately ten years of continuous exhibition, *For SAAM* experienced recurring technological failures in solder joints, LED segments, and integrated circuits. SAAM's objects conservator at the time, Hugh Shockey, replaced failed components with spare parts provided by the artist as an acceptable treatment. However, by 2014, replacing LED segments no longer maintained the intended appearance due to uneven aging and color degradation.

In 2015, the accumulation of technical problems led to the consequential institutional decision to undertake a major conservation project. Discussions with the artist and the museum resulted in the decision to completely re-fabricate the artwork. The only physical components that remained from the original piece were the top halo and base. While the overall dimensions remained the same, the original LEDs, LED boards, connections between the LED segments, motherboards, and computer were replaced while maintaining the properties of the work deemed visibly significant by SAAM, the artist, and fabricators. This approach aimed to reduce the amount of maintenance it required, ensure consistency of presentation, and increase energy efficiency.

In addition to addressing the hardware issues, the team considered changing the source of the animated text in the artwork from a generative software to pre-rendered video files. Initially, there was a debate about whether the animation source was a defining property of the artwork. While SAAM agreed to switch to pre-rendered text based on the artist's input and minimal impact on the observable behavior, the original generative method was ultimately maintained due to the inability to reproduce the exact fonts and typefaces. A report was created to document the project's history and serve as a reference for future decisions regarding the artwork's technology.

The new iteration of *For SAAM* addressed most of the technical issues present in the original version. However, one major concern remained, which was how to avoid the mismatched brightness issue that occurred over time in the original LEDs. To address this issue, a

spare lighting system was developed, which ages spare parts at the same rate as the artwork, ensuring that when needed, the spares match the color and brightness of the segments⁹.

3.2 Evaluation of Conservation Strategies

This case study represents a large-scale, advanced version of Strategy 2: Making new components or modifying equipment to match the significance of failed equipment⁶. Modern equipment was added to the piece to replace the failing ones, but it was still organized in the same casing with the same dimensions, number of LEDs, and viewing angles. Rather than only recreating the measurable outputs as described in Laurenson's third strategy, the conservators working on *For SAAM* strived to match the physical presence of the failed equipment because the aesthetic qualities were deemed significant by stakeholders.

The intentions of the artist as well as the site-specific context of the TBM artwork were diligently considered by the conservation team. There was a constant, heavily documented dialogue between the artist and SAAM about how the faulty components, technical issues, and the difficulty of maintenance in its pre-conserved state were obscuring the original meaning and function of the piece. To this end, re-fabrication was a valid strategy for the long-term stability of the piece after systematically exploring and rejecting other options. The development of a spare aging system to ensure color and brightness matching of the LED segments also addresses the topic of the work's sustainability. However, the text does not explicitly mention any plans for conservation and repair after this collection of spares is depleted. Considering the incredibly public-facing, immovable nature of *For SAAM* as well as the specific instructions from the artist to update the technology as the originals become obsolete, the museum's decision to value ease of maintenance over complete reversibility is rational. The commitment shown to following the ethics of conservation while fully addressing the technical issues nonetheless takes a significant investment on behalf of the institution regardless of their chosen strategy.

4 CASE STUDY III: MOMA'S CONSERVATION OF *LOVERS* BY TEIJI FURUHASHI

4.1 Description of Conservation Treatments

In Cass Fino-Radin's 2016 article "Art in the Age of Obsolescence: Rescuing an Artwork from Crumbling Technologies," they describe the conservation of Teiji Furuhashi's *Lovers* from start to finish (see Appendix B). The initial phase of the conservation process involved pulling the piece, acquired by the Museum of Modern Art (MoMA) in 1998, from storage. The team of conser-

vators began examining its various components, including documentation, LaserDiscs, 35mm slides, video projectors contained in an 8-foot-tall metal tower, robotics that control the display equipment's movements, control hardware, and software. The artwork—which consists of walking nude figures projected onto the walls from the middle of the room—had not been exhibited since its acquisition, making it necessary to conduct in-depth research to understand its anatomy and functionality.

Based on the research findings, the conservators determined that certain components, such as the original video projectors, needed to be replaced due to their instability and rarity. The process involved selecting suitable replacements that closely matched the original specifications and working closely with Shiro and Yoko Takatani, who had supervised the original technical execution and installation of the artwork before its acquisition in 1998. The aim was to stabilize the artwork using more modern technologies while ensuring reversibility.

In addition to replacing the projectors and after reverse-engineering the original algorithm that controlled how and when the robotics moved the projectors, conservators created a new system to regulate the rhythm, interactivity, and video playback. This program communicated with a microcontroller which transmitted commands to the robotic motors. In other words, new hardware and software were constructed during the conservation treatments to stabilize the work and make it playable for exhibition.

Conservators continued to work on the software to ensure the robotic movements and motion of the figures were synchronized. When they were confident that the timing of each was perfectly reproduced based on the specifications recorded when it was collected by MoMA, the team organized a showing for Shiro Takatani. After documenting his knowledge of the work's lighting, auditory output, and alignment—all identified as information gaps in the original documentation—he explained that Furuhashi intended for the synchronized motion of the figures to be refined with each installation, making the next more accurate, but different, from the last. Following extensive deliberation among conservators and curators, and with the understanding that all modifications would be meticulously recorded and entirely reversible, the team decided to refine the work as the artist envisioned⁴.

4.2 Evaluation of Conservation Strategies

The conservation strategy used in the case study exemplifies Strategy 3: Recreating significant features by approximate substitution⁶. The hardware and software were upgraded to more stable, usable technologies, and the work-defining features were emulated using these

new systems. The approach maintained the integrity of the piece; although this iteration was different from the last due to the refinement process, it still holds the authorship of Teiji Furuhashi and honors his intentions.

The case study demonstrates a strong emphasis on research and documentation. The museum team carefully studied and documented the artwork's components, condition, and potential risks. They conducted in-depth research and produced a comprehensive report, providing a solid foundation for subsequent conservation efforts. The team also documented the process of reverse engineering the original software and hardware, ensuring that the knowledge gained was preserved for future reference. This research generated a substantial body of knowledge, providing the conservators with a foundation for creating an informed treatment plan.

Conservators on this project decided to replace the original equipment—at risk of failure and obsolescence—with modern, stable technologies. The strategy of emulation used during this conservation treatment establishes a precedent that the equipment is not work-defining and can be variable based on the needs of the piece, allowing for its adaptation to emerging formats. This means that conservators in the future—if they still deem this approach valid—could emulate this work on contemporary hardware. After the conservation treatments of this case study, all the technical components used to emulate the original work, even though they are not original themselves, conveyed its immersive feel and became part of this authentic iteration. However, future conservators must also consider the vital, active role Shiro Takatani played in communicating *Lovers* unique installation and conservation requirements, and how not being able to consult him or Furuhashi may affect the authenticity of the work if it were to be shown again.

5 CONCLUSION

By carefully considering factors such as institutional needs, artist intentions, equipment availability, and the significance of work-defining features, conservators at the Guggenheim Museum, Museum of Modern Art, and Smithsonian American Art Museum determined the most suitable conservation strategies for their specific pieces, showcasing the nuanced and context-specific approaches required for the stewardship of time-based media artworks. These case studies shed light on the complex nature of TBM conservation, to which the rapid evolution of technology and the fragility of media formats pose significant challenges. The conservators on these projects encountered the ramifications of technological degradation and obsolescence, but each approach varied based on the state of the work, the artist's preference, the museum's parameters, as well their own expertise. While the equip-

ment for Nam June Paik's *Random Access* was determined to be vital to its artistic expression, while the opposite was true for Jenny Holzer's *For SAAM*. Given the artist's preferences that the aesthetic properties be deemed paramount, steps were taken to reconstruct the visual appearance—even if the original hardware had to be sacrificed. Documentation and constant communication between the institution and artist's studio was key in this case as in the conservation of Furuhashi's *Lovers*. Even though the technology was obsolete, the conservators worked with the late artist's collaborator to recreate the alignment, lighting, and sound of the original piece while refining the robotics as the artist would have done.

In each of these institutional examples, understanding the fundamentals of an artwork, considering its various contexts and stakeholders, was key in choosing the most appropriate strategy. To conserve is, ultimately, to interpret; every decision conservators make must align with their informed interpretation of the artwork. With the field of time-based media conservation still in its infancy, these case studies show that there is not a one-size-fits-all approach for these complicated artworks. Treatments that are accepted in this discipline—like complete refabrication—would be unthinkable in, for example, the conservation of paintings. In the future, it will be necessary to reassess the efficacy of the strategies used and possibly consider a different one entirely if prompted by the irreparable degradation of the original invariable equipment or the loss of vital expertise through the death of the artist or their collaborator. However, these three institutional examples represent a current and ongoing paradigm shift in what it means to preserve art, that is, through its use of technology that rapidly degrades and becomes outdated, more ephemeral than traditional mediums. Ultimately, the validity of each conservation strategy lies in its ability to navigate the delicate balance between preservation and exhibition, functionality and historicity, and authenticity and variability. Through continued research, documentation, and adaptive strategies, institutions can successfully navigate the challenges posed by time-based media artworks, ensuring their longevity and accessibility for future generations.

6 EDITOR'S NOTES

This article was peer-reviewed.

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Appendix A

List of Strategies for the Conservation of Display Equipment from Pip Laurenson's "The Management of Display Equipment in Time-Based Media Installations" (2004)

1. Acquiring spares to repair the original unit or substituting the failed unit with the same make or model. This maintains the integrity of the work on all counts except for any work explicitly designed to be ephemeral. This strategy is the closest to traditional conservation practice in that it preserves the link to the meaning of the work by preserving the identity of the physical components. Success is easy to evaluate – if the same equipment is used then (if all other conditions for installation are adhered to) no loss will occur. This strategy is only an option for the time spares are available.
2. Making new components or modifying another piece of equipment to match what was considered significant about the failed equipment. For example, putting a modern mechanism into an original

casing. When considering this strategy one should bear in mind the risk of undermining the spirit of the work if the technology is intended to be transparent and uncontrived.

3. Recreating significant features by inexact substitution perhaps by an item of equipment using the same technology or producing the best match of measurable outputs (quantifiable in terms of dynamic range, resolution, brightness etc.).

Appendix B



Figure 1. Nam June Paik, *Random Access*, 1963 (2000 version), strips of audiotape, open-reel audio deck, extended playback head, and speakers, dimensions vary with installation, Solomon R. Guggenheim Museum, <https://www.guggenheim.org/artwork/9536>.

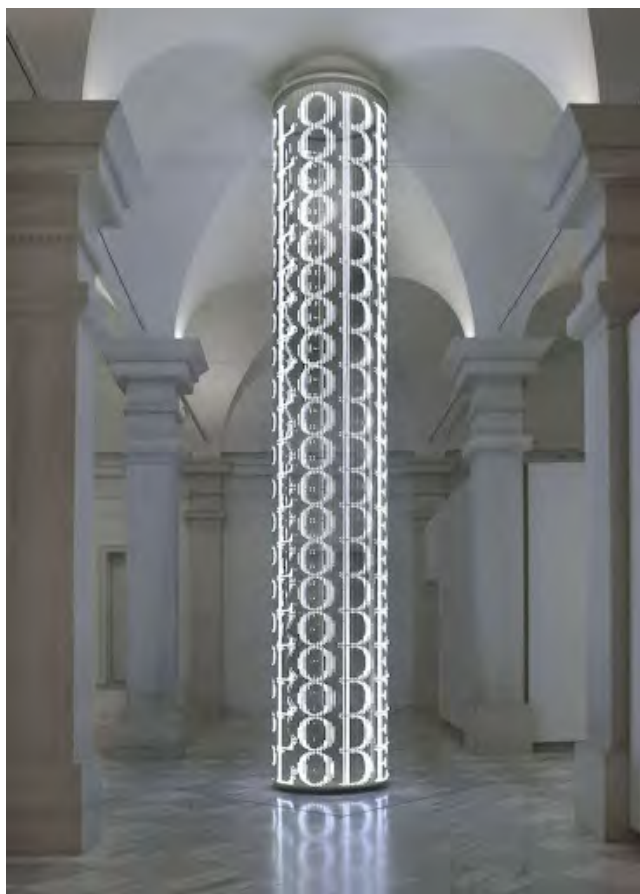


Figure 2. Jenny Holzer, *For SAAM*, 2007, electronic LED array with white diodes, 336" x 48", Smithsonian American Art Museum, <https://americanart.si.edu/artwork/saam-76771>.



Figure 3. Teiji Furuhashi, *Lovers*, 1994, Computer controlled, five-channel laser disc/sound installation with five projectors, two sound systems, two slide projectors, and slides (color, sound), 32' 10" x 32' 10", The Museum of Modern Art, <https://www.moma.org/collection/works/8136>.



Existence by Kiernan McCarty
Watercolor, Colored Pencil, and Ink on Paper

Dr. Scott Montgomery

University of Denver School of Art and Art History

Elijah Kruger¹, on behalf of the Editorial Board

¹DUURJ Editor at Large, University of Denver



1 WHAT DID YOU DO BEFORE YOU BECAME A PROFESSOR? WHERE DID YOU GO TO SCHOOL, WHAT DID YOU STUDY, WHAT WERE YOUR INTERESTS IN THAT PIPELINE?

Boy, well it goes all the way back to taking art history in high school and I had that revelation that we did more as a species than kill each other and make kings. So, art history blew my mind in that respect. I was rare—I went to college as an art history major. Usually that's something that people arrive at later. From college, I took a year off and then went straight to grad school. I went to my master's program which was mostly in Italy, with Syracuse University. They have an MA program in Italian Renaissance art. After that, I took a year to work but then applied for PhD programs and went to Rutgers in New Jersey and did my doctorate there. I

finished a while ago. Then I had a series of one-year appointments fresh out of graduate school and arrived at DU. I've been here for about 21 years now. I'm sort of the geezer in the department, I've realized.

2 WHAT WAS THE INITIAL DRAW TO DU?

DU was a big draw for a lot of reasons. It was a position in my area of expertise which is Medieval/Renaissance art. That was intriguing because I knew I would actually be teaching in my area. I also liked that DU is relatively small—it's kind of like a small liberal arts college tucked into a university. My undergrad, alma mater was Pomona, a small liberal arts college. I had been teaching at large state schools up to this point where there just wasn't enough of me to go around. There were so many students, and I couldn't serve them all comfortably. DU appealed; it was smaller. You can get to know the students, you can work with the students, instead of having a line down the hall. The World Art survey, at the place I taught prior to DU had 300 [students] and here it has 45 [students]. So, I just looked at the numbers and it wasn't even about the amount of grading, it was about the simple fact that when you have 300 students, you don't know them. So, I liked the mission of DU, I liked the value on research as well as teaching. I like to do both. And of course it was Denver, I was in North Texas for five years so that made the decision easy. Sure, I'll go to Denver. Didn't even have to blink. A lot of it really was the appeal of DU and the department—I got a very good vibe from the place.

3 WHAT WAS THE DRAW TO TEACHING FOR YOU?

Some of it may have to do with being the son of a professor. Both my older brother and I are professors, so it may just be that you gravitate toward the norm you grow up with. I'm sure that was some of it. I always liked the life of the mind—intellectual pursuit and questions. Academia provided that. I don't think I'd be as good at K-12. I want more teaching of complicated ideas and historical understanding. To me the whole point

in studying history is it opens your mind to different ways things are done, different ways people do things. In the ideal world, it makes you a better person, more compassionate. I don't know if it does, but in the ideal world it does. I also enjoy people. I couldn't do a cubicle. I always said that the Humanities starts with those five letters for a reason. I like the human interface of teaching. One of my favorite parts is office hours. I like people.

4 HOW WOULD YOU DESCRIBE YOUR RESEARCH IN LAYMAN'S TERMS?

First of all, my research is completely bifurcated—its split. I have two radically divergent lines of research, which is not normal. Traditionally, I study European Medieval Art—that's what my PhD is in. The bulk of my career has been working on that. Publishing books and articles on medieval pilgrimage art and saints' cults. I work with saints and relics, the body parts of saints, and what they would do with holy bones. It's holy art from the European Middle Ages and pilgrimage. I've done that for years. About ten years ago I also started branching out – which has now become my main line of research—into 1960's psychedelic poster art. I collected them from when I was younger and got to the point where I got to know most of the living artists and fell into a position where we became friends. They trusted me. I was an academic interested in their work so they were receptive. It hit me that I have a responsibility to capture all of this oral history that isn't written down. I've been working on posters more intently for the last ten years than I have on medieval works. The way I see it, my medieval saints will still be dead in ten years. These psychedelic poster artists will likely be dead. Most of them are in their 80s now. The likelihood is that I have a small period of time to capture as much of this oral history, work with them, and honestly, I enjoy watching the artists see their lives validated. I'm enjoying seeing the artists actually see the fruits of an art historian studying their work. I've been working lately with Lee Conklin. I wrote a book about him, just did an exhibition and catalog here at DU. He came out to visit in the Fall for the closing of the show. I love the idea that they're seeing that their place in history is well ensconced, and that they're being taken seriously by art historians, for the first time.

5 WHEN YOU'RE RESEARCHING PSYCHEDELIC POSTERS, WHAT DOES THAT PROCESS LOOK LIKE?

A lot of interviews. There's not much published out there. There's the basic history—there's the hippy movement in San Francisco and there's the catalogs of all the posters, but the stories behind them have never been

gathered. Michelangelo has tons written on him—if you're doing research on him, you've got a different problem. You have a ten-year reading list. But, if you're working on Lee Conklin, you have much less, so you piece together what you can. For me it's exciting to do something different because I'm a medievalist where you need a Ouija Board to talk to your sources, and that's unreliable. With posters, I can conduct first-hand research. Four years ago, I released a movie on Denver in the 1960s. It was a documentary that took five years to make, and it was much of the same process. We did a lot of first-hand interviews. Then I went through everything from the Denver Post and the Rocky Mountain News back in the 60s to the DU Clarion. Just piecing through every scrap of history because there isn't much written on it. The film was on the Family Dog Denver, which was a rock and roll club which opened in 1967, just up Evans Ave. A lot of DU students worked there. That was a challenge because there is no footage of this place. There are five photographs and 16 posters. That's it. Nothing else. We practically made a movie out of thin air. It was all done through firsthand interviews. So lately my research has been really different than my traditional research, which was in libraries and archives, looking at old Latin books. Now, it's looking through newspapers, something that I think the Clarion has been hugely helpful on. Case and point, the first time The Doors played in the State of Colorado was at the DU Student Union.

6 WE INTERVIEW A LOT OF POLITICAL SCIENTISTS AND STEM FACULTY FOR THE JOURNAL; THIS IS ONE OF OUR FIRST ARTIST INTERVIEWS. I WAS CURIOUS IF YOU HAD ONE OR TWO ISSUES, HOWEVER YOU DEFINE IT, THAT YOU WOULD ENCOURAGE PEOPLE TO KEEP THEIR EYE ON?

Wow. Kindness. I don't see it as much anymore. To me, social graces can be wrapped up in kindness. People have gotten real intent on giving themselves a permission slip to say whatever they want, regardless of how it might be received. I would like us all to take a breath, formulate our thoughts a little more constructively, a little more compassionately. I do subscribe to—I'm not a Tibetan Buddhist, or even Tibetan—but their notion that wisdom and compassion are inextricably linked. I'd like to see that fostered a little more. Many voices that we grant authority to, many of them out there are not compassionate. There's anger. There's divisiveness. Art has the power to bring us together. Music does the same thing; it brings us together like few other things. I'd like to see us tap into what unites us, rather than what divides us. We're in a political mess right now. It's how we engage with each other. I would try to be

mindful of what's being said. Does it need to be said? If there's more compassion then there will be more wisdom, and we'll get through turbulent times.

7 WHAT DO YOU LIKE TO DO WHEN YOU'RE NOT RESEARCHING, WHEN YOU'RE NOT TEACHING?

Any academic 'thing' is a 24/7 gig, that when you're not doing it, you're taking time off. It's not a 9-5 job. That being said, we're all nerds and we love that. I go on vacation and I look at medieval churches. It's what I like to do. That being said, on my own time, I play a lot of music, mostly guitar but really anything I can get my hands on. Not wind instruments, they're way above my paygrade. I doodle. I draw. Those are my biggest hobbies. There's always music in the house. I have a big record collection. A lot of music is made in the house. I used to make music with my kids when they were younger. I wanted them to grow up with the idea that music is not just something external that you digest but something you can also make. My eldest just graduated from Berklee College of Music, so I guess some of it sunk in.

8 WHAT WOULD BE A BOOK, PODCAST, OR FILM THAT YOU WOULD RECOMMEND TO PEOPLE?

Oh, my goodness. What a question. I don't listen to many podcasts because I'm not 'hip'. I tend to put music on. It's funny, there's the academic books which I would recommend for the nerds. If you wanted to study medieval art, I would say read Peter Brown's *The Cult of Saints: Its Rise and Function in Latin Christianity*. I just gave it to my aunt for Christmas—a real nerdy present. For where we are historically—now, I would say something like *Piece Is Every Step* by Thich Nhat Hanh. It was written by a Vietnamese Buddhist—I believe Martin Luther King Jr. nominated him for the Nobel Prize. He preaches mindfulness. Back to my compassion issue, it's what we need right now. It's what I rationalize. I teach medieval church art which is really obscure arcane stuff. I hope that what is learned from that are ways of seeing other realities. I wasn't raised Catholic but spent my career studying Catholic art. I always joke that I'm not Catholic, but I could play one on TV as long as the show took place before 1500. I'd be toast if it was after that. It's that idea of walking, putting yourself in someone else's footsteps, and trying to think the way they think. It makes us more subtle, elastic thinkers. What I like to think I teach at DU is less just Medieval and Renaissance art, but modes of approaching other belief system, other ways of visualizing. Compassionate understanding.



Untitled by Thane Gehring

DU Undergraduate Showcase: Research, Scholarship, and Creative Works

Abstracts

SPECIES-BASED MODERATION AND ATTITUDE-BASED MEDIATION OF THE HARDSHIP-TO-PAIN BIAS

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People tend to perceive others as having a lower pain sensitivity if those others have experienced hardship or are part of a disadvantaged and minoritized group, including people of color or of lower socio-economic background. To learn more about the mechanisms behind and the downstream consequences of this hardship-to-pain bias, we used an experimental approach to measure people's application of that bias on adults, children, and dogs. Results were that lay beliefs that hardship desensitizes individuals to pain were applied more strongly to adults and to children than to dogs. Perceived toughness mediated this differential effect, suggesting that general adaptation bias may not explain species-specific application of this hardship-to-pain bias. Control, paternalism, and responsibility over one's environment did not significantly moderate the mediation, indicating "humanness" as an important factor and human-specific hierarchy justification as an important mechanism behind the hardship-to-pain bias.

COMPARING CHRYSOCHUS BEETLE'S COPULATION PATTERNS

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The effects of copulation duration are understudied in heterospecific mating treatments of the Chrysochus beetles species. These species interactions and mating patterns can be closely observed in hybrid zones which are where the different species meet, mate, and reproduce. I was able to analyze the heterospecific and conspecific mating effects on copulation duration in the Chrysochus auratus beetle. The C. auratus species forms a hybrid zone with their sister species, C. cobaltinus, in south-central Washington state. The results of this study showed that the copulation duration was significantly longer in heterospecific matings compared to conspecific matings. It was also found that there was no significance of the female's previous mating partner on the overall copulation duration. Based on these results, we can further research the female preferences in the beetles' conspecific sexual partners and determine if the copulation duration affects the mating success.

MISSED EXITS: CAUSAL MECHANISMS INFLUENCING MILITARIZED INTERSTATE DISPUTE ESCALATION IN LATIN AMERICA

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Research on militarized interstate disputes (MIDs) and the reasons for their escalation to interstate war is sparse at the global level and the regional level in Latin America. This thesis contributes new research on militarized interstate dispute escalation in Latin America. In this project, I ask: how do differences in conflict escalation indicators between states affect whether a Latin American country will participate in a Militarized Interstate Dispute that escalates to the use of force? To answer this question, I conduct a case study utilizing the most similar cases analysis approach to compare the cases of the 1995 MID between Ecuador and Peru as well as the 1997 MID between Nicaragua and Honduras. I also utilize process tracing to analyze the impact of the causal mechanisms of territorial contiguity, natural resource contention, development level, and issue salience on the escalation of MIDs in the former cases to one where actual force is used. From this process tracing, I find that a difference in issue salience, or the degree of importance attached to an issue by the actors involved, between the two cases contributed to a difference in MID escalation. Overall, this thesis fills a preexisting gap in the literature on militarized interstate disputes in the Latin American region while contributing new points of discussion to research on militarized interstate disputes, conflict escalation, and conflict early warning.

DISRUPTING “GOOD” VS. “BAD” PERSON BINARIES BY HUMANIZING VICTIMS OF URBAN HOMICIDE

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In the summer of 2023, Dr. Byron, Malea Marxer, Ellie Barnett-Cashman, and Lily Baeza did a content analysis of nearly 300 obituaries in the summer of 2023. Working with obituaries from the Philadelphia Obituary Project website, we used a uniform code sheet to code for data such as the victim’s demographics and the personality of victims. The motivation behind our project was to disrupt the “good” vs. “bad” person binaries by humanizing victims of urban homicide. We noticed that we as a general population know very little about the victims of everyday urban violence. This is due to things such as deficits and distortion in the media about who the victims were and little to no media coverage if the victim did NOT fit the “ideal victim” stereotype. We aim to change the narratives of urban homicide victims and hone in on critical race theory’s tenet of counternarratives (in this case-giving a voice to minoritized people). For the demographics of the POP Obit samples, 72% of the victims were Black men followed by 9.4% Latino men and 74% of the sample was under the age of 30. While we do have some data on the cause of death of the victims, not all of them had the cause of death listed. For 15% of the sample, the proximal cause of death was more nuanced than typical victim-offender overlap predictions assumed. This data humanizes the victims as when we hear of a victim of urban violence, we assume that they must be a bad person. By working to destigmatize and humanize homicide victims we hope to motivate more privileged citizens to see themselves in these largely Black and Brown victims, sense the enormous familial and societal loss, and use this interest convergence to support violence prevention policy change.

HOW TO SOLVE A WICKED PROBLEM: AN INTRODUCTION TO ENVIRONMENT, SOCIETY AND SUSTAINABILITY

Sidney Barbier¹

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What might a new normal—one that respects the Earth and all of its inhabitants—look like? How can we use our knowledge of the world and its physical and social complexities to design better systems and communities? Where should change begin? These are just of the few questions that I grappled with in working towards writing a undergraduate textbook on sustainability. Over the summer, I worked in coordination with Professors of Geography Paul Sutton and Helen Hazen as a co-author in writing a textbook titled *An Introduction to Environment, Society and Sustainability* that will be used for the ‘Introduction to Sustainability’ course offered in the department of Geography and the Environment. This involved conducting research to write two individual chapters, organizing citations, creating and/or obtaining appropriate figures, building a glossary, and developing discussion questions and learning outcomes for each chapter. This book takes a new approach to compelling contemporary questions regarding the inter-related issues of population, social justice, and environmental sustainability using the framework of what are known as “wicked problems.” The idea of a “wicked problem” means that environmental issues are so complex and involve so many stakeholders that they require an understanding of systems at a broad variety of scales if they are to be addressed. For example, instead of focusing on simple solutions such as recycling, composting and renewable energy, this book will look to push towards broader economic, political, and social systemic change. Sustainability requires a complex and interdisciplinary approach, and this book aims to highlight the importance of systems thinking to develop solutions for the future. The project culminated in a full draft of the textbook including 13 chapters of 7,000-8,000 words per chapter (about 100,000 words total) which has an expected publication date later this year.

UNIQUE TRANSCRIPTOMIC PROFILES IN ATLANTIC KILLIFISH DURING SALINITY ACCLIMATION IN WARM WATER

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The warming effect of climate change threatens aquatic species’ ability to maintain temperature, water, and ion balance. For example, species native to brackish water estuaries are more vulnerable to temperature changes because of frequent salinity changes that are energetically taxing. We used Atlantic killifish (*Fundulus heteroclitus*) as a model to examine the effects of increased temperature during salinity acclimation on fish physiology and the transcriptomic response at the gill, the major organ for oxygen and ion/water balance. We acclimated killifish to brackish water, then separated the fish into one of six treatment conditions consisting of temperate (22°C) or warm temperature (28°C) and different salinities (freshwater, brackish water, saltwater) for three days. Using plasma glucose as a general stress indicator, we found that temperature induces stress in both salinity treatments. We also found that changes in salinity altered osmoregulation: plasma osmolality increased in saltwater in both temperatures, and average osmolality in freshwater was lower in warm water than in the control temperature, indicating impaired ionic homeostasis. Using standard RNA-seq approaches, we found that variation in gill gene expression between treatments was driven primarily by salinity and to a lesser extent temperature. Furthermore, we identified unique gene regulatory pathways during salinity acclimation in warm water compared to salinity or temperature acclimation alone. Overall, our results suggest that maintaining homeostasis in warm freshwater is more challenging than in warm saltwater. Climate change may thus pose a particular challenge for brackish water species especially when acclimating to freshwater.

THE RIGHT ECUMENISM: HOW AMERICAN CONSERVATIVES USED (AND ABUSED) THE SECOND VATICAN COUNCIL

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For decades, historians of American Catholicism have examined how the Second Vatican Council (1962-1965) was received in the American context. While widely seen as an event that created progressive inroads in the Catholic Church, the conciliar documents tell a more complicated story. Developments in Catholic doctrine on ecumenical relations, religious liberty, and political participation became primary sources that, in the United States, were taken in multiple ideological directions by grassroots political activists. This project argues that the documents of the Second Vatican Council, received in the American context, helped foster a rapprochement between conservative Catholics and white Evangelical Protestants in the 1970s and 1980s. Using the council's documents, American conservatives engaged with Catholics to create a broad, interdenominational conservative coalition that continues to influence American politics to this day.

FLAMETHROWER VOL. 1-3: INNOVATION IN MULTIDISCIPLINARY ELECTRONIC AND ACOUSTIC MUSIC

Trevor Briggs¹

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Electronic music is largely viewed by the music academic community as a boundless frontier for innovation. However, very few electronic music projects have been produced by students of the University of Denver's Lamont School of Music. Flamethrower, Vol. 1-3 is a series of three EPs (short albums) that combine jazz, classical, and commercial electronic music to produce an artistic work in which the perception, function, and musical context of electronic instruments is challenged. I approached these compositions treating electronic components as instruments, writing out scores as I would for brass and wind instruments. I also utilized cutting edge electronic hardware (such as the Arturia Minifreak Algorithmic Synthesizer and the Chase Bliss Lossy Digital Artifact Generator) to generate degenerated, fragmented, and evolving sounds. This type of in-depth sound design allowed me to write, perform, and record novel parts for unique instruments. The remainder of the sounds on these recordings incorporate sampling of field recordings to generate new instruments or soundscapes and unconventional recordings of woodwinds (saxophone, clarinet, flute, bass clarinet, and alto flute) from Professor Remy Le Boeuf, my faculty partner. Working on Flamethrower, Vol. 1-3 has allowed me to push the boundaries of what I am capable of creatively. By treating electronic hardware as an instrument in a more traditional sense, I was able to take the synthesizers and effects units on their own terms and write far more successfully. Once the music I've recorded and produced is released, it will likely show others within our community that experimenting with electronics is a viable and respectable avenue within music academia.

THE RELATIONSHIP BETWEEN EXPOSURE TO VIOLENCE DURING CHILDHOOD AND/OR ADULTHOOD AND GROSS COGNITIVE FUNCTIONING AMONG JUSTICE-INVOLVED INDIVIDUALS WITH TBI

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Background Recent estimates suggest approximately 2.7 million Americans were victims of violence in 2021 (USDOJ, 2022). Among justice-involved individuals, the prevalence of lifetime exposure to violence is as high as 87% (Wolff et al., 2014; Wolff & Shi, 2009). Like TBI, disruptions in cognitive functioning have been identified among individuals exposed to violence throughout their lifetimes (Daughterty et al., 2021). These disruptions, particularly impulsivity and emotional reactivity, may make individuals vulnerable to becoming involved in the criminal legal system (McIsaac et al., 2016; Ray & Richardson, 2017). **Main Objective** This study compared domains of cognitive functioning among justice-involved individuals with a significant reported brain injury history who were exposed to violence during childhood and/or adulthood. **Methods** Data from 586 justice-involved adults were analyzed. Information on cognitive functioning and exposure to childhood and/or adulthood violence was gathered from individuals with a significant reported history of TBI who completed the Colorado-Revised OSU TBI-ID (Corrigan & Bogner, 2007), the ANAM core battery, and unstructured clinical interviews. **Results** Significant differences were found in the domains of attention/processing speed, learning, working memory, and delayed memory. Specifically, individuals with a significant reported TBI history who were exposed to violence during childhood and also as an adult performed significantly poorer on cognitive tests than individuals who were exposed to violence only during childhood, only during adulthood, and individuals who were never exposed to violence. **Conclusions/Future Implications** These findings can inform secondary violence prevention efforts for individuals with TBI and exposure to violence, including routine brain injury screening and targeted interventions that address the cognitive deficits associated with exposure to violence. This study also highlights the need for primary prevention of childhood violence, as persons exposed to violence during childhood may be more vulnerable to poor post-injury outcomes if they are also victimized as an adult.

YOUTH ORGANIZING

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The motivation behind this project is to guide youth of color to foster creativity within community engagement. Youth Organizing is a youth civic engagement initiative based on the principles of community organizing, equity, and social justice. YO draws on talents of marginalized students of color who are exploring the dynamics of using their voice to organize for social change. In YO, we work closely with youth in the Socially Just Education class at Dr. Martin Luther King, Jr. Early College (DMLK) to identify, research, and act on issues that directly impact the youth in their communities. We visit the class weekly and facilitate this process for students based on the YO curriculum that draws on the traditions and diversities of youth organizing and youth participatory action research. DU Teams also engage in research on the impacts of this process and action on youth and community members. We will facilitate and support youth participatory action research, in which youth will select an issue, research the issue, design a plan to address the issue, and act on the issue. To facilitate these actions, we will facilitate class sessions utilizing a youth organizing curriculum. As the process is emergent, the issue, research questions and methods of the research phase, and action plan details are determined later on. The expected results are to be the following: to facilitate and support youth to take action and to reflect on that action, its impact, and its future in order for youth to enact public work and assess the extent to which it improved their communities; engage in quantitative and qualitative analysis of the quantitative and qualitative data to assess the impact of the YO showcase event on the community.

EFFECTS OF BIOCHAR ON SHORT-TERM GROWTH IN PINUS CONTORTA VAR. LATIFOLIA

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Rocky Mountain lodgepole pine (*Pinus contorta* var. *latifolia*) is a fire-adapted pine species that has evolved to survive a fire with serotinous cones that open to release seeds at specific temperatures. However, the increased intensity and frequency of modern wildfires has led to decreased germination of lodgepole pines, and recent widespread drought has weakened the immune systems of lodgepole pine, causing increased infestation of mountain pine beetle. As a result, there is a need for improved forest regeneration techniques in lodgepole pine forests. One method of improving revegetation could be through use of a biochar, a carbon-based substance that is produced when woody biomass is burned in a high temperature environment. Numerous studies have found that biochar has generally positive impacts on soil health and plant productivity. However, more research is needed on its impact on native plants, especially lodgepole pine and other species with serotinous mechanisms. This study looks to address how different applications of biochar can be utilized in early greenhouse growth of lodgepole pine, the primary step of many revegetation efforts. In the Olin Hall Greenhouse, following a stratification process, we compared the 6-month growth of lodgepole pine seeds sown in potting soil, potting soil incorporated with biochar, and biochar on top of potting soil. Our procedure is based on protocols developed by the Colorado State Forest Service nursery, the Native Plant Network, U.S. Forest Service, and other academic studies. In our observations 3 months following germination, soil plots with biochar amendments were more successful in promoting plant mass growth of lodgepole pine. After the full 6-month growing period concluded, we found that soil plots with biochar amendments were more successful in promoting shoot height growth of lodgepole pine. These results hold potentially valuable implications on revegetation efforts for an ecosystem increasingly challenged by a changing climate.

TRADE, GROWTH, AND INEQUALITY IN THE UNITED STATES

Daniel Cierasynski¹

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This study focuses on evaluating trade policy for the United States. Its goal is to evaluate the effectiveness of neoliberal, free trade policy on the economic situation of the United States. The prevailing defense behind this neoliberal, free trade policy is centered around the idea that free trade will always benefit countries and its potential damaging effects are very minimal and countries are very likely to quickly readjust and bounce back from any disadvantage caused by the effects of free trade policies. This paper will challenge this assumption. It will do so by focusing on economic indicators like GDP growth along with other factors like the GINI index, as I am to measure neoliberal trade policies effects on growth along with income inequality. It aims to also find the very best way to evaluate trade in the United States. Initially, it will detail and lay out a statistical analysis of the United States economic situation before the North American Free Trade Agreement (NAFTA) which was a massive milestone involving the liberalization of trade in the United States. It will discuss the results of this study but ultimately conclude that this simple statistical study cannot accurately capture and represent the complexity of this situation. This paper will therefore lay out the roadmap for a much more, detailed and specific study that can be explored in the future.

PREVALENCE INDUCED CONCEPT CHANGE IN GENDER PERCEPTIONS

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Feminist theories assert that societal norms and social contexts shape our understanding of gender. We suggest that prevalence-induced concept change (Levari et al., 2018) may explain why gender identity concepts vary based on context. To examine this, participants (N=300) in the current study evaluated faces or objects for their masculinity and femininity. Some participants viewed only masculine stimuli, some viewed only feminine stimuli, and some viewed both. Participants then completed a separate task in which they rated neutral behaviors for dominance (a stereotype associated with men) and warmth (a stereotype associated with women). As expected, when participants saw a higher prevalence of masculine stimuli or feminine stimuli, faces and objects were evaluated as less gender stereotypical than when participants saw an equal prevalence of masculine and feminine stimuli. Furthermore, participants who only saw masculine stimuli rated neutral behaviors as warmer and less dominant, indicating a potential mechanism by which people are evaluated in contexts with a disparate representation of men and women.

INVESTIGATION OF SEPTIN PROTEINS IN DROSOPHILA MELANOGASTER

Noah Craver¹

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Septin proteins are guanosine triphosphate (GTP)-binding proteins that play important roles in the development and physiology of some tissues and interact with the cell membrane and cytoskeleton. In humans, the septin cytoskeleton has been found to assist in many cellular functions, including regulation of cell shape and polarity, cytokinesis, cell migration, vesicle trafficking, and receptor signaling. This thesis aims to examine the location and function of specific septin proteins in the embryo of the common fruit fly, *Drosophila melanogaster*. The experimentation was performed on the embryos of *Drosophila melanogaster* flies during the process of germ band extension, a period of rapid cell division where the body segments of the fly begin to form. In the experiment, Septin 2 was labeled to determine its location within *Drosophila* embryo cells, while Septin 4 was genetically knocked down and its relationship with the developmental protein Rab35 was explored. Through this experiment, the organization and location of Septin 2 was determined, being punctate in pattern and generally widespread, though highly concentrated near the membrane of each cell. It was also discovered that cells lacking Septin 4 also have a greatly decreased amount of Rab35 puncta, a grouping of the developmental protein found near the cellular surface. This led to the conclusion that septin proteins play an important role in maintaining the structural integrity during the development of Rab35 puncta.

EMOTIONAL WELL-BEING OF GROUP FITNESS INSTRUCTORS

Nyah Cubbison¹

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Emotional well-being is an essential component of health overlooked in research on group fitness instructors, who are crucial to the fitness industry. Understanding emotional well-being and job-related outcomes will support them and their work. The study uses a questionnaire that measures whether emotion contagion and emotion labor (surface acting and deep acting) predict emotional exhaustion, job satisfaction, and turnover intention. Group fitness instructors hiding expressions of their true feelings (surface acting) reported more emotional exhaustion, more intent to leave their job, and less satisfaction with their job. Group fitness instructors trying to feel their displayed emotions (deep acting) reported less intent to leave their job, more satisfaction with their job, and more emotional exhaustion. related to more emotional exhaustion, more turnover intention, and less job satisfaction. Exploratory statistics are in the process of being analyzed further. Future interpretive studies are needed to gather more information about group fitness instructors' training on emotional well-being to better understand what instructors need to improve/maintain their emotional well-being, and thus the fitness industry.

INVESTIGATING THE REGULATION OF THE HYPOTHALAMIC-PITUITARY-INTERRENAL AXIS IN ATLANTIC STURGEON (ACIPENSER OXYRINCHUS) FOLLOWING AN ACUTE STRESSOR

Liam Doherty¹

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This study investigated the response to acute stress in Atlantic sturgeon (*Acipenser oxyrinchus*) and HPI axis regulation of glucocorticoid production during stress by examining the expression of key genes—corticotropin-releasing hormone (crh), corticotropin-releasing hormone receptor (crhr), proopiomelanocortin (pomca/pomcb), melanocortin 2 receptor (mc2r), and steroidogenic acute regulatory protein (star)—that are associated with hypothalamus/pituitary/interrenal (HPI) axis of bony fishes. Additionally, tyrosine hydrogenase (th1 and th2) and phosphoenolpyruvate carboxykinase (pepck), found in catecholamine-producing cells in the head kidney of the sturgeon, were investigated as alternative pathways of stress regulation outside of the HPI axis. We sought to test the hypothesis that there is an upregulation of one or several components of the HPI axis in *A. oxyrinchus* to produce a corticosteroidogenic response to acute stress. Atlantic sturgeons were exposed to an acute stressor and were sampled at 1, 6, and 24 h during recovery, whilst maintaining an unstressed control. The fish were examined for plasma cortisol, plasma glucose, and the relative abundance of crh, crhr, pomca, pomcb, mc2r, star, th1, th2, and pepck. Our investigations demonstrated a significant elevation in plasma glucose and cortisol in response to stress, however, there was no significant transcriptional upregulation of the expected corticosteroidogenic HPI axis components crh, crhr, pomca, pomcb, mc2r, and star. However, the investigation revealed significant upregulation of th2 and pepck in response to stress, which provides a possible explanation for elevated plasma glucose levels that were observed. These findings indicate that there may be alternative pathways for stress-regulation of plasma glucose in *A. oxyrinchus* and further investigation is necessary for a more comprehensive understanding. Future studies directed at the stress-responsive regulation of cortisol and catecholamines may offer a greater understanding of the neuroendocrine pathways regulating steroidogenesis and gluconeogenesis during stress in *A. oxyrinchus* as well as basal vertebrates in general.

CHARACTERIZATION OF ZINC HOMEOSTASIS IN MLIV FIBROBLASTS

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Mucopolidosis type IV (MLIV) is a neurological disorder characterized by corneal clouding, abnormalities in eye movement, reduced psychomotor abilities, and moderate to severe intellectual disability. While there is no cure for MLIV, it is known to be caused by a mutation of the MCOLN1 gene, which encodes for TRPML1, a non-selective cation channel in lysosomes. Previous research has found that TRPML1 is permeable to Zn^{2+} . Furthermore, we have discovered that there is a correlation between Zn^{2+} permeability and the severity of symptoms in MLIV mutations. My research goal is to study whether Zn^{2+} homeostasis is disrupted in MLIV cells. We first investigated optimal fibroblast transfection conditions. Ultimately, certain conditions of electroporation yielded the highest density of successfully transfected fibroblasts. Using this transfection method, primary human fibroblast cell lines were utilized to examine the differences in cytosolic and mitochondrial Zn^{2+} concentrations between healthy human fibroblasts (wildtype) and MLIV patient fibroblasts ranging from mild to severe phenotypes through the use of a genetically-encoded zinc sensor. My results revealed that there is a significant variation in cytosolic and mitochondrial Zn^{2+} among patient samples, but no significant differences were detected between the wildtype and MLIV cells. These findings indicate that mutations in TRPML1 may not affect the steady-state cytosolic and mitochondrial Zn^{2+} concentrations because of the compensatory effects of other Zn^{2+} transporters. MLIV phenotypes may be caused by the disruptions of transient and localized Zn^{2+} signals released via the TRPML1 channel. Therefore, future research will investigate TRPML1-mediated Zn^{2+} release in wildtype and MLIV cells.

MUTUAL BENEFITS OF NEAR-PEER MENTORING IN STEM POSTSECONDARY AND CAREER DEVELOPMENT

Nicole Doris¹, Alexander Nguyen¹, Lily Harmon¹, Shubh Todi¹, Naichen Zhao¹

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This study investigates the effectiveness of near-peer mentoring in promoting STEM career aspirations, particularly for underrepresented students. Focusing on the STEM mentor internship course, led by the biology department at a private university in collaboration with a local public school, the research examines the experiences of undergraduate mentors and high school senior mentees, and the benefits and challenges to both participant groups. Key questions addressed include the influence of near-peer mentoring on career choices and personal development for both mentors and mentees, its impact on high school seniors' STEM post-secondary decisions, and post-high school transition considerations. The study also assesses how the program enhances undergraduate mentors' cultural responsiveness, leadership skills, and equity-promoting roles in STEM. Drawing from three years of qualitative data, including surveys, exit tickets, curricula, newsletters, and assignments, the findings provide insights into the significance of near-peer mentoring for shaping STEM education and career pathways. This study employed a qualitative method followed by a sentiment analysis in natural language processing to comprehensively capture the multifaceted outcomes of near-peer mentoring. The results show that most responses from high school mentees and undergraduate mentors are overwhelmingly positive. Program materials effectively align with and address mentees' post-secondary career planning needs, dispelling common myths about studying and working in STEM fields and empowering individuals from traditionally marginalized backgrounds to pursue STEM careers. Undergraduate mentors develop social justice-oriented leadership, agency, and mindsets through newsletter drafting, mentoring sessions, and self-reflection. This holistic STEM mentoring program adds value to a holistic STEM education by engaging diverse communities. Further efforts need to focus on further strengthening virtual mentor-mentee collaboration and communication, specified mentoring for different sectors of STEM field, and collaboration with career centers and STEM professionals to provide more resources and practical experiences for both mentors and mentees.

INFLAMMATION IN PRIMARY HUMAN ASTROCYTES IS DEPENDENT ON TOLL-LIKE RECEPTOR 3 WHEN EXPOSED TO ASTROCYTE-DERIVED EXOSOMES ISOLATED FROM PATIENTS WITH COVID-19 AND TBI

Noah Fagello¹

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There have been 775 million confirmed cases of SARS-CoV-2 infections worldwide. With each SARS-CoV-2 infection the patient has a chance of developing an array of chronic symptoms referred to as Long-COVID. These symptoms including fatigue, brain fog, anxiety, and depression, could be the result of chronic inflammation of glial brain cells caused by Blood-Brain-Barrier disruption. Astrocytes are one of these glial cells involved in maintaining the Blood-Brain-Barrier. We hypothesize that the Astrocyte cells are packaging up and sending out pro-inflammatory "cargo" via exosomes that can then be taken up by other cells, inducing an inflammation phenotype. We believe that participants who have a combined history of COVID-19 and mTBI will produce more pro-inflammatory "cargo" and better be able to transmit an inflammatory phenotype. In order to determine through which receptor this neuroinflammatory phenotype is being transmitted, we selected 5 Toll-Like Receptors on Primary Human Astrocyte cells to treat with drug inhibitors. We found that inhibition of Toll-Like Receptor 3 blocked the transmission of an inflamed phenotype to the astrocyte cell. This finding will open the possibility of future studies into the use of current Toll-Like Receptor 3 inhibitory drugs for the prevention of glial cell inflammation.

IDENTIFICATION OF POTENTIAL THERAPEUTICS FOR PARKINSON'S DISEASE

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Our lab has successfully identified the aggregation-prone amino acid sequence that is important for the aggregation of α -Synuclein protein (α S), which is the process responsible for production of Parkinson's Disease (PD) phenotypes, with symptoms such as impaired motor functions. My goal is to further confirm the role of these sequences in aggregation and identify individual amino acid(s) within that sequence that are important for α S aggregation. This will be accomplished using design of α S variants with point mutations, created by substituting alanine for amino acids within the aggregation-prone sequence. Thioflavin T (ThT) fluorescence assays, transmission electron microscopy (TEM), cellular assays, and confocal microscopy will then be performed on the purified α S variants. This study will further develop understanding of the role of individual amino acid(s) in facilitating α S aggregation. In addition, this will advance identification of potential therapeutic targets for the treatment of PD. With this amino acid sequence identified, synthetic molecules can be synthesized to bind and potentially inhibit aggregation of α S.

COLLECTION AND ANALYSIS OF CHEMICAL REACTION PRODUCTS WHEN PROTEIN SAMPLES ARE EXPOSED TO DENVER URBAN AIR

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An increase in seasonal allergies has been observed over the years affecting human health. Environmental factors and atmospheric pollutants can induce chemical modifications of airborne allergens, increase oxidative stress in the human body, and skew the immune system toward allergic reactions [2]. Laboratory studies exposing certain allergenic proteins to simulated gas-phase air pollution have shown that the proteins undergo chemical modifications that make them even more allergenic. In continuation of work done by former student Dr. Rachel Davey, my project has been to collect and analyze protein samples exposed to ambient Denver air at two field-site locations. The goal of the study has been to further understand the types of processes that occur during the nitration of exposed tyrosine amino acid residues when exposed to ozone (O₃) and nitrogen dioxide (NO₂). Specifically, the work set out to extend the previous results by comparing the extent of both the nitration and oligomerization reactions to explore a hypothesis that Dr. Davey proposed. Two samples per field site were collected at the two sites over 9 months and analyzed in the lab. Through the experimental process, significant effort was needed to verify experimental steps, including the filter extraction efficiency and aspects of the analysis process. Furthermore, the project involved maintenance tasks, including the calibration of scientific instruments such as the ultraviolet spectroscopy and Gast pump. These activities were crucial to ensure the accuracy and reliability of the data collected throughout the experimental process. More recently, the first field samples were analyzed using high performance liquid chromatography. My work has been an important component of a multi-year experimental project that will help provide better understanding of the role that these reactions play on the surfaces of protein-containing airborne bioaerosols in inducing health effects in urban areas.

DESIGNING AN INTRODUCTORY COURSE ON COMPUTATIONAL SOCIOLOGY

Janelyn Geronimo¹

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This project explores the beginning stages of planning an introductory course in computational sociology for undergraduate students. Computational sociology is a field that combines computer science and sociology through the creation of computer simulations. These simulations are based on theories and frameworks from sociology and are modeled using coding languages such as Python. This course is geared towards students majoring in computer science or in sociology to encourage an interdisciplinary approach from each respective field to the other. This project looks at utilizing agent-based models for instructive purposes. Agent-based models are computer models that focus on how interactions between agents create larger patterns within the model. The agents are given simple rules and the resulting patterns that arise from the interactions between the agents is called emergent phenomena. The goal of this course is to show how the concept of emergence may tie the two fields together and encourage students to create their own models using Python.

PRESERVING PARADISE: INVESTIGATING BEACH LITERARY BEHAVIORS AND DEVELOPING SUSTAINABLE SOLUTIONS IN COASTAL NICARAGUA

Elsie Harrington¹, Shane Simmons¹

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Every year, billions of pounds of trash are littered on beaches all over the world, especially in developing countries. In Nicaragua, there has been little research conducted to understand the trash problem that coastal communities are afflicted by. Discovering why people litter regardless of waste bin accessibility and who may be the primary culprit is vital in creating sustainable solutions. This research was conducted through observation of beach behavior and cleanup efforts and informal community member interviews. Results suggest that due to poor access to proper education and waste management, recreational beachgoers abandon trash, and the local fishing economy traditionally does not prioritize beach health. This new understanding of the underlying causes of beach pollution in coastal Nicaragua allows sustainable solutions to be created and implemented with cultural sensitivity.

STEM NEAR-PEER MENTORING

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This year, our group engaged in near-peer mentoring with seniors at Westminster High School (WHS) regarding the transition to college and STEM specific fields. WHS has a program geared towards preparing students interested in STEM fields for the transition to those fields. Our near-peer mentoring (which involves mentoring between individuals close in age) group partnered with this program in order to conduct weekly Zoom meetings between one undergraduate or graduate student and 4-5 high school students. Some of the major goals of the partnership are to: 1) build upon evidence of near peer mentoring in improving STEM interest, readiness and success in STEM college majors for high school students, particularly those from historically underrepresented backgrounds; 2) provide DU STEM undergraduates a mentoring learning and leadership opportunity such that they could share their experiences in a low-stakes, constructive, curated environment; 3) provide the WHS biomedical sciences students a low stakes learning and engagement mentorship opportunity that integrates with their coursework and career development discussions; and 4) an opportunity for both the DU and WHS students to learn from each other. This year specifically, our group worked to increase participation and interaction between the mentor and mentees in the Zoom environment in order to maximize the success of the previously mentioned goals.

COMPARING THE US RESPONSE TO THE SOVIET INVASION OF AFGHANISTAN AND THE RUSSIAN INVASION OF UKRAINE: LEARNING FROM THE PAST AND PLANNING FOR THE FUTURE

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As the Russo-Ukrainian war continues to rage, the decisions of the present are of paramount importance. In order to make the most positive and well-supported decisions in this ongoing conflict, it would be wise to look to past instances of similar situations. The Soviet invasion of Afghanistan is such an instance. The parallels between the ongoing conflict in Ukraine and the past Soviet invasion of Afghanistan are extensive and, more importantly, informative for U.S. foreign policy. It is with this lens that this paper will pursue a historical foreign policy analysis of the Soviet invasion of Afghanistan, its circumstances and consequences, and suggest that based on these understandings, the U.S. ought to make it a top priority to avoid repeating the Afghanistan situation. The rise of the Taliban was fueled by U.S. involvement in Afghanistan, and as extremist movements in Ukraine become ever more threatening, the U.S. would do well to avoid the mistakes made in Afghanistan should it hope to avoid another war on terror.

RECORDING VETERAN'S HISTORY

Colin Kleckner¹

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For many years, I've worked with the University of Denver's Department of History recording and recovering oral histories from Colorado veterans of many eras. In particular, this project, Recording Veteran's History, focused on recording the history of the rapidly aging Vietnam veterans community, especially those individuals involved in veterans advocacy through groups like the United Veterans Coalition. My research focused on recording oral histories, focusing not only on service-based oral histories but also the recording of memory post-conflict. My results found a wide array of veterans experiences, but also highlighted the difficulties of working with an aging population, especially on a project which relied on memory. It is my hope that my part in this work will help continue the process of recording veteran's experiences, an endeavor which must be completed quickly as the target population ages.

ATMOSPHERIC PARTICULATE MATTER (PM) TRENDS OF THE FRONT RANGE OF COLORADO VIA PURPLEAIR SENSORS

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Atmospheric particulate matter (PM) contributes to a variety of individual health effects and public health challenges. PM data were collected and analyzed as a part of this thesis in an effort to contribute to broad efforts of collecting atmospheric measurements to help better understand their impacts on human health, social justice, and environmental causes. PurpleAir sensors were used in the data collection due to their accessibility and community engagement capabilities. Seven PurpleAir units were deployed at a suburban site in Denver for a four-month period (September 2023 – January 2024), during which sensor accuracy and confidence was assessed. Statistical analysis of the data provided a detailed technical intercomparison between sensor types and an overview of the multi-month PM trend in suburban Denver. A thesis project by another graduating student will explore the intercomparison period (ICP) in more detail. Following the ICP, a small network of six sensors was deployed in pairs at three sites at the Kennedy Mountain Campus (KMC) to begin initial data acquisition and analysis of the PM trends in order to lay preliminary work toward an atmospheric research station proposed for later development at the site. The deployment of the sensors and the acquisition and preliminary analysis of the PM data achieved the primary project goal of establishing real-time environmental research efforts at the KMC. These efforts and data will provide the beginning infrastructure and momentum used by students working with a future KMC research station. The research station is envisioned to be used not only by University of Denver students, but as a collaborative space among researchers within Colorado to investigate issues relating to PM and other atmospheric and environmental sciences.

A MIDSUMMER NIGHTS DREAM SPECIALTY PROPS

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A Midsummer Night's Dream is one of Shakespeare's most renowned plays steeped in a world of dreams and magic and will be the second show in DU Departments of Theatre's winter quarter season. After the Covid-19 pandemic, live theatre felt a heavy effect in loss of attendance. Even now, it is still very difficult to fill productions to full capacity. This show has the goal of bringing in college audiences that have not had the full experience of witnessing live theatre, and who may have previous, negative notions about Shakespearean plays. The goal was to transform our audience for the two hours they witnessed this play into people that can enter a world of magic, try something new, appreciate it, challenge their own thinking, and revitalize an art that took a heavy blow in recent years. In order to achieve this fantastical reality onstage, I worked closely with the costume designer (Janice Lacek) and director (Sabin Epstein) to research, design, prototype, and fabricate specialty props and costumes to create the multiple distinct worlds present in A Midsummer Night's Dream. One of the distinct worlds was created with a black and white newspaper theme to tie those characters together and create a handmade look but with an extremely durable structure that had the ability to last three and a half weeks of dress rehearsals and performances. By the end of the project, I designed, prototyped, and fabricated 5 large scale specialty props sporting at least 50 separate pieces each using advanced painting and texturing methods, LEDs lights and wiring techniques, foam molding, paper mache, and wig making techniques. We were successful in creating a fantastical world for about 700 people and allowed them to experience the magic of live theatre as we move out of the Covid-19 era."

MEASURES OF EFFECTIVENESS ON THE PARENT PROJECT CLASS

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Parenting is an inherently challenging journey, more so when faced with children exhibiting destructive behaviors like truancy, substance abuse, and violence. The absence of a definitive guide leaves parents feeling overwhelmed and unequipped to manage such extreme situations. The Parent Project, developed by a dedicated team, aims to empower parents of difficult adolescents through a structured curriculum. This study evaluates the effectiveness of the Parent Project Course, focusing on the enhancement of parenting skills and confidence. In collaboration with the non-profit organization One More Moment, a longitudinal study was conducted involving 25 parents enrolled in the Parent Project Course. Utilizing Qualtrics, weekly surveys assessed various aspects of the course's impact, including session usefulness, strategy application, parental self-efficacy, support group attendance, and therapy engagement. Preliminary findings indicate a significant uptake of positive parenting strategies, notably the daily affirmation of love, which saw an increase from 42% to 75% usage over nine weeks. All participants reported finding the course beneficial, with 62% feeling substantially more effective as parents, and 38% noting a slight improvement. The consistent positive feedback and strategy adoption underscore the course's potential in transforming parenting practices. The data collected offers valuable insights for refining the curriculum, ensuring that future iterations of the Parent Project Course are even more impactful.

CLINICAL IMPLICATIONS OF GENDER DIFFERENCES IN ADHD SYMPTOMATOLOGY

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Attention Deficit Hyperactivity Disorder (ADHD) is one of the most prevalent neuropsychiatric disorders, characterized by hyperactivity, inattention, and/or impulsivity. However, much of the knowledge of the disorder is based off of research on a homogenous Caucasian male sample, and a growing body of research reveals disparities between genders in regards to ADHD symptomatology, diagnosis, and treatment. Thus, there is a need for a focus on analyzing gender differences in ADHD symptomatology, and the present paper aims to highlight the known research. Gathering data from 12 studies on ADHD and gender differences, the present meta-analysis aims to answer: What are the known gender differences in ADHD symptomatology, and how can the processes of diagnosis and treatment be improved by understanding these gender differences? The studies revealed that there are numerous known gender differences in ADHD symptomatology: females with ADHD had more internalizing symptoms, were more likely to have comorbid diagnoses of anxiety and depression, had more social and emotional impairment rather than behavioral, and were heavily influenced by hormonal factors. Understanding such gender differences urges parents, teachers, and clinicians to be more educated on recognizing ADHD symptoms in both males and females. Education of different presentations can address numerous of the flaws in the diagnostic process. Diagnosing clinicians should more carefully look at females' social relationships and self-report and can encourage treatment plans to focus more on their internalizing symptoms and their hormonal cycles. Clinicians and the general public must expand ideas of not only ADHD but other mental health conditions beyond a single presentation.

LAB EXPERIMENTS TO OPTIMIZE A NEWLY DEVELOPED ULTRAFINE PARTICLE COUNTER

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Ultrafine particles ($< 0.1 \mu\text{m}$ in size) are much smaller than the EPA-regulated PM_{2.5} ($< 2.5 \mu\text{m}$) and pose even stronger health risks because they are small enough to penetrate deep into the lungs. Ultrafine particles are challenging to measure. Currently available condensation particle counters (CPCs) capable of detecting them are expensive ($> \$25,000$), which limits the extent of further research. Collaborators at the University of Arizona developed a new style of ultrafine particle counter which utilizes inexpensive components. The Arizona ultrafine particle counter (AUPC) uses an expansion-based approach for forced condensation of water vapor onto condensation nuclei, which scatter light from a green diode laser as they fall and are recorded by the instrument's camera. The thesis project involved laboratory experiments comparing number concentrations measured by both a commercial CPC and the AUPC. Experiments focused on changing particle size and particle composition. Particle size experiments compared counting efficiency of each instrument by aerosolizing sizing standard polystyrene latex beads to verify the AUPC counting capability over a range of particle diameters. The AUPC matched the relative trend of the commercial CPC, but with a lower counting efficiency over particle sizes 25 - 345 nm. The composition-based experiments included aerosolizing a solution with particles of differing chemical properties. Particles composed of either pure ammonium sulfate (more polar and hygroscopic) or oleic acid (less polar, more hydrophobic) were chosen to represent materials with opposite water adsorbing properties. Results again showed the AUPC can reproduce the behavior of the CPC, but at lower count efficiency. The AUPC may represent a useful approach toward providing information about ultrafine particles in a variety of indoor and outdoor environments at dramatically lower cost (est. $< \$2,000$), but the instrument will require further improvements to more closely compete with commercial CPCs.

SAME PLAY, DIFFERENT WAY: RECURRENT LOSS OF SEXUAL SIGNALS IN A FIELD CRICKET

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Evolution has often shown an ability to solve the same problem in seemingly endless creative ways. Here we present an unusually rapid example of this phenomenon, documenting the recurrent loss of sexual signals in populations of Hawaiian crickets (*Teleogryllus oceanicus*) in real time. Males of this species produce a conspicuous song using specialized wing structures to attract potential mates. However, in Hawaii, this song also attracts a deadly parasitoid fly (*Ormia ochracea*). In response to this strong natural selection pressure, a new type of male, known as “flatwing,” arose ~20 years ago. These males adaptively lost many sound-producing structures on their wings, leaving them unable to produce songs but ensuring their protection from the eavesdropping parasitoid. More recently, during field sampling, we found males in two different populations that were also unable to produce song, but unlike flatwings, they surprisingly appeared to have intact wing structures. To understand why these males were unable to sing, we investigated their wing morphology using microscopy, hypothesizing that their loss of song was due to a loss of microstructures that contribute to sound production. We found that in both populations, these males indeed had a highly altered and reduced important microscopic wing structure called the “file.” To determine whether this mechanism differed from that of the silent flatwings that arose two decades ago, we next compared the wings of these new males to old flatwing specimens and found broad morphological differences between the two, confirming that this new male type lost their ability to sing in a novel way. Our findings highlight evolution’s remarkable ability to reach similar outcomes through unique pathways when faced with a common ecological challenge.”

SHAMING WOMEN TO SHAME MEN: A CASE STUDY OF THE HOUTHIS AND THE RELATIONSHIP BETWEEN HONOR CULTURE IN YEMEN AND THE USE OF SEXUAL VIOLENCE IN THE YEMENI CIVIL WAR

Emma Loeber¹

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The factors that influence an armed group’s use of sexual violence against women during times of conflict is a much studied area due to the prevalence of the phenomenon, and the significant implications it has for human rights. Studies on the subject have generally contended that cultural attributes and practices present during peacetime play a significant role in determining whether or not an armed group will incorporate sexual violence as a part of their strategy. A relatively under researched cultural practice that could influence the use of conflict related sexual violence (CRSV) is the presence of and importance of honor culture in a society experiencing conflict. This article seeks to expand on the understanding of its influence by analyzing the relationship between honor culture in a society and how its characteristics influence the groups operating within it to use sexual violence against women as part of their strategy. It uses examples of female victims of CRSV carried out by the Houthis in Yemen. It concludes that the honor culture of the society the group operates within influenced them to use more CRSV. This understanding has significant implications for policymakers and academics in predicting the severity of sexual violence that might occur in a given conflict happening in an honor based culture.

DETERMINING THE DIFFERENCE BETWEEN HISTORY OF DEPRESSION ON FAMILY HEALTH HISTORY FORM AND SCID USING SOCIOECONOMIC STANDARD MEASURES

Alina Mali¹

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This project was completed as a part of earning my Micro-credential in Psychology in Data-Informed Decisions. With this project, I wanted to learn how to analyze data using RStudio to contribute research to Dr. Pilyoung Kim's study on prenatal pathways for poverty's influence on the brains of two generations that explores the relationships of parent-infant social, emotional, and brain development. Using data from this study, I formulated the research question: What is the difference between the self-reported history of depression on the family health history (FHH) form and history of depression assessed via the Structured Clinical Interview for DSM (SCID) and can the discrepancies be predicted by socioeconomic standard measures? I found discrepancies in the FHH form and SCID and used the income to needs ratio (INR) data to determine if the existence of a discrepancy was due to this variable. I also determined whether the type of discrepancy (on the SCID and not on FHH form or on the FHH form and not the SCID) was correlated with INR data. I used INR because the differences in reports could be related to disparities in health care access and mental health education, which can likely be shown through INR data. I ran t-tests to determine if there was a correlation between the variables and created violin plots to display the data. The p-values were 0.2334 and 0.8516, respectively, so there does not appear to be a correlation between discrepancy in the two forms and INR. Based on the fact that I did not find any correlation between discrepancy and INR, it is clear that this problem is much more complex than income. I would like to look at other variables that may have an influence on SES such as education level, race/ethnicity, and living conditions.

UNDERDIAGNOSED & OVER-PUNISHED

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The school-to-prison targets vulnerable populations and exacerbates preexisting racial and ethnic disparities in the justice system. Harsh disciplinary practices at school coupled with inequitable and discriminatory treatment of minority students, and an underdiagnosis and lack of treatment of disabilities such as ADHD, place children of color and children with disabilities at an academic disadvantage and increase their chances of contact with the criminal justice system. The current priority of punishment rather than education in the United States is problematic. By addressing and bringing awareness to the school-to-prison pipeline, conversations can be opened about the importance of equity and inclusion in the classroom, and the harm that is created by the current use of harsh school practices. In addition to this, educating individuals about the ways in which the school-to-prison pipeline can be brought to a halt and why change needs to happen is important. With this purpose, a ten-week project was created. It consisted of hours spent on researching and using thematic coding and analysis to breakdown the school-to-prison pipeline and how it affects vulnerable students. The result was two products; an infographic poster which exposes research on the school-to-prison pipeline, and an informational sheet which provides some steps that can be taken to put an end to the school-to-prison pipeline. Students with disabilities account for a quarter of all children arrested in schools despite making up only twelve percent of school populations in the U.S. In particular ADHD is present in forty-six percent of juvenile offenders. At risk children are slipping between the cracks without adequate support. Therefore, creating a shift from punishment into reformation and education can protect and provide support to our most vulnerable children. It starts with improving student-to-teacher relationships and student-to-school bond building.

USING BIO INDICATOR SPECIES TO VISUALIZE GROUND-LEVEL OZONE POLLUTION IN DENVER

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Bioindicator plants are species that are more sensitive to ground level (tropospheric) ozone, and show identifiable damage when exposed to high ozone concentrations. It is important to monitor ground level ozone, as it is extremely toxic to plants and decreases the amount of carbon storage and the amount of carbon dioxide (CO₂) that can be pulled from the air, decreases crop production, and weakens the plants- making them more susceptible to other issues. Bioindicator plants are so valuable because they provide visible measurements of ozone concentrations, showing the first hand effects of pollutants on the air chemistry and in turn the effects on plants. Ground level ozone is created through the reaction of sunlight, nitrogen oxides and volatile organic compounds produced from the fuel combustion of driving cars. To understand the damage ozone is having on plants in Denver, I used two varieties of beans: a common variety that is sensitive to ozone, and a modified variety that is tolerant to ozone damage. The tolerant bean variety acted as a control group to compare the damage of the sensitive group to. These plants were cared for and their leaves were monitored for ozone damage every other day from July to October. This project shows evidence that ozone pollution is both increasing damage to the plants' leaves and decreasing the crop production of the sensitive (common) bean varieties as compared to the tolerant varieties. It also shows that high temperature and ozone concentrations are correlated with more damage to the sensitive varieties. This data was added to a nationwide database of ozone gardens, to answer the questions of what concentration causes damage, how severe the damage can become, and how damage differs across location.

POLICY AND PUBLIC OPINION: THE RELATIONSHIP BETWEEN THE PHILOSOPHY OF BUEN VIVIR AND ENVIRONMENTAL PERSPECTIVES IN ECUADOR

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Through the question, how has environmental awareness changed in Ecuador and Peru following the inclusion of the philosophy of Buen Vivir in Ecuador's 2008 Constitution? I explore whether the philosophy of Buen Vivir was simply a political campaign strategy executed by Ecuadorian president at the time, Rafael Correa, or if it exacted tangible change among the Ecuadorian public. Peru is included as a control variable, as it displays similar foundations of Buen Vivir, though did not grow to national recognition as it did in Ecuador. The concept originated among Quechua communities in South America, contrasting from the mainstream model of economic development, instead focusing on human and environmental well-being. As the threat of climate change grows, Buen Vivir offers a potential solution. I first analyzed Ecuador's 2008 Constitution and Peru's 1993 Constitution for articles related to Buen Vivir. Then, utilizing the Latin American public opinion survey Latinobarómetro, I analyzed survey responses regarding environmental awareness in the two countries. I considered responses between the years of 2002 and 2016. I analyzed the questions "In your opinion, what is the most important problem in the country?" "How much have you heard about global warming or climate change?" "To what extent do the following freedoms, rights, life-chances and guarantees apply in [country]?" and "What it takes to be a good citizen." Each contained responses related to the environment. I predicted that there would be an increase in environmental awareness in Ecuador, but not in Peru following 2008, due to the mainstream nature of Buen Vivir in Ecuador as opposed to Peru. My results revealed increases in both countries, which ultimately did not align with my hypothesis. There are a variety of explanations as to why this may have been the case, including that perhaps Buen Vivir was not as successful as anticipated.

DEVELOPMENTAL AND ADHD SYMPTOM-RELATED CHANGES IN MOTIVATED COGNITIVE CONTROL

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ADHD, Attention-Deficit-Hyperactivity disorder is a frequently diagnosed childhood disorder. Variations in cognitive control may be a vital factor in ADHD. The present, ongoing study's goal is to understand how reward modulation modulates the temporal dynamics of cognitive control in children (ages 8-16) with and without ADHD with an AX continuous performance task (AX-CPT). This task is a reward incentivized cognitive control task. In addition to AX-CPT, high-resolution pupillometry is used as another measure of cognitive effort. Upon preliminary analysis of results, there are potential differences in cognitive and motivational processes in children with ADHD compared to those without it.

EXTREMOPHILES MAY HELP MITIGATE TDP43 AGGREGATION IN ALS

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Amyotrophic Lateral Sclerosis (ALS) is a rare but devastating neurodegenerative disease. While there are no known cures for the disease, one of the most reliable causes of the disease is the aggregation of a protein called TDP43 in the brain. Although the reason for this aggregation is still under investigation, treatments which aim to inhibit the aggregation of these proteins seem promising in slowing down the disease's progression. Seeing as the brain undergoes extreme stress during ALS, I was interested in seeing if Ectoine, an extremophile stress solute which helps reduce cellular stress for organisms living in extreme environments, could provide similar protective properties for cells under stress from ALS. By exposing human embryonic kidney (HEK) cells overexpressing TDP43 to various levels of ectoine, I was able to determine that it does have neuroprotective qualities as it successfully reduced the amount of TDP43 protein aggregation. The protective nature of extremolytes provides an interesting avenue for future neurodegenerative research, suggesting the possibility of further uses and investigation into the supportive properties these unique organisms can provide.

CREATING AN ADAPTIVE AND INTUITIVE SINGLE-OPERATOR MULTI-MAV INTERFACE USING AUGMENTED REALITY

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The goal of this research is to achieve safe and effective singular operator supervision and control of multi-micro aerial vehicle (MAV) swarms with an intuitive and easy-to-use Augmented Reality interface. Singular-operator swarm control is applicable to multiple industries and scenarios [2]. MAVs currently navigate pre-defined paths and accomplish given tasks [1]. However, there is a loss of efficiency, as a single operator must have programming knowledge & manage multiple systems. Achieving singular operator control software would allow for users to spatially task the swarm within various environments, preventing conflicts due to errors in other operators/software. The design of the augmented reality interface was done using 3D interactable objects that are mapped to the positions of the MAVs in the 3D-space. Path-planning and execution is done within an AR headset by moving 3D objects to draw the desired path each drone should follow. This is accompanied by a user interface (UI) orbiting the user with options to delete paths, upload the paths to the swarm, emergency shutoff and to execute/stop. This project will be accomplished by integrating existing software and hardware, such as the Robot Operating System (ROS), Crazyswarm [1], Optitrack motion-capture, HoloLens 2[5] as well as the crazyflie's Micro-Aerial-Vehicle (MAV) [6] and creating new software with the above capabilities. Control of the swarm through this augmented reality interface has been achieved through the above method using HoloLens 2 and the execution of software on a ROS-receiving PC. Further improvements in terms of safety features such as environmental obstacle avoidance, better safety features, accessibility, and integrating more of Crazyswarm's controls, are in progress. My findings show that AR as a means of controlling MAV swarms is viable in an intuitive manner that is easy to utilize for novice users. Additionally, this project allows for further studies into human-robot interaction with MAV swarms & augmented reality.

QUESTIONING THE EFFECTIVENESS OF THE OLYMPIC TRUCE

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A modern model for peace is the "Olympic Truce," a United Nations General Assembly resolution that calls for the pausing and prevention of new conflicts from one week before the Olympic Games through one week after the Paralympic Games. Olympic Truce scholars have focused on identifying cases that demonstrate effective implementation of the Olympic Truce and have come up with mixed results. Some argue that the symbolic nature of the Truce allows it to create moments of peace in conflicts, while others argue that it is nothing more than a gesture of goodwill that has not actually been used for peace. This study will aim to bridge the gap by determining if there are any cases of conflict in which the Olympic Truce has made a difference for peace. My research question is: Has the Olympic Truce ever been successfully implemented to prevent the onset of new conflict or in creating a ceasefire during an ongoing conflict? I use conflict data and case studies to determine the prevalence of conflict during Olympic Truce periods and four case studies to analyze attempts to use the Olympic Truce and some of the challenges faced. It is found that across the four cases (Yugoslav Wars, India-Pakistan, Cyprus, and Russia) the Olympic Truce has not been effectively used to prevent or end the conflict because of the overwhelming motivations of religion, ethnicity, and territory present in wars, and the non-binding nature of the Olympic Truce as a UN General Assembly recommendation.

EVALUATING MICROGLIA & ASTROCYTE ‘CROSS-TALK’ IN SUSTAINED NEUROINFLAMMATION SECONDARY TO COVID-19 & TBI

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The long-term neurological impacts of COVID-19 reflect an emerging field of research, and the need to appreciate their physiology as it relates to biochemical and molecular pathways proves understudied. Independent of one another, traumatic brain injury (TBI) and COVID-19 can lead to increased risk for neurodegenerative diseases, yet this phenomenon and their combined impacts remain largely unknown. This novel research study investigates the combined impacts of COVID-19 infection and TBI on sustained neuroinflammation, a possible mechanism for underlying and prolonged neurological symptoms. In particular, this research evaluates the extent of microglia and astrocyte “cross-talk,” given their known individual roles in neuroinflammatory processes, and their communication facilitated by exosomes. It was hypothesized that patients with a history of both COVID-19 and TBI may exhibit sustained neuroinflammation due to the combined interaction of these conditions, which reflects the combined response of microglial and astrocytic activation secondary to the neuroinflammatory responses initiated by injury and viral illness - like those of COVID-19 and TBI - transmitted through the contents of exosomes that induce a neuroinflammatory or CNS immune response. To evaluate this, BV2 microglial cells were treated with human patient astrocyte-derived exosomes to appreciate the “cross-talk” between the microglia and astrocytes that may be facilitated by exosomes. Understanding the interplay between COVID-19 and TBI in sustaining neuroinflammation proves crucial for developing targeted therapeutic interventions. By bridging the gap between symptomatology and pathology, this research lays the foundation for potential therapeutic strategies to alleviate neurological symptoms in patients with histories of COVID-19 and TBI, addressing an emerging and pressing need in post-COVID-19 pandemic global health.

TECHNOLOGY AND HOMELESSNESS: HOW ACCESSIBILITY AND BLOCKCHAIN TECHNOLOGY COULD IMPACT THE UNHOUSED

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Although technology could be used to combat inequality, it is instead increasing it. This paper discusses how the unhoused population suffers at the hand of technological inequality despite being relatively offline. It presents theories on how this would change if we reapproached how technology is used to assist the unhoused. It suggests implementing blockchain as a resource as well as modifying the websites built for the unhoused. Employees at shelters are interviewed for this paper about their experiences with using digital resources to rehouse and restabilize the vulnerable. They are asked how the sites can be improved for more optimized use. The sites are also tested against current UX standards for accessibility. Currently, they are extremely outdated and difficult to navigate. It also suggests that blockchain would assist the unhoused population in their ability to get the government assistance that they are entitled to in the U.S. Blockchain is, put simply, a network of distributed and encrypted pieces of data, which is already frequently used by the government to store sensitive data. It has been suggested in prior research papers about the unhoused population that blockchain could be used to store identification data, such as a copy of a birth certificate, drivers license, or other vital documents, which can be easily lost when one is living transiently. This impacts someone’s ability to get food stamps, get a job, remain a legal citizen, and receive healthcare, among other things. Blockchain could assist this population, but there are barriers that might make that difficult to implement, specifically when it comes to potential concerns from participants about personal security.

ASSESSING CHATGPT'S EFFICACY IN INTERPRETING PRIVACY POLICIES

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In the contemporary digital landscape, the intricacy of privacy policies poses a considerable challenge, often leaving users confused and at risk of compromising their privacy. This study explores the capabilities of generative AI, with a particular focus on ChatGPT-4, to aid users in deciphering, summarizing, and interpreting an array of 102 privacy policies. Utilizing the Flesch-Caid readability score as a benchmark, our findings reveal that ChatGPT enhanced the readability of 56 out of the 102 policies evaluated. However, in certain instances, the interpretations by ChatGPT resulted in reduced readability (such as–), highlighting potential limitations of the current state of AI in processing complex legal text. Despite this, the application of ChatGPT's capabilities is seen as a pivotal step towards distilling complex legal verbiage into explanations that are accessible with lesser complex jargon, thereby enabling users to make well-informed decisions.

LA VIRGEN REINVENTED: POLITICAL ACTIVISM, IDENTITY, AND TRANSNATIONAL USES OF AN ICON

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La Virgen de Guadalupe is a complex figure in religion and history. She is considered to be the Mexican iteration of the Virgin Mary, known by many names in both Spanish and English. Her image is one that is well-known, particularly in Catholic Mexican communities as well as Mexican-American and Chicano[a] communities. Since Her initial appearance in 1531, Her image has undergone changes, largely throughout the 1960s to the present day. She has become significant and changed in significant ways for Mexican, Mexican-American, Chicano[a], and Catholic communities within religious contexts and outside of religious contexts too. This sparked a great deal of interest in how exactly the image of La Virgen changed over time and across the Mexico-United States border as well. In order to gain a sharpened understanding of the differences in images, interpretations and uses of La Virgen de Guadalupe in Mexico, it was crucial to go and observe the many presentations of Her image in Mexico, specifically Mexico City. Her original image is present in La Basílica de Nuestra Señora de Guadalupe along with other traditionally Catholic renditions. Museums display Her image of course but She can also be found on t-shirts, jewelry, murals, and other less traditional forms of art. These observations while in Mexico City provided unique insights regarding how people in Mexico interact with her image in a social, cultural, political, and religious way in daily life rather than as some sort of unique phenomenon. The information gained from this exploration of La Virgen de Guadalupe's image in Mexico City, Her place of origin, resulted in an enriched understanding and enhanced perspective of how La Virgen plays a role in Mexican, Mexican-American or Chicano[a] and Catholic communities and how Her role has changed drastically over the past sixty years.

INVESTIGATING THE INVITRO PRO-INFLAMMATORY EFFECTS OF ASTROCYTE-DERIVED EXOSOMES FROM PATIENTS WITH A HISTORY OF COVID-19 AND MILD TRAUMATIC BRAIN INJURY

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Traumatic Brain Injuries (TBIs) and COVID-19 infections are both linked to heightened inflammatory responses within the central nervous system, which leads to cell death, increased release of pro-inflammatory cytokines, deregulation of the blood-brain barrier (BBB), and other harmful effects. The compounded impacts of inflammation phenotypes from COVID-19 and mild TBIs have not been previously researched. Covid and TBI have both been found to lead to similar immune responses that increase inflammation in the brain by inflammatory pathways potentially mediated through exosomes. This study will evaluate if a history of TBI and COVID-19 infection in a patient's isolated exosomes from astrocytes induces higher inflammation responses in cultured-rat-astrocytes, compared to a patient with either TBI history only, COVID-19 infection only, or a healthy control. Significantly increased cellular area and fluorescence from COVID-19 and m TBI group demonstrate heightened inflammation phenotype compared to any other group. Currently, data is still being quantified, however, the qualitative analyses support these claims. Implications of this novel research establish a mechanism for neuroinflammation increase which can be used for pharmaceuticals and therapies targeting inflammation reduction.

THE EFFECTS OF ARTIFICIAL LIGHT AT NIGHT ON NOCTURNAL INSECT IMMUNITY

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Exposure to artificial light at night (ALAN) has negative impacts on endogenous circadian rhythms in animals, which has known negative endocrinological effects on immune functioning. While this is well studied in vertebrates, there is less research on immunological impacts for invertebrates. To address this research gap, we assessed the impact of ALAN over the course of a biologically relevant timescale in the Pacific field cricket, *Teleogryllus oceanicus*, a model invertebrate species. We reared crickets under a 12 hr daylight (2600 lx) 12 hr dark (0 lx) or relevant ALAN (50 lx & 100 lx) cycle for their entire adult life (28 +/- 3 days) then took hemolymph samples and performed an encapsulation assay, which are two established measures of insect immune function. We found that crickets reared under the 50 lx treatment had an upregulated encapsulation response compared to the control and 100 lx crickets and that male crickets reared under the 100 lx ALAN had the highest mortality rate. Our data suggests that contrary to previous studies, the emergent process of mounting an encapsulation response may be more susceptible to the effects of ALAN than circulating immune cell number. Additionally, it appears that there are sex based differences in mortality effects of intense levels of ALAN which could have significant impact on population demographics.

JAYCE RUMSEY'S SENIOR CAPSTONE: THE DOOR BY PAUL ELLIOTT

Jayce Rumsey¹

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Jayce Rumsey, a third-year senior, participated in the University of Denver's theatre department's senior capstone cycle this year, where he directed the play, "The Door." The play is a compelling story that revolves around a grandmother in her late 50s who isolates herself after her grandson's brutal murder due to suspected homosexuality. Her teenage grandson, Justin, attempts to help her re-engage with the world. Through their interactions, the play emphasizes the importance of family support during difficult times and sheds light on the issue of violence against LGBTQ+ individuals. It aims to raise awareness and advocate for societal change to create a more inclusive and accepting community. Why this show? Jayce is a member of the LGBTQ+ community and he believes it is important to bring queer voices to the theatre on and off stage. Another reason he picked this show for his capstone is because at the end of the show there is a slideshow of hate crime victims. It brings attention to the fact that hate crimes against the LGBTQ+ community are still a present-day issue. This grant allowed him to put on a wonderful production of "The Door."

ANALYSIS OF THE EFFECTS OF ALCOHOL ABLATION ON THE MECHANICAL PROPERTIES OF HEART TISSUE

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Heart diseases are the leading cause of death and many techniques have been developed to treat them. One such disease affecting the heart's mitral valve, severe mitral regurgitation, affects over five million adults in the US and can be fatal. To combat diseases like this, transcatheter mitral valve replacement (TMVR) emerged as a less invasive alternative to surgical mitral valve repair or replacement. However, TMVR can cause life-threatening complications such as the obstruction of blood flow in the aorta, the main artery in the human body that is responsible for carrying oxygen-rich blood from the heart to the rest of the body. To reduce risk and prevent this obstruction from occurring, alcohol septal ablation (ASA) is often performed on TMVR patients, though the effects of ASA on the performance of the heart have not been studied. Therefore, the goal of this project was to analyze the effects of ASA on the mechanical properties of the septal region of the heart. To achieve this, square samples of tissue from the septal region of swine hearts were stretched to 20% displacement on a biaxial stretcher before and after experiencing either a three- or five-minute period of ASA. Data indicated that the mean force required to achieve this displacement in the tissue increased significantly after ASA, with the percent differences in the mean forces required in pre- and post-ASA being 62.45% and 87.12% in the main fiber direction and 49.47% and 75.42% in the cross-fiber direction for three-minute ASA and five-minute ASA, respectively. This suggests that tissue stiffens following ASA, with the amount of stiffness increasing with increasing periods of ASA. The degree of stiffness found indicates that regions of the heart affected by ASA will not contract normally, which can lead to patients experiencing a reduced cardiac output following the ASA procedure.

THE EFFECT OF FIRE SEVERITY ON BEE NESTING HABITATS

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Increased fire severity in western United States forests due to climate change and accumulation of fuels can have lasting impacts on vegetation structure that especially impact pollinators. Fire severity has been found to strongly influence bee abundance, with increasing fire severity often correlated with increasing bee abundance. One mechanism for this relationship is altered nesting habitat due to the effects of fire on forest vegetation. The availability of nesting resources varies with burn severity as well as time post-burn. Previous research has mainly been conducted within 5 years post-burn, but here we examine sites more than 20 years post-burn to test if burn severity affects bee nesting resources longer term. We quantified the habitat available to ground-nesting bees at 18 sites located in 2 different burn areas (Buffalo Creek and High Meadow). Within each of these 2 fires, we studied 3 burn severities (low burn, high burn, and unburned) with 3 replicate sites for a total of 18 sites. We recorded groundcover using Fire Effects Monitoring and Inventory System groundcover codes. We also recorded the diameter at breast height of snags (standing dead trees) in every site and percent canopy cover surrounding focal trees. We found fire severity significantly affected percent canopy cover and the frequency of groundcover types. Fire severity did not significantly affect mean snag basal area (a measurement of forest density), but higher severity fire sites did have a higher snag basal area. Our research aids in understanding the long-term effects of fire on native bees and ecosystem function.

INVESTIGATING THE ROLE OF EBF3A IN CRANIOFACIAL DEVELOPMENT

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Proper craniofacial development requires many genes. Single-cell RNA sequencing (scRNA-seq) allows us to identify genes expressed in precursor cells for craniofacial structures, but the function of many of these genes in craniofacial development has yet to be characterized. In our scRNA-seq of cranial neural crest cells (NCCs), which are precursor cells for the craniofacial skeleton, we found a gene called early B-cell factor 3 (*ebf3a*) that may be involved in craniofacial development. In our scRNA-seq data, *ebf3a* expression is restricted to cranial NCCs of the dorsal and ventral domains of pharyngeal arches 1 and 2. In humans, damaging variants in EBF3 are associated with facial dysmorphism. Based on these observations, we hypothesize that *ebf3a* is an important gene in craniofacial development. In this study, we begin to test this hypothesis by characterizing the expression pattern of *ebf3a* in cranial NCCs in zebrafish. Through fluorescence in situ hybridization, we confirmed that *ebf3a* is expressed in the cranial NCCs of the dorsal and ventral patterning domains of pharyngeal arches 1 and 2. This result will be a starting point for future experiments that will investigate the function of *ebf3a* in craniofacial development.

DEVELOPMENT OF NON-ENZYMATIC GLUCOSE SENSORS USING COPPER ELECTRODES & NANOPARTICLES

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Glucose sensing plays a vital role in various fields, including medical diagnostics, biotechnology, and diabetes management. Traditionally glucose sensing is done using enzymatic sensors, which are susceptible to a variety of changes that can manipulate the effectiveness or reliability of the sensors. Therefore, the increase of demand for developing non-enzymatic sensors that meet or exceed its counterpart. Copper has shown itself to be a suitable and promising material to develop these non-enzymatic sensors. Copper contains this catalytic property when it come into contact with glucose creating an oxidation reduction reaction. Adding in copper nanoparticles can further help improve the sensitivity of the sensors by promoting more of the electrochemical reaction. The overall objective of this study is to explore and hopefully develop a suitable way of creating these non-enzymatic sensors using Copper nanoparticles and substrate. Investigating the electrochemical performance and comparing the results with other forms of glucose detection. In addition, this study aims to use Copper availability, and “multiple manufacturing techniques” to create a cost-effective sensor that can enhance its feasibility of large-scale production. The study is currently in its first round of iterations for these sensors, testing different variations and individual components to determine the optimal setup that yields the best results in terms of detection limits, sensitivity, and sensor durability.

PATTERNS IN MOTIVATING FACTORS IN PRENUP NEGOTIATIONS: A QUALITATIVE CASE STUDY

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Prenuptial agreements (prenups) are similar to traditional long-term financial contracts between two entities. However, there are some key differences between prenups and other kinds of contracts, particularly in the social and relational factors that can influence people’s decision-making in the negotiation process. So, in this project, I interviewed seven lawyers in the Denver area with significant experience negotiating prenuptial agreements about how social factors influence the prenup negotiation process. Through thematic analysis of transcripts of these semi-structured interviews, several themes emerged from the data ranging from “power imbalances” and “familial pressure” to “lawyer intervention” and “the law itself.” This study found that factors like familial pressure and significant wealth gaps can alter negotiation dynamics and occasionally create power imbalances, but the representation lawyers provide helps counteract those imbalances. This project and further research examining these themes can help inform policy and jurisprudence surrounding the formation/enforcement of prenuptial agreements.

NITRIC OXIDE SYNTHASE PATHWAYS AFTER MTBIS

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The inflammatory response in concussions is not completely understood. Secondary concussions can occur as part of the inflammatory response which needs to be further researched. Different molecular pathways can be affected after a concussion. The purpose of this study is to be able to identify concussion associated blood biomarkers, specifically the role of endothelial nitric oxide synthase (eNOS) in concussions, as well as be able to identify the main polyamines involved with the inflammatory response in concussions. We hypothesized that eNOS will increase at 3 days post-concussion then decrease over time. The first step of this project was the collection of blood samples from athletes. There were three samples taken from each athlete: a baseline blood draw, 72 hours after the concussion, 1 week, 1 month and finally 6 months post-concussion. The data processing used plasma from the athlete's blood. Samples were processed using a previously reported protocol 6. In brief, the sample is filtered, and large molecules (proteins) eliminated. Next, these samples were prepared using a Nitric Oxide Synthase Eliza Kit and then put on a plate reader. The results showed that eNOS did increase at the 72-hour mark. At the 1 week and 1 month mark, the eNOS levels had slightly decreased but stayed elevated relative to baseline. At 6 months there was a decrease in eNOS below baseline levels. The impact of this project will help explain how cerebral blood flow is a part of secondary concussions and the role of eNOS in blood flow and concussions.

THE ROLE OF AUTONOMIC AROUSAL IN ANXIETY'S EFFECT ON COGNITIVE CONTROL

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Anxiety can impact a host of cognitive functions from learning to attention (Roy, 2013; Bar-Haim et al., 2007). Cognitive control is an important collection of cognitive functions central to goal pursuit, and can vary with psychopathology (Mueller, 2001; Hallion et al., 2017). The impact of anxiety on cognitive function may be particularly pronounced under threatening contexts (Chand & Marwaha, 2023). However, cognitive control performance in threatening contexts, and how it might vary with anxiety, has been sparsely studied. To examine this relationship, performance on the AX Continuous Performance Task (a well-known cognitive control measure) was examined under threat of performance-contingent punishment relative to a no-threat condition, and related to trait anxiety, measured with the State-Trait Anxiety Inventory (Spielberger et al., 1983). We hypothesized that high-anxiety individuals would engage in lower and/or more reactive cognitive control relative to low-anxiety individuals, especially under the possibility of punishment.

MULTIVOCALITY OF THE CALIFORNIA GOLD RUSH: THE INTER-OCEANIC ROUTE VIA NICARAGUA

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The California Gold Rush played a central role in shaping American history. However, descriptions of this event often overlook its reach within international territory. Exposing this interconnectedness addresses the lack of diversity in historical archives. Through cartography and first hand accounts, this project unpacks the various narratives and discourses of the journey from the U.S. Eastern Seaboard to the West Coast via the Nicaragua interoceanic route during the mid 19th century. By illustrating how this pivotal time drew thousands of Americans in their quest to explore California's gold fields, this project shows how and why many opted to embark on the passage via Nicaragua. While representations of historical events cannot always capture every experience, highlighting the various voices often absent in past accounts provides a fuller and more nuanced picture of this journey.

SAINT BRIGIT AND HER HABITS: EXPLORING QUEERNESS IN EARLY MEDIEVAL IRELAND

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Saint Brigit's behavior in Cogitosus's *Life of Saint Brigit* and her reception by society highlight an avenue by which women in the early medieval period could escape societal strictures, exercising agency over their bodies and their romantic choices, and carve out a distinct and unexpected place for themselves in a Christian patriarchal society. Saint Brigit's position, actions, and depiction by Cogitosus can be interpreted through the lens of queer theory in order to ask key questions regarding attitudes towards queerness in early medieval Ireland. To render the queerness of female sanctity acceptable in a patriarchal system, there were significant elements of compensation for the deviance from these societal norms in the depictions of female saints, such as hyperfemininity contrasting with contemporary masculine traits. This balance of deviance and compensation is most clear in hagiographies, texts where the saints and their actions were recorded and mediated for the explicit purpose of demonstrating sanctity. As Cogitosus's *Life of Saint Brigit* depicted a woman who not only stepped out of one social structure, that being secular, but also monastic ones, his portrayal of Saint Brigit demonstrates that within female sainthood, queerness was not only accepted, but a prerequisite and inherent feature worthy of veneration. By examining how scholars have used a lens of queerness and mediation to analyze key hagiographies first of saints more broadly, and then of female saints, and using these approaches to examine the inherently queer actions, positions, and roles found in Saint Brigit's *First Life*, we can gain a clearer view of societal views towards queerness during the early medieval period, and in early medieval Ireland in particular. In doing so, this thesis will help chip away at the monolithic view of the period, as well as the queer erasure within, demonstrating that queerness has always been a fundamental part of human society.

THE SECULARIZATION OF RELIGIOUS STUDIES

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My research focuses on the secularization of religion within Religious Studies and other academic fields. Throughout my time as a Religious Studies student I have observed religion being compared to secular activities such as football both in classroom discussion and in scholarly research. This leaves students with the impression that religion is not a tool which shapes society, but rather that religion is an obsolete human habit which a progressive society no longer needs. Research, such as that of Jonathan Haidt, which claims secular activities are a form of religion, positions religion's functionality as more important than its spirituality. By treating religion as purely functional and excluding the spiritual as primitive we are saying that spirituality is archaic and not conducive to modern societies. Upholding secular logic as the key to understanding religion is a modern continuation of the linear evolution of religion in accordance with the, "natural evolution," of society as outlined by George Galloway and J.Z. Smith. I approach the topic of religion as an anthropological category, and secularization as a cultural mindset rooted in the colonial ideal of logical reasoning. My research will be based on the analysis of how the definition of religion within the field of Religious Studies has changed over the years as described by J.Z. Smith. Throughout my essay I will relate my findings to the process of Settler Memory, which is defined by Kevin Bruyneel, as the way in which settler societies reproduce settler and indigenous history in order to maintain settler colonialism as the social norm. The purpose of my research is to shed light on a pervasive issue within the field of Religious Studies and persuade scholars to rethink how religions are studied in order to abolish the modern-primitive dichotomy which erases Indigenous religions from our field of study.

THE ACCUMULATION OF ANTHROPOGENIC DEBRIS ON BEACHES IN NICARAGUA

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Anthropogenic debris poses a significant threat to coastal ecosystems globally, yet comprehensive studies on accumulation patterns and impacts are lacking, particularly in continental coastal areas. This research investigates the accumulation of anthropogenic debris on beaches along Nicaragua's Pacific coast, shedding light on distribution patterns, types of debris, and potential impacts on wildlife. Data collected from five beaches near Gigante, Nicaragua, reveal high concentrations of debris, predominantly consisting of plastics and, styrofoam. Analysis of color distribution shows a prevalence of white, blue, and clear items, with implications for wildlife ingestion, particularly among sea turtles. Microplastic analysis further underscores the pervasive nature of pollution in this region. The study discusses historical trends, community engagement initiatives, and challenges in cleanup efforts, highlighting the complex socio-environmental dynamics influencing waste management practices. Findings emphasize the need for holistic approaches integrating education, community engagement, and improved infrastructure to address marine pollution effectively. This research contributes essential insights for targeted conservation strategies and underscores the urgency of addressing anthropogenic debris accumulation in coastal regions worldwide.

HAWAI'I UNCOVERED

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While the Hawaiian Islands are undeniably beautiful, the state is not the paradise it is often stereotypically perceived to be. Through photography, Hawai'i Uncovered aims to explore the conflicting aspects of identity in Hawai'i, reveal the true characteristics of the state, and separate its perception by tourists from the reality that locals know all too well. Photos were taken at popular tourist and lesser known "locals-only" destinations on multiple of the Hawaiian Islands. The photos focused mostly on the way that people interact and exist within these places and amongst each other through a candid and observational lens. Hawai'i's identity is deeply rooted in its diverse array of cultures and backgrounds. And yet, most tourists never get the opportunity to see Hawai'i for more than just a tropical playground. The idea of community and belonging are both the saving grace and downfall of these islands, allowing many to be proud and excited about who they are while also leaving some cast out and forgotten. Both the romanticized and ignored aspects of these islands are what make the state unlike anywhere else in the world and are essential in defining Hawai'i in an honest fashion.

EXPLORING SUBSTRATES FOR RING CLOSING METATHESIS BASED ETHYLENE DETECTION

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Recently, ruthenium-mediated olefin metathesis has been employed for the detection of the small alkene, ethylene. An approach currently being developed in our lab utilizes ring closing metathesis of profluorescent substrates to study the amplification of signal transduction in sensing ethylene. Upon relay ring closing metathesis of these substrates, an increase in fluorescence is observed. Our group is interested in synthesizing and evaluating new substrates to improve signal output in the detection of ethylene and other analytes. By altering the structure and functional groups tethered to the substrates, the amount by which the signal is generated upon ring closing metathesis can be increased. To improve the photophysical properties and increase signal output, we have synthesized and evaluated a number of new substrates. Synthetic efforts, substrate-product properties, and application in sensing assays will be presented.

COMPARISON OF THE FUNCTIONAL COMPOSITION OF THE OVERSTORY AND UNDERSTORY IN DISTURBED RIPARIAN FOREST COMMUNITIES

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Plant functional traits (e.g., seed weight) have been shown to provide a mechanistic understanding of how communities respond to disturbance. Historically, riparian ecosystems have experienced flooding as their dominant disturbance regime, however, human occupation of the floodplain has introduced new types of disturbances. This has resulted in altered trait composition, however, no research has compared the functional trait composition of the overstory and understory against different disturbance types (natural and anthropogenic). Therefore, it is unclear if these vegetation layers are responding similarly or differently to a variety of disturbances within riparian ecosystems. Functional trait theory suggests that certain traits are associated with environmental conditions, like those created by disturbance, regardless of species region or growth form. My research project aims to test this hypothesis by comparing the functional composition of the overstory and understory vegetation in disturbed riparian ecosystems. At the Ebro River Basin in Spain and along the Garonne River in France, restoration and management efforts have resulted in a variety of natural and anthropogenic disturbances, including sites with cleared overstory, overbank flooding, cleared understory, and undisturbed sites. Seven reproductive functional traits (chosen because reproductive strategies influence a species' ability to respond to disturbance) were collected for 250 species sampled from 99 sites along the Ebro River Basin and Garonne River. Trait composition was quantified by calculating community-weighted means (CWMs) for overstory and understory species at each site. Preliminary data analysis has revealed that across all sites, the understory has significantly heavier seeds on average when compared to the overstory. Additionally, the difference in CWM seed weight between overstory and understory vegetation varies depending on disturbance type. This indicates that the overstory and understory of riparian communities respond differently to disturbance, and the difference is influenced by the type of disturbance at each site.

LONG-TERM IMPACTS OF FIRE SEVERITY ON THE DIVERSITY OF CAVITY-NESTING BEES AND WASPS

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Bees are essential pollinators and vital to ecosystem function, and thus it is important to understand how fire impacts bee communities and diversity. Human activities are changing fire regimes, which impact the resources upon which bees depend, such as nesting material and floral resources. Fire's impacts on bee communities vary depending on the time since the fire and fire severity. However, the majority of previous research has examined the impact of relatively recent fires on bee diversity (<5 years post-burn). We addressed this gap in research by examining the impacts of fire on bee diversity over 20 years post-burn. We selected 18 sites, which varied in burn severity (high burn, low burn, and no burn). We used trap nests to test if fire severity affected cavity nesting bees' abundance and diversity. We made trap nests using bamboo reeds of varying sizes and installed them at two different heights at each of the 18 sites. Cavity nesting bees and wasps used caps to plug the reeds in the trap nests, which we used to identify the occupants. We assessed the effects of burn severity on cavity-nesting bee and wasp diversity by comparing the richness and abundance. Our initial findings did not show any statistically significant results, but we will overwinter the nests in the lab and identify the species as they emerge, which may impact our results. Our study will help us to improve our understanding of the long-term impacts of fire severity on pollinator diversity.

TOWARDS NOVEL GENERATION OF CLASSICALLY ENTANGLED VECTOR BEAMS

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In physics, entanglement was first described as a purely quantum phenomenon in which two systems are non-separable, where measuring one system affects the outcome of the measurement of the other. However, it is possible to produce such a result in a purely classical environment (i.e. with locality of the systems), which is classical entanglement. One way this can be done is by considering entanglement of internal degrees of freedom of vector vortex beams in coherent light rather than quantum objects such as two entangled photons. This method allows for classical entanglement between the orbital and spin angular momenta of a vector vortex beam. We present progress towards a new method to produce these inequality-violating beams experimentally using two overlapped beams with spatial and polarization modes from a single laser. This method is inherently phase-stable because it uses common-path optics, which removes the need for active stabilization, which is expensive and complicated. This will also allow for further analogues to quantum measurements to be applied to classically entangled light and will provide easier access to making these measurements. Thus, this novel method of generation will provide a simpler method for studying quantum phenomena mimicked in a classical setting.

SYSTEMATIC REVIEW OF PARENTING AND FAMILY MEASURES USED TO STUDY OF FAMILY FACTORS AND ADOLESCENT ANXIETY

Hunter Whitehouse¹

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This poster provides a systematic review of extant youth self- and caregiver-reports used in the examination of family factors linked to youth anxiety. Following PRISMA guidelines, data was extracted to examine measure features and content, as well as strength of associations with youth anxiety symptoms and diagnoses. The review results in a decision tree that aids researchers and clinicians in making informed decisions about which parenting and/or family questionnaires might suit their needs when studying or conducting clinical work in the context of adolescent anxiety.

WRITERS IN THE SCHOOLS

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Writers In The Schools is a project meant to provide students an opportunity to express themselves through creative writing, with the ultimate goal of producing an anthology of their work to celebrate their artistic achievements. In order to achieve this goal, guest teachers create a series of lesson plans meant to encourage students' writing, then teach students at Ricks Center, collecting the writing they're most proud of for the anthology at the end of the project. Thus far, this project has already spurred the creation of a poetry anthology, and an anthology of students' poetry, short stories, and plays is forthcoming. It is often a great sense of pride for students to see their writing published.

EVALUATING THE EFFICIENCY OF LOW-COST AIR QUALITY SENSORS TO SIZE PARTICULATE MATTER AT A SUBURBAN FIELD SITE

Olivia Wuttke¹

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Science surrounding the use of low-cost sensors (LCS) to monitor air quality is rapidly expanding to satisfy the desire to fill in regional air quality data gaps. This project evaluates the suitability of two types of LCS: Modulair-PM and PurpleAir (SD and flex models) as efficient means to measure airborne particulate matter. The study involved physical installation of sensors at a suburban site in Denver, connectivity troubleshooting as necessary, and data analysis/modeling of data over multiple months. PM data was compared between individual sensors of the same type as well as across the two different sensor models and used to draw conclusions about air quality trends at the field site. Comparisons between sensors were generally in good agreement, but an additive bias was observed for several sensors, highlighting the importance of calibration of these types of units. The project concluded with aiding in a recent installation of PurpleAir units at a field site at the Kennedy Mountain Campus. Results from the project create a base level of understanding of LCS functionality to be expanded upon in future project applications.

EDITOR'S NOTES

These abstracts have not been peer-reviewed.



Great Sand Dune by Nicole Doris



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