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Dear Reader,

This journal has been an integral part of my—and many of our editors'—time while an undergraduate at the University of Denver. Although undergraduate research is often viewed as a simple extension of the research conducted by already established academic professionals, we believe that this negates the undeniable impact of undergraduate contributions. This journal exists as a testament to the importance of centering undergraduate voices within research—both current and novel conversations.

Within this year's publication, you will find a characteristic example of DUURJ's wide range of topics published. Science-focused papers within this issue examined hormone release during acute stress, dietary restrictions of larvae, the moderating effects of interpersonal relationships, and racial bias in medical recovery. Humanistic-focused papers within this issue explored the role of educational attainment in U.S. politics and contrasted media coverage of the 2022 Uvalde terror attack. Following these papers, you will find interviews with three professors at the university specializing in the fields of Andean literature, Physics, and Gender Studies. Finally, you will find the continued spark of undergraduate research at DU within abstracts from the 2025 Student Signature Work Showcase. Throughout the journal, artistic captivations—ranging from photography to ceramics—accompany the written investigations.

This year, the journal experienced its largest period of growth yet. A more visible position on campus led to higher recruitment of new editors. Each new editor has strengthened the journal ten-fold; entering with unique perspectives, experiences, and academic paths. Despite being an entirely student-run organization, this growth was made possible by collaboration and guidance from various individuals and groups across campus. Dr. Kate Tennis and Grace Warner have remained pillars of DUURJ's success. Continued and expanded collaboration with Dr. Juli Parrish and the Writing Center has even further cemented our commitment to academic excellence. Other collaborations with the Career Center, Student Signature Work Department, and various individual professors across campus have allowed DUURJ to become what it is today.

I want to take the time to thank the editors who decided to join and explore what DUURJ has to offer from within. Without your unwavering dedication and support this year, I would not be writing this letter. Furthermore, I want each author published within this issue to take the time, sit back, and recognize the work you have dedicated to reach this point. For most, this is a senior thesis, capstone, or project that encapsulates their time as an undergraduate student and nods toward their future goals.

To quote my father's reminder throughout my childhood, "Great things don't have to be explained." Whether as a reader or author, professor or student, aspiring academic or retiring awardee, continue to follow—or even demand—the path you envision for yourself. At a time of continuous uncertainty and once-in-a-lifetime events never stop questioning, exploring, and—of course—researching.

Thank you,



Nicole Doris
Editor in Chief



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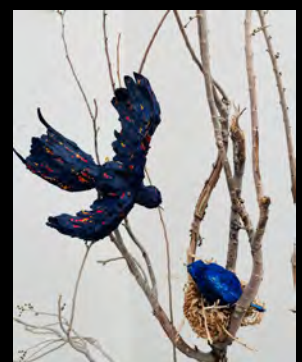
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Investigating the regulation of the hypothalamic-pituitary-interrenal axis in Atlantic sturgeon (*Acipenser oxyrinchus*) following an acute stressor

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Abstract

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, netting, 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*. 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. Our findings fail to explain the increase in plasma cortisol levels that was observed. 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.

1 INTRODUCTION

In mammals, the hypothalamic-pituitary-adrenal (HPA) axis is an endocrine relationship between the hypothalamus, pituitary gland, and adrenal glands, with the primary function of regulating the body's stress response by controlling glucocorticoid production¹. When a stressful event occurs, stimulation of the sympathetic nervous system occurs where epinephrine and norepinephrine are released from the adrenal medulla and are released quickly into circulation². Concurrently, the HPA axis is also stimulated. The hypothalamus releases corticotropin-releasing hormone (CRH) into a portal vein network connecting the hypothalamus and the pituitary gland, allowing the hypothalamus to com-

municate with the anterior pituitary³. At the anterior pituitary, CRH binds to the corticotropin-releasing hormone receptor (Crhr), stimulating corticotropic cells in the anterior pituitary to release ACTH (adrenocorticotrophic hormone, a cleavage product of the proopiomelanocortin (POMC) precursor protein), which travels through the bloodstream to the adrenal cortex⁴—this is where ACTH binds to the melanocortin 2 receptor (Mc2r). When bound by ACTH, the Mc2r upregulates cAMP via its association with G_{αs} protein and leads to the activation of protein kinase A. This ultimately results in the transcriptional upregulation and phosphorylation of steroidogenic acute regulatory protein (StAR)⁵. This is the rate-limiting step in the biosynthesis and release of corticosteroids, which involves a serial

enzymatic conversion of cholesterol and transport from the outer to the inner mitochondrial membrane. The final result of this pathway is the production of glucocorticoids, primarily cortisol. Cortisol plays a crucial role in the body's stress response by increasing plasma glucose levels and subsequently raising the metabolic rate of the body. This increases the available energy the body can use in response to a stressful event.

There is no HPA axis in the bony fishes, as members of this group lack distinct adrenal glands like those present in mammals. Instead, bony fishes utilize an HPI axis (hypothalamic-pituitary-interrenal axis), wherein the interrenal tissue of the head kidney region is the putative site of corticosteroid production and release in bony fishes⁶. Thus, in this way, the head kidney of the bony fish is analogous to the adrenal gland in mammals. The HPI axis regulates glucocorticoid production via an endocrine signaling pathway similar to the HPA axis found in mammals, including the expression of CRH in the hypothalamus, Crhr, and POMC/ACTH in the corticotropic cells of the anterior pituitary, and Mc2r and StAR in the head kidney. In the HPI axis, the hypothalamus releases CRH at the median eminence, which binds to Crhr on corticotropic cells within the pituitary gland and stimulates the release of POMC-derived ACTH. Then, ACTH binds to Mc2r in the head kidney, stimulating the production of corticosteroids, including upregulation of the rate-limiting step of StAR transcription and phosphorylation.

Although much is known about the arrangement and stress-responsiveness of the HPI axis of derived bony fishes (i.e., teleosts), relatively little is known about the HPI axis of basal bony fishes, such as sturgeons (Acipenseridae). In sturgeons, components of an HPI axis have been identified⁶, in which cortisol has been identified as the predominant glucocorticoid, and its circulating concentration in the blood is stress-responsive². However, whether and how an HPI axis regulates stress-responsive production of cortisol has not been adequately investigated. In this study, we examined the response to acute stress in Atlantic sturgeon (*Acipenser oxyrinchus*), with a particular focus on HPI axis regulation of glucocorticoid production during stress by examining the expression of key genes that are believed to be involved in the signaling pathway of the HPI axis⁶. These included the genes of *crh*, *crhr*, *pomca*, *pomcb*, *mc2r*, and *star*. Additionally, we investigated two genes encoding a tyrosine hydrogenase (*th1* and *th2*), which are involved with catecholamine synthesis in the head kidney, as well as a gene encoding phosphoenolpyruvate carboxykinase (*pepck*), which is a hepatic gluconeogenic enzyme. As there is very little known about the HPI axis in the lineages of fishes that predate the sturgeons, including the cartilaginous fishes (Chondrichthyes) and the jawless fishes (Agnatha), our work represents an investigation into the stress-responsiveness of an HPI

axis of one of the most basal vertebrates studied to date.

2 METHODS

2.1 Live Animal Care

The Atlantic sturgeons (*A. oxyrinchus*) that were used in this investigation were handled and cared for following procedures that were approved by the Institutional Animal Care and Use Committees at the University of Massachusetts (Protocol No. 20160009) and U.S. Geological Survey (Protocol No. C0907). Atlantic sturgeon juveniles were obtained 14 days after hatching from the Bears Bluff National Fish Hatchery (USFWS, Wadmalaw Island, SC, USA) and were reared at the Conte Anadromous Fish Research Laboratory (USGS, Tumers Falls, MA, USA). The fish were held in 1.5 m diameter tanks supplied with 4 L min⁻¹ of dechlorinated municipal water with natural photoperiod and ambient temperature. The Atlantic sturgeons were fed a progression of diets as they grew, including only live brine shrimp, then a mixture of bloodworms and a fine commercial pellet (Otohime, Reed Mariculture, Inc., USA), and then a diet of only a standard commercial pellet (Bio-Oregon, USA).

2.2 Experimentation and Tissue Sampling

For experimentation, the individual Atlantic sturgeon (~1-year post-hatch; 22.7 ± 3.3 cm total length; 39.9 ± 16.4 g mass) was randomly assigned to 'stressed' or 'unstressed' (control) groups. The procedure for the acute stress treatment consisted of 5 consecutive repetitions of 1 min netting (approximately 5 fish per 1.6 m² net) followed by 5 min confinement (5 fish confined to 15 L tank), lasting 30 min in total. After the acute stressor, fish were placed back in rearing tanks to recover and sampled at 1, 6, and 24 h during recovery. Unstressed fish were sampled alongside stressed fish as time-matched controls.

During sampling, the Atlantic sturgeon were euthanized using a lethal dose of MS-222 (200 mg L⁻¹ buffered using NaHCO₃, pH 7.4). The fish were measured for body length and mass and then sampled for tissues. The tissues sampled included the brain (hypothalamus region), pituitary, head kidney (anterior-most region of the kidney), and liver. The tissues were immediately frozen and stored at -80 °C to be used in later RNA extraction. Blood was collected from the caudal vasculature into heparinized capillary tubes. Plasma was separated from the blood by centrifugation at 2000 g for 5 min.

2.3 Plasma Glucose and Cortisol

The levels of plasma glucose were determined against a standard curve in an assay using the enzymatic coupling of hexokinase and glucose 6-phosphate dehydrogenase⁷. Plasma cortisol was determined by enzyme immunoassay⁸.

2.4 Gene Expression Analysis

The total RNA was extracted from frozen tissue using the TRIzol method by following the manufacturer's instructions (Molecular Research Center, Inc.). RNA was quantified and analyzed for purity using a Take3 microvolume plate reader (BioTek Instruments, Inc.). High purity samples ($A_{260}/A_{280} > 1.9$) were used for the cDNA synthesis and real-time PCR analysis. A set of samples was examined electrophoretically to confirm the batch-level RNA integrity. The first strand of cDNA was synthesized using a high-capacity reverse transcription kit and following the manufacturer's instructions (Applied Biosystems Inc.). Real-time quantitative PCR was performed in 10 μ l reactions that contained 2 ng cDNA, 150 nmol L⁻¹ forward and reverse primers, and 1 \times SYBRselect master mix by following the manufacturer's instructions (ThermoFisher Inc.). The thermal profile of the reactions was first 2 min at 50 °C, then 2 min at 95 °C (holding and activation), then 40 cycles of 15 s at 95 °C, then 1 min at 60 °C, 30 s at 72 °C (cycling), and finally, a ramp from 60 to 95 °C (melting curve analysis) was used to ensure there was a single product in each reaction. The relative abundance of *crh*, *crhr*, *pomca*, *pomcb*, *mc2r*, *star*, *th1*, *th2*, and *pepck* was calculated using the comparative method ($\Delta\Delta CT$) using *actb* as a reference gene.

2.5 Statistics

One-way ANOVA analyses were used to determine the significant difference over time between the control and stress groups. Individual t-tests were performed at each time point to determine the significance between the control and stress groups at any given time point. An α -value of 0.05 was selected to denote statistical significance in all analyses, and all P-values are presented in figures or figure captions.

3 RESULTS

3.1 Stress-Responsive Regulation of Plasma Glucose and Cortisol

Unstressed levels of plasma cortisol were at ~ 2.7 ng mL⁻¹ (Fig. 1A) and did not significantly change over time ($P = 0.64$, one-way ANOVA). In response to stress, plasma cortisol levels at the 1 h and 6 h time points increased significantly ($P_{1h} < 0.001$; $P_{6h} < 0.05$;

t-test). At the 1 h time point, the plasma cortisol levels were at 24.2 ng mL⁻¹. At the 6 h time point, the plasma cortisol levels were at 9.9 ng mL⁻¹. By the 24 h time point, the plasma cortisol levels were no longer significantly increased ($P_{24h} = 0.41$; t-test) and were at 3.8 ng mL⁻¹. Unstressed plasma glucose levels were at ~ 4.8 mM (Fig. 1B) and did not significantly increase over time ($P = 0.24$; one-way ANOVA). In response to stress, plasma glucose levels at the 1 h and 6 h time points increased significantly ($P_{1h} < 0.001$; $P_{6h} < 0.001$; t-test). At the 1 h time point, the plasma glucose levels were at 9.9 mM. At the 6 h time point, the plasma glucose levels were at 7.2 mM. By the 24 h time point, the plasma glucose levels were no longer significantly increased ($P_{24h} = 0.75$; t-test) and were at 4.9 mM.

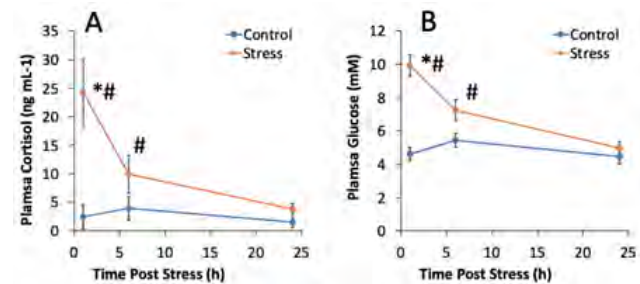


Figure 1. Stress response in Atlantic sturgeon. Plasma concentrations of cortisol (A) and glucose (B) in Atlantic sturgeon at time 1, 6 and 24 h post stress. Data represent means \pm s.e.m. Asterisks indicates difference from control and stress at each respective time point. Pound symbol indicates difference from the mean control value.

3.2 Gene Expression in the Brain and Pituitary: *crh*, *crhr*, *pomca*, and *pomcb*

The relative abundance of *crh* mRNA in the hypothalamus (Fig. 2A) of the stressed fish were not significantly different from the unstressed fish at any of the time points 1 h, 6 h, and 24 h ($P_{1h} = 0.82$, $P_{6h} = 0.21$, $P_{24h} = 0.53$; t-test). The relative abundance of *crhr* mRNA in the pituitary (Fig. 2B) did have a significant decrease in response to stress at the 6 h time point when compared with the unstressed fish ($P_{6h} < 0.001$; t-test). The relative abundance of *crhr* mRNA in the pituitary (Fig. 2B) did not significantly increase in response to stress at the time points 1 h and 24 h when compared with the unstressed fish ($P_{1h} = 0.054$, $P_{24h} = 0.89$; t-test). The relative abundance of *pomca* mRNA in the pituitary (Fig. 2C) did not significantly increase in response to stress at the time points 1 h, 6 h, and 24 h when compared with the unstressed fish ($P_{1h} = 0.074$, $P_{6h} = 0.74$, $P_{24h} = 0.58$; t-test). The relative abundance of *pomcb* mRNA in the pituitary (Fig. 2D) did have a significant decrease in response to stress at the 1 h time point when compared with the unstressed fish ($P_{1h} < 0.05$; t-test). The relative abundance of *pomcb* mRNA in the pituitary (Fig. 2D)

did not significantly increase in response to stress at the time points 6 h and 24 h when compared with the unstressed fish ($P_{6h}=0.66$, $P_{24h}=0.16$; t-test).

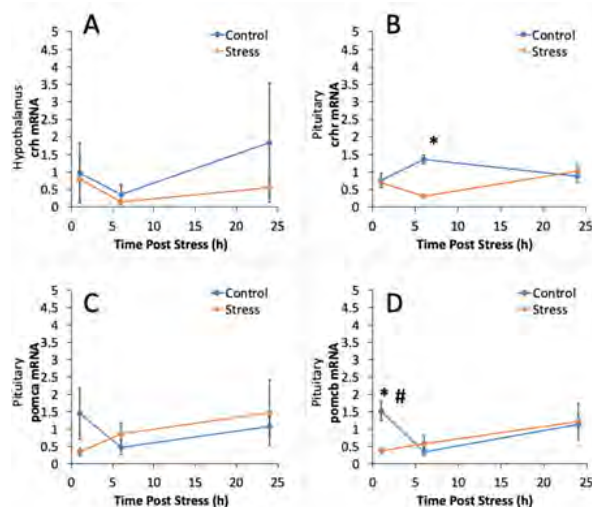


Figure 2. Stress response in Atlantic sturgeon. mRNA concentrations in Atlantic sturgeon of *crh* in the hypothalamus (A), *crhr* in the pituitary (B), *pomca* in pituitary (C), and *pomcb* in the pituitary (D) after 1, 6, and 24 h post stress. Data represent means \pm s.e.m. Asterisks indicates difference from control and stress at each respective time point. Pound symbol indicates difference from the mean control value.

3.3 Gene Expression in the Head Kidney: *mc2r*, *star*, *th1*, and *th2*

The relative abundance of *mc2r* mRNA in the head kidney (Fig. 3A) did not significantly increase in response to stress at the time points 1 h, 6 h, and 24 h when compared with the unstressed fish ($P_{1h}=0.97$, $P_{6h}=0.62$, $P_{24h}=0.19$; t-test). The relative abundance of *star* mRNA in the head kidney (Fig. 3B) did not significantly increase in response to stress at the time points 1 h, 6 h, and 24 h when compared with the unstressed fish ($P_{1h}=0.66$, $P_{6h}=0.21$, $P_{24h}=0.099$; t-test). The relative abundance of *th1* mRNA in the head kidney (Fig. 3C) did have a significant increase in response to stress at the 6 h time point when compared with the unstressed fish ($P_{6h}<.05$; t-test). The relative abundance of *th2* mRNA in the head kidney (Fig. 3D) did not significantly increase in response to stress at the time points 1 h, 6 h, and 24 h when compared with the unstressed fish ($P_{1h}=0.38$, $P_{6h}=0.73$, $P_{24h}=0.32$; t-test).

3.4 Gene Expression in the Liver: *pepck*

The relative abundance of *pepck* mRNA in the liver (Fig. 4) did have a significant increase in response to stress at the 1 h and 24 h time points when compared with the unstressed fish ($P_{1h}<.001$, $P_{24h}<.05$; t-test). The relative abundance of *pepck* mRNA in the liver (Fig. 4) did

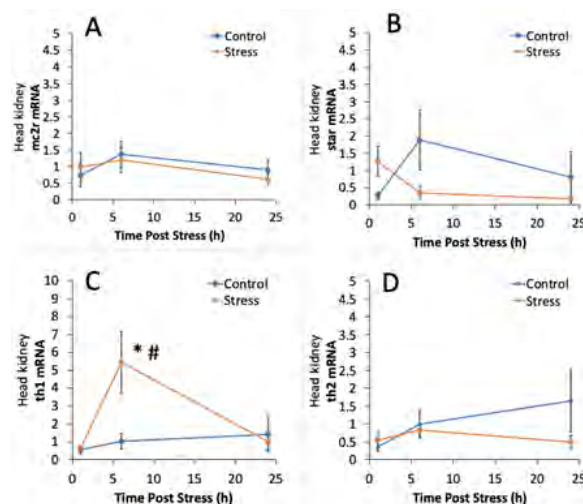


Figure 3. Stress response in Atlantic sturgeon. mRNA concentration in Atlantic sturgeon of *mc2r* in the head kidney (A), *star* in the head kidney (B), *th1* in the head kidney (C), and *th2* in the head kidney (D) after 1, 6 and 24 h post stress. Data represent means \pm s.e.m. Asterisks indicates difference from control and stress at each respective time point. Pound symbol indicates difference from the mean control value.

not significantly increase in response to stress at the time point 6 h when compared with the unstressed fish ($P_{6h}=0.06$; t-test).

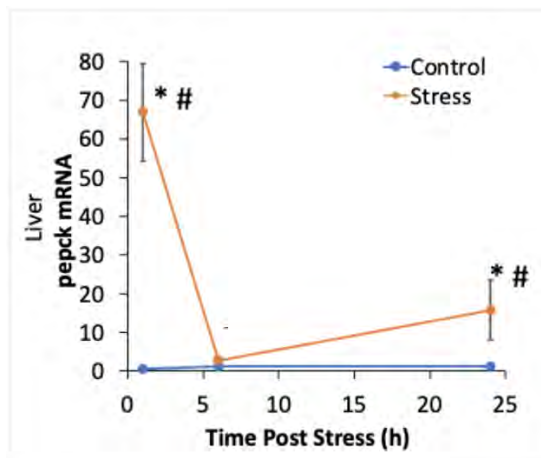


Figure 4. Stress response in Atlantic sturgeon. mRNA concentrations in Atlantic sturgeon of *pepck* in the liver after 1, 6 and 24 h post stress. Data represent means \pm s.e.m. Asterisks indicates difference from control and stress at each respective time point. Pound symbol indicates difference from the mean control value.

4 DISCUSSION

This study aimed to investigate the stress-responsiveness of an HPI axis and to provide evidence of regulation of corticosteroidogenic response to acute stress in a basal bony fish, Atlantic sturgeon (*Acipenser oxyrinchus*). The plasma glucose and plasma cortisol

levels were increased under stress, similar to previous studies of the HPI axis in fish^{10;11}, and liver *pepck* mRNA production was also significantly increased in response to acute stress, together demonstrating that there was corticosteroidogenic and gluconeogenic acute stress responses in the Atlantic sturgeon. If the HPI axis was regulating this gluconeogenic response, we would expect an upregulation of gene expression of one or several components of the HPI axis in *A. oxyrinchus* to produce a corticosteroidogenic response to acute stress. Similar studies show that in rainbow trout (*Oncorhynchus mykiss*) and zebrafish (*Danio rerio*), there is upregulation of either or a combination of *pomca*^{12;13}, *pomcb*^{12;13}, *mc2r*^{12;14;11}, *crh*^{12;10;11}, or *crhr*¹², and *star*^{10;11}. However, in this study, there was no evidence of any upregulation of the investigated HPI axis gene components. The sturgeons subjected to the acute stress demonstrated similar levels of mRNA production of *pomca*, *pomcb*, *mc2r*, *crh*, *crhr*, and *star* to those of the control group, indicating there was no stress-responsive upregulation at either of the 1 h, 6 h, or 24 h time points. Thus, our current results fail to support our hypothesis that the HPI axis of the Atlantic sturgeon is activated to promote corticosteroidogenesis in response to acute stress.

In derived bony fishes, upregulation of certain HPI components to increase the corticosteroidogenic response after acute stress has been demonstrated. In rainbow trout (*Oncorhynchus mykiss*), when exposed to an acute stressor, there was a significant increase in plasma cortisol and plasma ACTH levels. Plasma cortisol and plasma ACTH levels peaked at 1 h post-stress, after which they declined to similar levels of the control at 4 h and 24 h¹⁴. This is a similar response to acute stress as the Atlantic sturgeon in this study. It was demonstrated that ACTH upregulates *mc2r* mRNA levels, which corresponded with higher transcript levels of *star* and elevated cortisol production, suggesting *mc2r* activation by ACTH is the primary signaling pathway to corticosteroid biosynthesis in teleosts¹⁴. In sturgeon, ACTH does activate *mc2r*, which is expressed alongside *star* in the head kidney⁶. However, no significant upregulation of *mc2r* mRNA after acute stress was observed at the 1 h, 6 h, or 24 h time points in the Atlantic sturgeon in this study.

In zebrafish (*Danio rerio*), another derived bony fish, when exposed to acute stress, there was a significant increase in plasma cortisol levels post-acute stress, which significantly decreased with time^{12;13}. This is a similar response to acute stress as the Atlantic sturgeon in this study. There was also a significant post-stress upregulation of *pomcb*¹³, *pomca*, *mc2r*, *crh*, and *crhr* levels¹². The upregulation of these transcripts suggests that *pomca*, *pomcb*, *mc2r*, *crh*, and *crhr*, and thus the HPI axis, may have a role in the increased plasma cortisol levels that were seen post-acute stress in zebrafish^{12;13}. However,

we observed no such significant upregulation of *pomca*, *pomcb*, *mc2r*, *crh*, and *crhr* mRNA post-acute stress at either of the 1 h, 6 h, or 24 h time points in the Atlantic sturgeon in this study.

The increase in plasma glucose and plasma cortisol indicated that there is function of a stress-responsive neuroendocrine axis. However, the lack of upregulation of the expected corticosteroidogenic components raises the possibility that there are alternative pathways, other than the HPI axis, that Atlantic sturgeon use to regulate their response to acute stress. Catecholamines, such as epinephrine and norepinephrine, are another class of gluconeogenic hormones regulated by the sympathetic nervous system that can cause an increase in plasma glucose and plasma cortisol. Tyrosine hydroxylases, TH1 and TH2, are important enzymes in the biosynthesis of catecholamines in the adrenal gland or the head kidney. In a previous study in zebrafish, an upregulation of the expression of *th2* was observed after exposure to acute social stress, while there was no significant change in *th1*¹⁵.

In our current study, we observed similar results to the previous study in zebrafish, as the Atlantic sturgeon exhibited an upregulation of *th1* in the head kidney post-acute stress, while there was no significant change in *th2*. While the particular TH ortholog that was upregulated in response to stress differed between zebrafish and Atlantic sturgeon, the upregulation of *th1* in response to acute stress suggests that regulation of catecholamines, rather than the HPI axis, may be driving gluconeogenesis post-acute stress in Atlantic sturgeon, and thus may be responsible for the increases in liver *pepck* and plasma glucose that were observed. However, this interpretation still fails to explain what regulates the increase in plasma cortisol after acute stress, if not the HPI axis. The lack of upregulation of the *crh*, *crhr*, *pomca*, *pomcb*, and *mc2r* genes does not necessarily indicate a complete absence of involvement of the HPI axis—it may suggest that the Atlantic sturgeon HPI axis is already at a high level of expression. The expression of the target genes may be at a high level, making it unnecessary for the upregulation of the genes in response to acute stress. This interpretation provides a possible explanation for the increase in plasma glucose and plasma cortisol and the lack of upregulation of the target genes that were investigated. Further investigation into the stress-responsive regulation of cortisol and catecholamines in Atlantic sturgeon will provide greater insight into the neuroendocrine pathways regulating steroidogenesis and gluconeogenesis during stress in basal vertebrates.

5 CONCLUSION

In this study, we investigated the expression of key genes that are involved in the signaling pathway of the *A. oxyrinchus* HPI axis. Our investigations demonstrate

a lack of upregulation of the expected corticosteroidogenic components (*crh*, *crhr*, *pomca*, *pomcb*, *mc2r*, and *star*). However, our investigation revealed that plasma glucose levels in response to acute stress might be regulated by alternate pathways due to the upregulation of *th2* and *pepck*. Nevertheless, there is a lack of explanation of the increase in plasma cortisol, and future studies aimed 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 as a whole.

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7 EDITOR'S NOTES

This article was peer-reviewed.

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Examining the performance of an insect generalist reared on unused host plants in Colorado

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Abstract

Dietary generalist insects are important to ecological communities because they are commonly found in many environments and play important roles in ecosystem services like pollination and decomposition. Although dietary generalist herbivores eat a broad range of plant species, regional populations of these species may have significantly narrower or specialized diet breadths. Fall webworm (*Hyphantria cunea*, hereafter FW) is a dietary generalist at the species level, but we do not know if there is dietary generalism at the population level or how generalism varies across populations. In Colorado, FW larvae feed on only a few plant species, but many plant species are available that are used by FW elsewhere and not locally. We investigated if FW may be an example of a species that is a dietary generalist when considered over a large geographic range but is composed of populations with narrower diets regionally. We reared FW larvae from fifteen maternal lines in Colorado on a local high-quality host plant and compared their performance (survival, development time, and pupal mass) with larvae reared on plants that are not used locally. We found that FW performance was significantly reduced on plant species that Colorado FW does not use. Our findings demonstrate that Colorado FW cannot eat the same plants as FW in the eastern United States and thus lack the physiological ability to feed on these plants. Our research also suggests that FW are a generalist species with narrower diets that vary regionally at the population level.

Keywords: diet breadth, dietary generalism, Erebidæ, insect herbivore, Lepidoptera

1 INTRODUCTION

There are over half of a million species of described herbivorous insects, the vast majority of which are dietary specialists that typically eat fewer than three plant species¹. However, insects that are dietary generalists are important to ecological communities because they play key roles in ecosystem services, such as pollination and decomposition. Insect dietary generalists are also important because they are often crop pests². Although dietary generalist herbivores eat a broad range of plant species, Fox and Morrow³ suggested that regional populations of these species may have significantly narrower or specialized diet breadths. A generalist population may have a narrow diet breadth and use different plant species for food regionally due to a number of different ecological or evolutionary processes³. For example, herbivore diet can vary depending on genetic variation among herbivores, competition with other herbivores for high-quality plants, or plant availability³.

Thus, species that are dietary generalists can be categorized into two groups: 1) species that are true dietary generalists are composed of populations with generalized diets across their entire range, or 2) species that are regionally composed of populations with narrower diet breadths, but the species is considered a dietary generalist when all populations are considered together over the species' geographic range.

Herbivorous insects may select which plant species to eat because of plant-related traits (interactions between two trophic levels: plant and herbivore). This bi-trophic view on diet breadth considers interactions between herbivore and plant as the most important variables determining the herbivore's food plants. For example, an herbivore may select a food plant because its nutritive value yields a faster development time, or the plant is more abundant than other plants in the environment and thus easier to find. Further, plant quality can vary regionally depending on environmental factors, so bi-

trophic interactions are important to determine the diet breadth of generalist herbivores².

Herbivorous insects may also select which plant species to eat because of traits that only appear when considering their natural enemies: predators, parasitoids, and pathogens (interactions between three trophic levels: plant, herbivore, and natural enemy)⁴. A tri-trophic approach considers these interactions with natural enemies along with interactions with the plant in relation to the herbivore. The presence of predators can decrease herbivore performance (survival, development time, and/or pupal mass) on a host plant even when the plant is a high-quality host. For example, Murphy⁵ found that the Alaskan swallowtail butterfly (*Papilio machaon aliaska*) had low performance on high-quality host plants because mortality from natural enemies was higher on these host plants than on low-quality host plants. A tri-trophic approach is important to understand herbivore community structure and population specialization or divergence⁴. However, by conducting a bi-trophic experiment, we can determine the viability of a plant for herbivores to eat depending on plant-related traits.

Fall webworm (*Hyphantria cunea*, hereafter FW) is an insect herbivore that is a dietary generalist, and the larvae feed on more than 400 plant species worldwide^{6,7}. However, in Colorado, FW larvae feed on fewer plant species, as we have only found them on 17 host plants⁸. Many plant species are available to Colorado FW that are used by FW elsewhere but not locally. For example, FW commonly eat box elder (*Acer negundo*) in the eastern United States but have not been found on this plant species in Colorado⁸, even though box elder is relatively common at sites where we collect FW (personal observation). Thus, FW may be an example of a species that is a dietary generalist when considered over a large geographic range but is composed of populations with narrower diets regionally, as described by Fox and Morrow³.

We examined the performance of Colorado FW when reared on plant species that are frequently used as host plants by FW on the East Coast but are not used by FW in Colorado even though these plants can be found in the Front Range of Colorado where FW occur. It is important to consider that there are two morphotypes of FW; red-head FW are the only morphotype found in Colorado, whereas red-head and black-head FW are found sympatrically in the eastern United States⁹. Currently, these morphotypes are considered a single species, but Vidal et al.⁹ showed that genetically they are likely different species. The genetic differences between these morphotypes may influence the regional diet preferences of FW. The goal of our research was to test if the plant species used by eastern FW (black-head) could be physiologically viable host plants for Colorado FW (red-head) even though they are not currently used

as hosts by FW in Colorado. Previously, we have reared eastern, black-head FW on some of these host plants (e.g., box elder) in Colorado, and they performed well on these plants (Murphy and Vidal, unpublished data). Here, we used a bi-trophic approach in this experiment to understand the effects of plant-related traits on herbivore performance. If Colorado FW larvae perform poorly when reared on the available but unused plant species, then this would indicate that FW larvae cannot feed upon the same food plants in all regions and may suggest that FW are a generalist species with narrower diets that vary regionally at the population level. If Colorado FW larvae perform well when reared on the available but unused plant species, then this would indicate that FW can feed upon the same food plants across geographic regions and may suggest that FW is a true dietary generalist.

2 METHODOLOGY

2.1 Study System

FW is a moth that is native to North America and introduced in Asia and Europe¹⁰. FW feeds on over 400 host plant species across its wide geographic range^{6,7}, but how these plant species are used differently by red-head and black-head FW is unclear. As a species, FW feed on a wide range of host plants, but individual larvae feed on the host plant where their mother laid eggs and are thus restricted to a single plant. Although FW is highly polyphagous across its range, populations often have a diet breadth that is limited regionally. In Colorado, red-head FW have been observed on only 17 woody tree species, although many other plant species are available as potential hosts and are used as hosts by FW elsewhere⁸.

2.2 Experimental Design

In June of 2023, we used the egg clusters laid by 15 red-head FW females selected haphazardly from our colony for our experiment. FW in the colony have been reared on multiple host plants, and new individuals are introduced each summer from wild populations. To compare larval performance across host plants for each maternal line, we cut each egg cluster into evenly sized groups and placed each group onto different plant species. We split four of the maternal lines into six groups that were reared on six different plant species. We used black willow (*Salix nigra*, abundant in CO) as a control because it is a high-quality host plant for Colorado FW, so we could compare larval performance on the unused plants with a known high-performance plant. We selected unused plant species for our experiment from a published list of plant species used by black-head FW in the eastern United States⁸ and then selected plants

to use for our experiment based on their availability in Colorado. The five unused plant species were: American linden (*Tilia americana*; abundant in CO), American sycamore (*Plantanus occidentalis*, rare in CO), box elder (*Acer negundo*, abundant in CO), Eastern redbud (*Cercis canadensis*, rare in CO), and tree of heaven (*Ailanthus altissima*, abundant in CO). We then decided to add mulberry (*Morus alba*; rare in CO) into the experiment, so we split the next 11 maternal lines onto seven plant species (the same six listed above plus mulberry). We placed each egg cluster group on a host plant leaf in a 0.5 L deli container along with a piece of damp filter paper to prevent desiccation. We reared the FW larvae in a lab setting with ambient temperature and lighting and fed them leaves from trees located near the University of Denver campus. Once the larvae were large enough to count, we placed five in each container. We fed all larvae a single plant species throughout their development, as wild FW commonly remain on one host plant for the duration of their larval development (personal observation).

Throughout development, we replaced any dry or moldy leaves with fresh foliage three times per week. We reared up to 15 larvae per host-maternal line treatment; some treatments did not have 15 surviving larvae, while other treatments had to be culled to 15. In total, our final sample size was 602 larvae. Thirty days (\pm one day) post-pupation, we recorded pupal mass as a proxy for lifetime performance (to the nearest 0.001 mg; Mettler-Toledo XP6, Columbus, Ohio¹¹). We waited 30 days to gain a more precise pupal mass as FW pupae deplete their fat stores and lose water via evaporation over time¹¹.

2.3 Statistical Analysis

We analyzed FW survival with a Chi-square test, treating host plant and maternal line as fixed effects. Some of the larvae died early in the experiment because their containers were too dry, so we removed these FW from the dataset before analysis. We calculated an individual fitness score by multiplying survival (binary measure, 0 or 1) by pupal mass and dividing by development time. We analyzed FW larval fitness score using a mixed-model ANOVA with host plant as a fixed effect and maternal line as a random effect. To meet assumptions of normality and equality of variance, we square root transformed fitness score for our analyses. We performed all statistical analyses with JMP Pro 15.2.0.

3 RESULTS

For FW survival, we found a significant effect of both host plant species ($\chi^2=186.6$, $df=6$, $P<0.0001$) and maternal line ($\chi^2=43.8$, $df=14$, $P<0.0001$) Figure 1. While both factors were significant ($p<0.05$), host plant had a

stronger effect on FW survival. Notably, no larvae ever survived on box elder. Larvae did eat box elder, so it was not an avoidance of the host plant that caused their mortality, but rather a physiological inability to survive on this plant. For FW fitness score, we found a significant effect of both host plant ($F_{6,545}=69.2$, $P<0.0001$) and maternal line ($F_{14,545}=2.6$, $P=0.0015$) Figure 2. Using Tukey's HSD, we found significant differences in fitness scores across host plants with the highest FW fitness scores on black willow, which is a high-quality host plant used by FW in Colorado, and the lowest on American sycamore and Eastern redbud Figure 2.

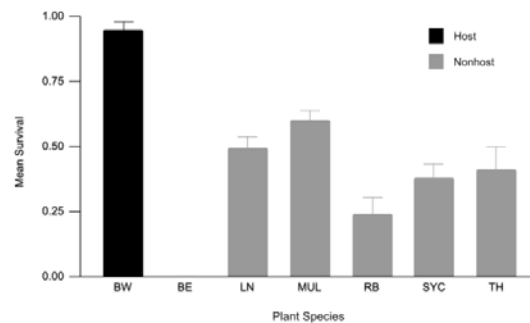


Figure 1. Mean proportion survival (\pm SE) of FW larvae reared on seven plant species in the summer of 2023 in Colorado, USA. The plant species we used were black willow (BW), which is a commonly used and high-quality host plant by FW in Colorado (black bar), along with several nonhost plants (BE = box elder, LN = American linden, MUL = mulberry, RB = Eastern redbud, SYC = American sycamore, TH = tree of heaven; gray bars). FW commonly use nonhost species in the Eastern United States but not in Colorado.

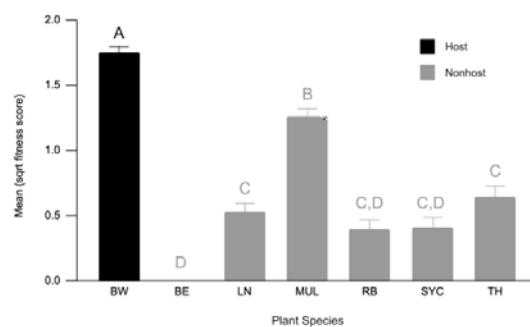


Figure 2. Mean fitness scores (fitness score is square root transformed; \pm SE) of FW larvae reared on seven plant species in the summer of 2023 in Colorado, USA. The plant species we used were black willow (BW), which is a commonly used and high-quality host plant by FW in Colorado (black bar), along with several nonhost plants (BE = box elder, LN = American linden, MUL = mulberry, RB = Eastern redbud, SYC = American sycamore, TH = tree of heaven; gray bars). The nonhost species are commonly used by FW in the Eastern United States but not by FW in Colorado. The letters above the bars indicate significant differences between plant treatments (Tukey's HSD).

4 DISCUSSION

We found that Colorado FW do not perform well on host plants that FW commonly use on the East Coast, which supports the hypothesis that FW larvae cannot feed upon the same food plants in all regions. Our results suggest that FW may be a generalist species composed of populations with narrower diets that vary regionally, as suggested by Fox and Morrow³. While tri-trophic interactions are important to understand how a species interacts with its environment^{4,12}, for our research, bi-trophic interactions are able to explain why FW do not use certain host plant species. Notably, even in a controlled environment without top-down pressure from natural enemies, we found that all FW larvae die on some plant species such as box elder; this finding suggests that bi-trophic interactions are solely responsible for FW not using box elder in Colorado. However, which components of the bi-trophic interactions cause FW to die on box elder are unknown and could be due to either plant-related traits or FW physiology or microbiota.

FW morphotype likely plays a role in our findings that Colorado FW cannot feed on the same host plants as FW in the eastern United States. Vidal et al.⁹ found that the two morphotypes of FW are likely distinct species, but they have not been formally described as such. Our research supports the suggestion that the red and black morphotypes are distinct species as first reported by Vidal et al.⁹. We found that red-head FW from Colorado cannot feed on box elder plants here, but box elder is a commonly used host plant by black-head FW in the eastern United States. It is possible that Colorado box elder trees are different from box elder trees in the eastern United States, but this is not likely to explain our results. Previously, we have reared black-head FW from the eastern United States on box elder trees in Colorado, and we found that they performed well on these plants. Therefore, any chemical differences between eastern and Colorado box elder plants cannot explain the failure of Colorado FW to survive on these plants because eastern FW are able to survive on these same plants. Our findings demonstrate that red-head FW cannot eat the same plants as the black-head populations in the eastern United States and lack the physiological ability to feed and survive on these plants.

Plant abundance may explain why some plant species that were tested in this experiment (e.g., American sycamore, mulberry, and Eastern redbud) are not used by Colorado FW in nature because they are relatively rare in Colorado at FW field sites (Shannon Murphy, personal observation). Because Colorado FW do not frequently encounter these plant species, there may not be selection for individuals to thrive on them. However, box elder is abundant at our field sites and Colorado FW would encounter it frequently, yet no larvae in this

experiment survived on box elder. The abundance of plant species in Colorado also does not explain why American linden and mulberry yielded moderate survival and performance for FW larvae in this experiment; American linden trees are very abundant, yet FW fitness scores were low, and mulberry trees are rare, yet fitness scores were higher.

5 CONCLUSIONS

We found that Colorado FW physiologically cannot feed on some of the same plant species as populations of FW in the eastern United States. Further research should investigate the physiological mechanisms that inhibit or reduce survival on these plants. Some species are true generalists that can uniformly eat a wide range of foods across their range. Other species, including FW, are likely extensive generalists only when considered at the species level, with narrower diet breadths at the population level. Additional research is required to determine what factors prevent FW from using these plant species, and tri-trophic interactions should also be investigated for further understanding. Furthermore, the ability (or inability) to consume wide diets should be investigated across a greater range of FW populations. The complexity of generalist diets and the factors that shape them could have broad implications for many ecosystems.

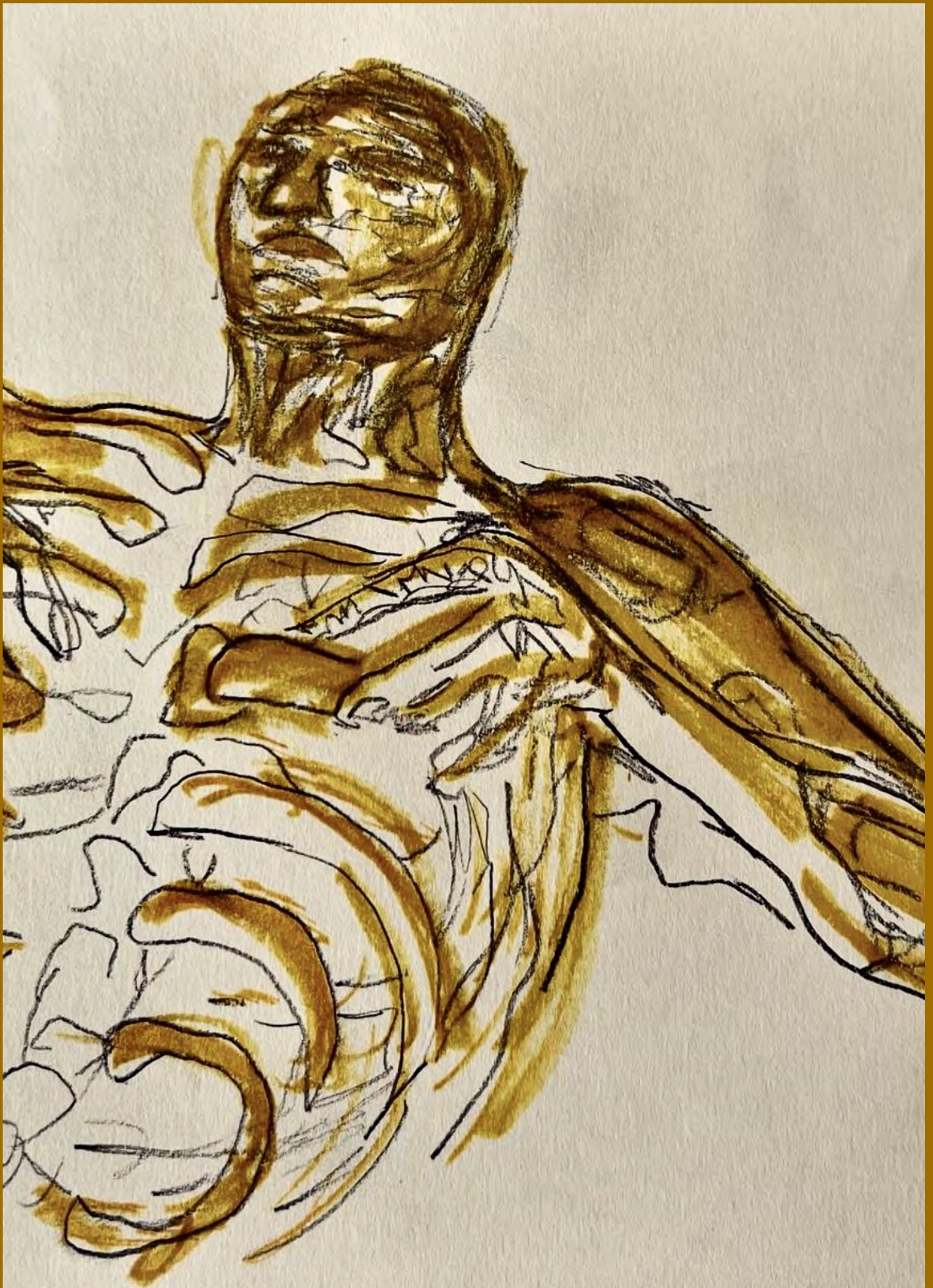
6 ACKNOWLEDGEMENTS

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Caged by Micah Sullivan

Exploring buffering effects of interpersonal relationships on the impacts of stress on physical health

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Abstract

We examined the potential moderating effects of interpersonal relationships on the association between stress and physical health. We hypothesized that there would be a significant main effect of stress on physical health, a significant main effect of relationships on physical health, and a significant interaction between stress and relationship quality on physical health, such that quality relationships provide a buffering effect, reducing the negative impacts of stress on physical health. Data was collected through a self-report Qualtrics survey on CloudResearch. We found a significant main effect of stress on physical health and a significant main effect of relationship quality on physical health. An interaction was only observed in romantic relationship subtypes, such that low-quality romantic relationships exhibit a greater decline in physical health than high-quality romantic relationships in conditions of low compared to high stress. Important implications exist in which enhancing relationship quality could be a vital strategy in mitigating stress-related health consequences. This may include therapeutic interventions, socioemotional-based school curricula, and holistic healthcare opportunities.

Keywords: stress, interpersonal relationships, relationship quality, close relationships, health, physical health

1 INTRODUCTION

An estimated 62% of women and 51% of men between the ages of 18-34 stated that most days, they are completely overwhelmed by stress¹. This trend, in conjunction with research suggesting potential links between stress and negative physical health outcomes, such as cardiovascular diseases and diabetes², draws concern toward the need to mitigate the negative impacts of stress on physical health. In the present study, we will investigate the potential moderating effects of quality interpersonal relationships, including familial, romantic, and friendship, on the relationship between stress and physical health.

1.1 Effects of Stress on Chronic Physical Health Outcomes

High stress can impact many realms of physical health, regardless of how long ago one was exposed to the stress. Childhood stress (e.g., violence, abuse, divorce, etc.), especially exposure to intense and chronic stressors (e.g., war), can have lasting psychological effects, but *also* lasting neurobiological effects, immune dys-

function, and a reduced lifespan^{3;4}. Similarly, high levels of stress can lead to increased smoking habits, sleep disorders, substance use, eating disorders, and a generalized weakened immune system³.

Socioemotional stress places physical stress on the body, disrupting its ability to engage in homeostatic regulation, thus leading to an increased potential for adverse health outcomes. This is evident in the overactivation of the hypothalamic-pituitary axis that is initiated by stress and results in the hypersecretion of cortisol, the stress hormone⁵. Altering key homeostatic regulatory systems leads to downstream dysfunction of various biological processes, including tissue damage and bodily overload, dysregulation of the autonomic nervous system, elevated heart rate and blood pressure, and weakened immune functioning⁵.

Ultimately, stress has the capability to alter many aspects of healthy functioning, placing bodily systems at an increased susceptibility to disease, infection, and dysfunction⁵. This is evident in one study which related daily stress levels to "healthiness," as operationalized by the frequency of pathologies including the flu, sore throat, headache, and pain⁶. Research suggested a possible positive correlation between daily stress and

“healthiness” such that as daily stress increased, so did the occurrence of various pathologies⁶.

Similarly, research also points to potential correlations between stress and specific pathologies because of the biological dysfunction stress induces. For example, one 2013 study found that people who reported a higher baseline stress level were 2.12 times more likely to have a myocardial infarction⁷, suggesting that stress may increase the risk of cardiovascular problems. Notably, this is important in addressing how daily stress can result in chronic health complications.

Another study found potential impacts of stress on female reproductive endocrinology and subsequent fertility, suggesting that the oxidative stress induced by chronic daily stress disrupts ovarian cycles, leading to a higher risk of developing polycystic ovary syndrome (PCOS)⁸. Similarly, women who score higher on perceived stress scales prior to in vitro fertilization (IVF) treatments are less likely to become pregnant than those who score lower⁹. As a result, research suggests that stress negatively relates to the number of viable oocytes⁹, thus decreasing the probability of successful fertilization. Stress plays a crucial role in the regulation of bodily homeostasis, and when unchecked it poses the ability to induce a variety of chronic negative downstream physical health effects across body systems.

1.2 Effects of Supportive Relationships on Mitigating Stress

Research suggests that supportive relationships may improve physical health outcomes which are negatively related to stress. Some research explains this connection through the ability of relationships to mitigate the upstream instigator of physical health decline: stress itself.

The leading theory on the mechanism by which relationships reduce stress is referred to as *stress buffering*. Stress buffering suggests that positive aspects of relationships, such as social support and social integration, “block” the negative impacts of stress¹⁰. Put simply, social support makes it easier to cope with stress, thus limiting its ability to initiate harmful downstream effects.

Additional research addresses the social support aspects of stress buffering through the framework of coping assistance¹¹. This research suggests specific interventions for the stress that relationships provide. These include having a support person to intervene, distract and provide reassurance in a multitude of stressful situations¹¹.

These theories were put into practice in a 2021 study in which students were experimentally exposed to varying conditions of emotional support and subsequently assessed on their levels of academic stress. Results supported theories of stress buffering and coping assistance,

displaying that students who were educated on effective social support strategies reported less academic stress than the control group who received no education on effective strategies¹².

Experimental support of these theories provides an interesting framework for the ability of relationships to reduce stress, which creates the potential to explore how stress reduction improves health, and ultimately suggesting that relationships may serve as a moderator in the stress-physical health axis.

1.3 Effects of Relationship Quality on Physical Health Outcomes

In addition to the negative consequences of stress on physical health discussed above, some research suggests that quality relationships may induce positive consequences on physical health. Psychological studies regarding the how of the stress and relationship axis seek to learn what variables are responsible for the benefits of interpersonal relationships on health.

On the most basic level, healthy relationships have the capacity to direct positive social norms which support health. For example, adopting habits such as quitting smoking, being health conscious, and visiting a doctor are all important to one’s personal well-being and health¹³. While the support of these general practices inherently encourages health as a primary effect, some research also investigates corresponding physiological changes that improve specific health outcomes.

For example, research suggests that romantic relationships may improve cardiovascular functioning by lowering blood pressure¹⁴. This is exemplified in a 2019 experiment where participants who could consult with their partner during a stressful task presented with lower blood pressure readings during the task than those in the control group with no partner influence¹⁴. Given the existing literature suggesting negative relationships between stress and cardiovascular health, identifying potential protective factors is critical.

Another study implies that relationships are closely intertwined with the immune system, exhibiting the potential to boost immune functioning and better protect the body from infection¹⁵. The suggested mechanism explains that social exposure and connection upregulates the antiviral response of the immune system, ultimately making the body better equipped to identify and target pathogens which may negatively impact health¹⁵.

Some research even goes as far as to suggest a positive correlation between healthy attachment styles and life expectancy¹⁶. Although these findings are less notable, the abundant literature on the positive impacts of relationships on physical health speaks volumes about the positive impacts of healthy relationships.

1.4 Intersection of Quality Interpersonal Relationships, Stress, and Health

While the connections between stress and physical health, relationships and physical health, and relationships and stress, have been well established, as discussed above, less conclusive research exists on the dynamic between all three factors. This study seeks to add to and clarify existing literature on the interplay of stress and relationship quality on physical health outcomes.

Additionally, while previous literature does exist addressing subsets of relationship types individually, to our knowledge no such study exists comparing the buffering effects of different relationship types within one research design. This study will explore how the significance of any potential buffering effects of a relationship on the stress-physical health axis varies across relationship subtypes including romantic, familial, and friendship.

From a clinical perspective, better understanding the relationship between stress, physical health, and relationship quality offers opportunities to better inform health-conscious practices. Given the associations previously discussed between stress and quality relationships, targeting the development and maintenance of high-quality relationships may be an effective upstream therapy for adverse physical health conditions. Primarily, mental health providers can tailor their strategies for clients to focus on improving their own health amidst stressful circumstances. This is essential for examining health in a broader context with a holistic approach. In addition, practitioners can introduce family/couples therapy in a way that is supported by both physical and mental health research. In the education realm, this study is essential to provide new insights into social-emotional learning among different types of relationships. By researching the impact of relationships on stress and health, public knowledge as well as school curricula can drastically improve and be tailored to more specific strategies for the community and students.

1.5 Overview of the Current Work

We assessed perceived stress, physical health, and relationship quality among familial, romantic, and friendship dynamics through self-report questionnaires to analyze the potential main effects of stress and relationship quality on health and the potential interaction of stress and relationship quality on physical health.

Based upon the existing literature outlined above we hypothesized that (1) there would be a significant main effect of stress on physical health, such that higher stress levels correlate to lower levels of physical health and (2) there would be a significant main effect of relationships

on physical health, such that higher quality relationships correlate to higher levels of physical health.

Additionally, given the potential overlap between bivariate studies on stress and relationships, and health and relationships, as outlined above, we predicted that (3) there would be a significant interaction of stress and relationship quality on physical health such that quality relationships provide a buffering effect, reducing negative impacts of stress on physical health. We also conducted exploratory analyses to analyze how different types of relationships, including familial, romantic, and friendship, would act on physical health through the proposed buffering effect.

2 METHODOLOGY

2.1 Methods

In conducting the reported research, the ethical guidelines of the American Psychological Association were followed, and the research was conducted following exemption by the Institutional Review Board at the University of Denver. The rights of the participants were protected throughout the study. All measures, manipulations, and exclusions are disclosed. The reported study was preregistered (<https://aspredicted.org/xt7bm.pdf>)¹.

2.2 Participants

We recruited 160 participants through Amazon Mechanical Turk, an online participant recruitment platform, using CloudResearch (formerly TurkPrime; see Hauser et al., 2022¹⁷; Litman et al., 2017¹⁸; Litman & Robinson, 2021¹⁹). Each participant was compensated one dollar. Any participant who was +/- four standard deviations from the mean, indicated they did not complete the surveys accurately or carefully, failed one or both of the attention checks, or had a chronic physical disability that impacted their daily life was excluded from the data. Out of the 160 participants, 142 were included in our analysis (16 indicated they had a chronic disability and two failed at least one attention check). We collected demographic information on race, sex, gender, and age (see Table 2). Participant ages ranged from 18 to 74 ($M_{age} = 38.00$, $SD_{age} = 11.13$). A sensitivity power analysis conducted in G*Power²⁰ indicated this sample size ($N = 142$) could detect a small to medium effect ($F = 2.67$; $f^2 = 0.079$) or greater for a multiple regression with three predictors and 80% power.

¹One of the preregistered hypotheses is not reported in the main text and instead it has been reported in the Appendix (see Appendix A). We did not have enough power to test this effect because our measure of sunlight exposure was limited and drastically reduced our sample size.

2.3 Materials

2.3.1 Perceived Stress Scale (PSS) (modified)

The PSS is a ten-item questionnaire used to assess the amount of stress an individual perceives based on both frequency and intensity measures²¹. Participants self-reported the frequency of stress-related symptoms listed on a scale of zero to four (0 = never, 1 = almost never, 2 = sometimes, 3 = fairly often, 4 = very often). We modified this scale to include responses surrounding the intensity of each of the ten symptoms listed as well (see Appendix B). This was also rated on a scale of zero to four (0 = not severe, 1 = mildly severe, 2 = moderately severe, 3 = severe, 4 = very severe). Four of the items were reverse-coded (4, 5, 7, 8). Sample items include "How often have you been upset because of something that happened unexpectedly?" or "How often have you felt that you were unable to control the important things in your life?"²¹. One composite variable was created from the sum of the 20 total items ($M = 42.82$, $SD = 15.30$, $\alpha = 0.94$). Higher values indicate higher stress levels.

2.3.2 Multidimensional Scale of Perceived Social Support (MSPSS)

The MSPSS is a 12-item questionnaire used to assess the quality of the participant's familial, friend, and romantic relationships²². It consists of three subscales: familial (Q3, 4, 8, 11; Cronbach's $\alpha = 0.95$), friends (6, 7, 9, 12; Cronbach's $\alpha = 0.96$), and romantic (1, 2, 5, 10; Cronbach's $\alpha = 0.97$) (see Appendix C). Participants rated how much they agreed with the statements on a scale of one to seven (1 = very strongly disagree, 2 = strongly disagree, 3 = mildly disagree, 4 = neutral, 5 = mildly agree, 6 = strongly agree, 7 = very strongly agree). Sample items include "There is a special person who is around when I am in need," and "My family really tries to help me"²². A composite variable was created from the sum of the 12 items ($M = 60.89$, $SD = 16.00$, $\alpha = 0.94$). Higher values indicate better-quality relationships.

2.3.3 36-Item Short Form Health Survey (SF-36) (modified)

The SF-36 is a 36-item self-report questionnaire aimed to assess the physical health of a participant²³. Participants rated how much they agreed with the statements using one six-item Likert scale (1 = none, 2 = very mild, 3 = mild, 4 = moderate, 5 = severe, 6 = very severe), four different five-item Likert scales (never severe to always severe, excellent to poor, much better to much worse, and not at all to extremely), one three-item Likert scale (1 = limited a lot, 2 = limited a little, 3 = not limited at all) and one Yes/No response. Five of the items were reverse-coded (Q1-2, 20-22). Sample items include "Compared to one year ago, how would you

rate your health in general now?" and "How much bodily pain have you had in the past four weeks?"²³. We modified this scale from a 36-item scale to a 23-item scale by omitting questions not pertaining to physical health (Q 17-19, 23-32) (see Appendix D). A composite variable was created from the sum of the 23 items ($M = 64.93$, $SD = 8.30$, $\alpha = 0.84$).

2.4 Procedure

Participants accessed the study through Amazon Mechanical Turk using CloudResearch (Formerly TurkPrime; see Hauser et al., 2022¹⁷; Litman et al., 2017¹⁸; Litman & Robinson, 2021¹⁹) and were informed that completion of the survey implied their consent to participate. Participants completed three questionnaires regarding current stress levels (PSS²¹; modified), the quality of their interpersonal relationships (MSPSS²²), and current physical health (SF-36²³; modified). Participants completed attention checks following the PSS and SF-36 which required them to accurately identify which constructs they had just been assessed on (stress and health) to ensure participants were reading the questions carefully. Then, participants completed demographic measures of their sex assigned at birth, current gender, age, race, and city of residence. Finally, participants were provided the opportunity to share anything else they would like related to the study and validated that they completed the study carefully, such that their data should be used for the analysis of the study. Participants read a debrief form and then were compensated one dollar for their time.

2.5 Analysis Plan

We analyzed relationships between physical health, stress, and quality relationships using a multiple regression analysis. We tested the moderation via PROCESS MACRO, an extension software to SPSS Statistics²⁴, for total relationship quality using a composite variable of the relationship subscales, as well as each relationship subscale (romance, friendship, familial) on its own. In this case, the relationship type served as the moderator, stress served as the predictor, and physical health served as the dependent variable.

3 RESULTS

We tested three hypotheses: (1) there would be a significant main effect of stress on health such that higher stress levels correlate to lower levels of health, (2) there would be a significant main effect of relationship quality on health such that higher quality relationships correlated to higher levels of health, and (3) there would be a significant interaction between stress and relationship quality on health such that quality relationships provide

a buffering effect, reducing negative impacts of stress on health at higher levels of stress than lower levels of stress. Additionally, we tested whether the buffering effect of relationship quality differed for romantic, family, or friendship relationship subtypes.

3.1 Analyses

3.1.1 Correlational Analysis

Prior to hypothesis testing, we ran correlational analyses with all key variables to see the pairwise relationships between variables (see Table 1). We found significant correlations between stress and health, $r(140) = -.31, p < .00$, and relationships and stress, $r(140) = -.23, p = .006$. Regarding relationship subtypes, familial and peer relationships also showed significant correlations with stress, whereas romantic relationships did not. There was a significant negative correlation between familial relationships and stress, $r(140) = -.20, p = .017$. There was also a significant negative correlation between friend relationships and stress, $r(140) = -.20, p = .015$.

The correlational analysis also displayed associations within relationship types (see Table 1). All relationship types had a significant association with each other. There was a significant strong positive correlation between familial and peer relationships, $r(140) = .49, p < .001$. There was a strong positive correlation between familial and romantic relationships, $r(140) = .46, p < .001$. There was a strong positive correlation between romantic and peer relationships, $r(140) = .52, p < .001$.

Demographic information was also collected on sex, gender, race, and age (see Table 2).

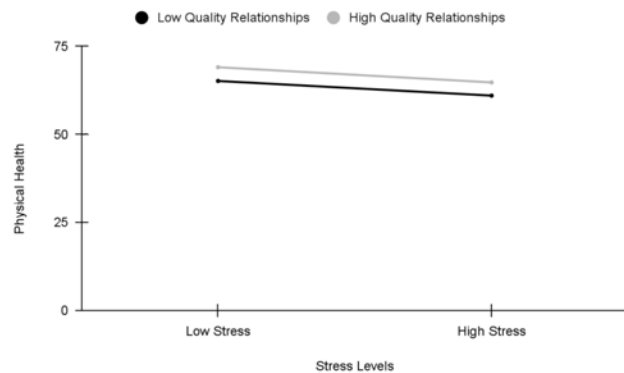
3.1.2 The Impact of Stress and Relationships on Health

A moderation analysis was conducted in which physical health was regressed onto stress, quality interpersonal relationships, and their interaction (see Figure 1). All constructs listed were mean-centered before calculating the interaction term. The overall model was significant, $F(3, 138) = 8.57, p < .001$. There was a significant negative main effect of stress on physical health, $b = -0.13, t(138) = -3.07, 95\% \text{ CI } [-0.22, -0.05], p = .003$, such that higher stress levels indicated worse physical health. There was also a significant positive main effect of relationships on physical health, $b = 0.13, t(138) = 3.14, 95\% \text{ CI } [0.05, 0.21], p = .002$, such that quality interpersonal relationships indicated better physical health. There was no interaction between stress and relationships on physical health, $b = -0.00, t(138) = -0.08, 95\% \text{ CI } [-0.00, 0.00], p = .936$.

3.1.3 The Impact of Romantic Relationships on Stress and Physical Health

A moderation analysis was conducted in which physical health was regressed onto stress, romantic relation-

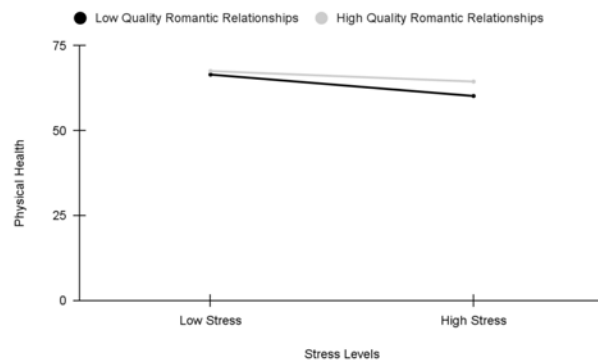
Figure 1. Stress and Health Moderated by Interpersonal Relationships



Note. Association between stress, physical health, and relationship quality. Higher levels indicate better physical health.

ships, and their interaction (see Figure 2). All constructs listed were mean-centered before calculating the interaction term. The overall model was significant, $F(3, 138) = 9.93, p < .001$. There was a significant negative main effect of stress on physical health, $b = -0.12, t(138) = -2.92, 95\% \text{ CI } [-0.21, -0.04], p = .004$, such that higher stress levels were associated with worse physical health. There was also a significant positive main effect of romantic relationships on physical health, $b = 0.26, t(138) = 2.83, 95\% \text{ CI } [0.08, 0.45], p = .005$, such that better quality romantic relationships were associated with better physical health.

Figure 2. Stress and Health Moderated by Romantic Relationships



Note. Interaction between stress (low and high levels), physical health, and romantic relationships (high and low quality). Greater values along the y-axis indicated better physical health.

There was a significant interaction between stress and romantic relationships on health, $b = 0.01, t(138) = 2.10, 95\% \text{ CI } [0.00, 0.02], p = .037$. For those who reported higher-quality romantic relationships, there were no differences in physical health between those who reported higher stress levels and those who reported lower stress levels, $b = 6.86, t(138) = -0.95, 95\% \text{ CI } [-0.17, 0.06], p = .344$. However, for those who report low-quality

Table 1 Correlation Between Relationship Type, Physical Health, and Stress

	Mean	SD	Total	Friend	Family	Romantic	Stress
Total	60.84	16.10					
Friend	19.64	6.53	.820**				
Family	20.06	6.43	.794**	.485**			
Romantic	21.14	6.86	.822**	.518**	.464**		
Stress	42.90	15.20	-.230**	-.204*	-.199*	-.157	
Health	64.93	8.30	.315**	.222**	.260**	.285**	-.306**

* $p < .05$ ** $p < .01$

Note. Correlation analysis between overall relationships, familial relationships, peer relationships, romantic relationships, stress, and physical health levels.

romantic relationships, there is a significant difference in health between those in high-stress and low-stress environments, such that those in high-stress environments with low-quality romantic relationships have the worst health outcomes $b = -7.14$, $t(138) = -4.02$, 95% CI [-0.29, -0.10], $p < .001$. These results suggest that high-quality romantic relationships have the potential to buffer the negative health outcomes associated with high stress, supporting our third hypothesis.

3.1.4 The Impact of Peer Relationships on Stress and Physical Health

A moderation analysis was conducted in which physical health was regressed onto stress, peer relationships, and their interaction. All constructs listed were mean-centered before calculating the interaction term. The overall model was significant, $F(3, 138) = 6.70$, $p < .001$. There was a significant negative main effect of stress on physical health, $b = -0.15$, $t(138) = -3.36$, 95% CI [-0.23, -0.06], $p = .001$, such that higher stress levels indicated worse physical health. Consistent with our hypothesis, there was also a significant positive main effect of peer relationships on physical health, $b = 0.22$, $t(138) = 2.18$, 95% CI [0.02, 0.42], $p = .031$, such that better quality peer relationships indicated better physical health. Inconsistent with our hypothesis, there was no interaction between stress and peer relationships on health, $b = -0.01$, $t(138) = -1.06$, 95% CI [-0.02, 0.01], $p = .292$.

3.1.5 The Impact of Familial Relationships on Stress and Physical Health

A moderation analysis was conducted in which physical health was regressed onto stress, familial relationships, and their interaction. All constructs listed were mean-centered before calculating the interaction term. The overall model was significant, $F(3, 138) = 7.21$, $p < .001$, such that family relationship quality moderated the relationship between stress levels and physical health. There was a significant negative main effect of stress on physical health, $b = -0.14$, $t(138) = -3.29$, 95%

Table 2 Descriptive Statistics

Characteristic	n	%
Race		
Native American	1	0.8
East Asian	23	16.2
South Asian	1	0.8
Hispanic or Latino/a/x	8	5.4
Native Hawaiian/Pacific Islander	1	0.8
Black/African American	15	10.8
White/European American	89	63.1
Bi- or multiracial	1	0.8
None of these options	2	1.5
Decline to share	1	0.8
Sex		
Female	65	45.8
Male	77	54.2
Gender		
Female-identifying	62	43.7
Male-identifying	78	54.9
Nonbinary	2	1.4

Note. $N = 142$. Participant ages ranged from 18 to 74 ($M_{age} = 38.00$, $SD_{age} = 11.13$).

CI [-0.23, -0.06], $p = .001$, such that higher stress levels indicated worse physical health. There was also a significant positive main effect of familial relationships on physical health, $b = 0.27$, $t(138) = 2.59$, 95% CI [0.06, 0.47], $p = .011$, such that better quality familial relationships indicated better physical health. There was no interaction between stress and familial relationships on health, $b = -0.00$, $t(138) = -0.33$, 95% CI [-0.01, 0.01], $p = .745$. These results provide additional support for our second hypothesis, as they suggest that in addition to peer relationships, better familial relationships can also lead to better physical health. However, similar to peer relationships, they do not support our third hypothesis since there was no interaction.

3.2 Exploratory Analysis

3.2.1 Comparison of Effect Sizes Across Relationships

Across relationship subtypes, the romantic subtype had the largest effect size for the effect of relationships on health ($f^2 = 0.22$), followed by familial relationship effect subtype ($f^2 = 0.16$), and the friend relationship subtype ($f^2 = 0.15$). Although the family and friend subtypes were slightly different, the magnitudes only differed by 0.01.

4 DISCUSSION

The present study aimed to explore connections between interpersonal relationships, stress, and physical health, illustrating the potential buffering effects of relationships in reducing the established negative correlation between stress and health⁶. We expected to replicate the previously established negative link between stress and health⁶, as well as observe a significant positive main effect of relationship quality on health. Further, we expected a significant interaction between stress and relationship quality on health, such that quality relationships would provide a buffering effect, reducing the negative impacts of stress on physical health.

Our first and second hypotheses were supported. We found that higher levels of stress were negatively associated with physical health and higher-quality interpersonal relationships were positively associated with physical health. This finding was consistent with literature stating that unsupportive family and friend behaviors were associated with greater psychological stress²⁵.

Interestingly, no interaction was found between stress, health, and a composite score of familial, romantic, and friendship interpersonal relationships; however, we observed an interaction within romantic relationships, suggesting that high-quality romantic relationships may buffer against the negative health outcomes associated with conditions of high stress.

Furthermore, we tested whether the main effects of different relationship subtypes (romantic, familial, and friendship) on health would vary in their significance. We found that each relationship subtype does have a positive effect on health, however, the greatest impact is seen in romantic relationships. Previous literature attempts to relate these findings to the unique physical aspects related to romantic relationships, for example, finding that individuals who receive more hugs more often tend to have less severe illness and stress²⁶; however, the rationale for why these trends are observed is unclear. Future research should expand on the mechanisms of how physical touch reduces stress in romantic relationships.

4.1 Application of Findings

The potential ability of romantic relationships to improve physical health outcomes resulting from chronic stress poses valuable insights into supporting the physical health of those experiencing chronic mental illness, short-term transition, and life adversity. This may provide a preventative tool to support strong psychological health among those whose physical health might be negatively impacted. The present research also expands the theoretical understanding of human stress resilience and may provide important insights into why some individuals maintain good health despite experiencing significant stress²⁷.

Implications of these findings may provide support for enhancing therapeutic strategies focused on interpersonal relationships as a tool to support physical health. Therapeutic practices that identify and leverage the strengths inherent in relationships build resilience against stress and improve overall physical health. Similarly, targeted interventions based on supporting effective relationships for individuals with chronic health concerns may support health prevention, potentially reducing hospitalizations and the need for medical interventions.

Additionally, by underscoring the crucial role of interpersonal relationships, healthcare providers may be more adept at providing holistic treatment. For example, prioritizing the practice of extensive visiting hours and active family/partner participation in daily life is crucial. Hospitals and in-patient care centers are forced to make tough decisions surrounding when and how the doors will be opened to loved ones, because of the inherent risks and challenges involved in letting individuals from the general public into tightly regulated buildings designated for healing. Inside hospitals, visiting hours are heavily regulated for safety concerns. Over time, literature has found significant benefits, including those related to safety in relation to having visitors in a hospital setting. In fact, existing literature has found that when intensive care unit (ICU) patients have a greater familial presence, they report an increased sense of safety²⁸.

4.2 Suggestions for Future Research

Notably, limitations to these findings do exist. While the measure used to assess relationship quality, the MSPSS, is an established and validated scale²², ambiguous wording of relationship measure items may impact construct validity regarding the classification of relationship type. Specifically, the romantic relationships subscale includes statements like "There is a special person who is around when I am in need." Although this language intends to reference romantic relationships, it does not explicitly ask participants about their cur-

rent involvement with a steady or exclusive significant other. Additionally, the study's reliance on self-reported data to assess physical health is subjective. Biological markers such as cortisol samples, heart rates, or blood pressure to get an objective physical health measure would be more reliable and provide a more in-depth understanding of specific effects on direct physiological processes.

Moreover, we excluded participants reporting physical chronic disabilities or illnesses that greatly impacted general health and well-being on a day-to-day basis. Although this was intentionally done to improve the internal validity of our physical health measures and limit confounds, this exclusion limits the applicability of our findings to a broader population. Future research should consider including a more diverse sample to enhance the generalizability of the results to those with chronic health problems.

Future research might also examine the role of attachment styles within romantic relationships; specifically, how the difference in secure to insecure attachment in relationships moderates the extent of buffering effects. Attachment theory suggests that individuals with secure attachment styles experience more stable and supportive relationships, thus suggesting that attachment style moderates the buffering effect of relationships on the stress-health axis such that secure attachment provides a higher degree of buffering²⁹. Similarly, future research may also include an analysis of features of romantic relationships (e.g., physical touch, quality time, sense of commitment, etc.) and how they contribute to these findings³⁰.

Also, future research may include further analysis of the role of demographic factors. The present sample had a mean age of 38, which likely encompasses many individuals in long-term monogamous relationships or marriages. Literature notes that long-term monogamous relationships do play a role in outcomes including perceptions of life satisfaction³¹, which may be related to health. To better understand how generalizable the findings are and reduce covariates of relationship status, future research may explore differences in moderation effects within age groups to identify whether the buffering effects of relationship quality vary across different life stages or relationship statuses.

4.3 Conclusion

The present research highlights the crucial role of the presence of high-quality interpersonal relationships in people's lives, particularly ones that are romantic in nature, in mitigating the detrimental effects that stress can have on physical health. By demonstrating that romantic relationships can act as a significant buffer against stress, especially in conditions of high stress, our results underscore the importance of relationship-focused ther-

apeutic strategies to enhance physical health outcomes. This research not only contributes to a deeper understanding within the broader scientific and psychological community of human stress resilience, but it also offers actionable insights that can be applied to clinical psychology and healthcare practices.

This work paves the way for future studies to further examine these relationships and refine interventions, leading to improved effectiveness and specialization of treatments for health and resilience in a diverse range of populations.

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6 AUTHOR NOTE

Authors contributed equally. We have no conflicts of interest to disclose. Correspondence concerning this article should be addressed to Emma Slatnick. Email: emma.slatnick@du.edu

7 EDITOR'S NOTES

This article was peer-reviewed.

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Appendix A

Supplemental Analysis

The Impact of Sun Exposure on Stress and Physical Health

We conducted an exploratory analysis to investigate the potential buffering effects of exposure to sunlight on the relationship between stress and health. Sun exposure was operationalized with the Sunny Days Per Year Index, a count of the total number of days in a year with less than 30% cloud cover in that city or town³².

All participants who were eligible for inclusion in the main portion of the study were eligible for inclusion in the exploratory analysis. However, an additional 51 participants were excluded due to failure to report the city they were from, or due to residing in a town without adequate online data about weather trends. After exclusions, this analysis included 91 participants whose cities had adequate data on Sunny Days Per Year.

A moderation analysis was conducted in which physical health was regressed onto stress, sunny days per year, and their interaction. All constructs listed were mean-centered before calculating the interaction term. The overall model was positive and significant, $F(3, 87) = 3.12$, $p = .03$, however, there was no main effect of Sunny Days Per Year, $b = 0.00$, $t(87) = 0.17$, 95% CI [-0.04, 0.05], $p = .866$, no significant main effect of stress, $b = -0.24$, $t(87) = -0.78$, 95% CI [-0.83, 0.36], $p = .435$, and no interaction between Sunny Days Per Year and stress, $b = -0.00$, $t(87) = -0.19$, 95% CI [-0.00, 0.00], $p = .852$.

This exploratory analysis was done to address potential correlations between stress, health, and sun exposure, however, no significant findings were observed. It is possible that this resulted from confounding environmental factors, such as air quality³³, or low-quality data and measurement.

Appendix B

Perceived Stress Scale (Modified)

For each question choose from the following options:
Frequency: 0 = never, 1 = almost never, 2 = sometimes, 3 = fairly often, 4 = very often
Intensity: 0 = not severe, 1 = mildly severe, 2 = moderately severe, 3 = severe, 4 = very severe

1. In the last month, how often have you been upset because of something that happened unexpectedly?
(a) How intense was this?
2. In the last month, how often have you felt that you were unable to control the important things in your life?
(a) How intense was this?
3. In the last month, how often have you felt nervous and stressed?
(a) How intense was this?
4. In the last month, how often have you felt confident about your ability to handle your personal problems?
(a) How intense was this?
5. In the last month, how often have you felt that things were going your way?
(a) How intense was this?
6. In the last month, how often have you found that you could not cope with all the things you had to do?
(a) How intense was this?
7. In the last month, how often have you been able to control irritations in your life?
(a) How intense was this?
8. In the last month, how often have you felt that you were on top of things?
(a) How intense was this?
9. In the last month, how often have you been angered because of things that happened that were outside of your control?
(a) How intense was this?
10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?
(a) How intense was this?

Appendix C

Multidimensional Scale of Perceived Social Support

For each statement choose from the following options:

Options: 1 = very strongly disagree, 2 = strongly disagree, 3 = mildly disagree, 4 = neutral, 5 = mildly agree, 6 = strongly agree, 7 = very strongly agree.

1. There is a special person who is around when I am in need
2. There is a special person with whom I can share joys and sorrows.

3. My family really tries to help me
4. I get the emotional help & support I need from my family
5. I have a special person who is a real source of comfort to me.
6. My friends really try to help me
7. I can count on my friends when things go wrong
8. I can talk about my problems with my family
9. I have friends with whom I can share my joys and sorrows
10. There is a special person in my life who cares about my feelings
11. My family is willing to help me make decisions

Appendix D

36-Item Short Form Health Survey (Modified)

1. In general, would you say your health is:
(options: excellent, very good, good, fair, poor)
2. Compared to one year ago, how would you rate your health in general now?
(options: much better, somewhat better, about the same, somewhat worse, much worse)
3. The following items are about activities you might do during a typical day. How does your health now limit you in these activities? If so, how much?
(options: limited a lot, limited a little, not limited at all)
 - (a) vigorous activities such as running, lifting heavy objects, and participating in strenuous sports
 - (b) moderate activities such as moving a table, pushing a vacuum cleaner, bowling, or playing golf
 - (c) lifting or carrying groceries
 - (d) climbing several flights of stairs
 - (e) climbing one flight of stairs
 - (f) bending, kneeling, or stooping
 - (g) walking more than a mile
 - (h) walking several blocks
 - (i) walking one block
 - (j) bathing or dressing myself
4. In the past 4 weeks, have you had any problems with your work or other regular daily activities as a result of your physical health? (options: yes, no)
 - (a) cut down the amount of time you spent on work or other activities
 - (b) accomplished less than you would like
 - (c) were limited in the kind of work or other activities
 - (d) had difficulty performing the work or other activities
5. During the past four weeks, how often has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?
(options: not at all, slightly, moderately, quite a bit, extremely)
6. How much bodily pain have you had in the past four weeks?
(options: none, very mild, mild, moderate, severe, very severe)
7. During the past 4 weeks, how much did pain interfere with your normal work (including both your work outside the home and housework)
(options: not at all, a little bit, moderately, quite a bit, extremely)
8. How true or false are the following statements to you?
(options: definitely true, mostly true, don't know, mostly false, definitely false)
 - (a) I seem to get sick a little easier than other people
 - (b) I am as healthy as anybody I know
 - (c) I expect my health to get worse
 - (d) My health is excellent



Still life of bones by Abi Newell
Charcoal on paper, a practice in eraser-drawing

Exploring relationships between racial bias, state empathy, and perceived recovery time following a medical hardship

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Abstract

This experiment investigated whether racial biases exist in laypeople's perceptions of recovery time following a common, medically-related hardship and whether these biases can be explained by differential empathy across race. White participants ($n=133$) read a vignette describing either a White or Black target who experienced a minor car accident. They then rated the amount of time they felt was reasonable for the target to take off from work and normal activities and how much time it would take to recover physically and mentally. Participants also completed measures of state empathy toward the target and their sleep quality. Results showed a significant main effect of target race, such that participants perceived shorter recovery times for the White (relative to Black) target. The predicted mediation through state empathy was not significant, and sleep quality did not moderate recovery time judgements. Current literature related to race and recovery-related perceptions focuses primarily on medical contexts, but little to no work has investigated the perception of medical recovery times in everyday scenarios such as school life, work life, and social life. We addressed this gap in the literature by investigating whether lay perceivers' predictions of recovery time varied across target races. Understanding lay perceivers' racialized beliefs about recovery time may have implications across employment (e.g., supervisors determining appropriate time off following hardships), education (e.g., different expectations for students coming back from personal hardships), or social domains (e.g., perceptions of one's ability to return to normal social life following a hardship). This experiment adds to a better understanding of the mixed findings in the current literature, though further research is needed to clarify whether and why people judge the recovery time of individuals differently based on their race.

Keywords: Race, Empathy, Hardship Recovery, Sleep

1 INTRODUCTION

The allocation of time is fundamental to all individuals, regardless of their diverse identities and experiences. However, the freedom to allocate how time is spent disproportionately impacts individuals based on elements of privilege, including race. In workplaces, schools, and sports, those with authority—such as HR managers, teachers, and coaches—make critical judgments about how much recovery time individuals need after experiencing medical hardship. For example, an HR manager may determine the number of days off an employee can take, a teacher may grant or deny extra time for a student's assignment, and a coach may decide when an athlete is able to return to competition again. The power to make decisions about how others allocate their time can have significant consequences. These decisions can be influenced by racial biases, potentially leading to

inequitable outcomes across racial groups.

Time is often recognized as a social determinant of health, as time is crucial for health maintenance (e.g. getting adequate sleep) and healing (e.g., recovery from an injury¹). Racial disparities related to time within the medical sphere means that people of color, especially Black individuals, often spend more time seeking medical appointments², face longer wait times³, and spend more time traveling to receive medical care compared to White individuals⁴. Length of stay in hospitals (LOS) has also been found to differ across White and Black patients, as White patients are often seen faster by medical staff, shortening their LOS compared to Black patients⁵. Time dedicated to seeking healthcare not only consumes time that could be spent elsewhere but can also worsen health conditions, leading to further consumption of time and resources that would otherwise

be allocated to non-medical pursuits such as education, employment, and social commitments. Similarly, differences in recovery or perceived recovery time may have similar detrimental effects on both individuals and broader social structures.

In addition to facing racial disparities in healthcare related to time (e.g., LOS), Black individuals also face racial biases in pain perceptions. To this point, Trawalter and colleagues' seminal work found that Black individuals were believed to feel less pain than White individuals following the same injuries⁶. These racial biases in pain perception also bias treatment recommendations among medical students⁷. In their work, researchers found that participants who more strongly supported false beliefs about biological differences (i.e., "Black people's skin is thicker than White people's skin") reported lower pain ratings for a Black (vs. White) target and recommended less intensive pain treatment. Similarly, Druckman and colleagues found that National Collegiate Athletic Association (NCAA) Division 1 sport medical staff perceived Black targets as having higher initial pain tolerance than White targets⁸. Thus, it's apparent that even medical professionals, who are educated and trained, consistently perceive Black individuals to experience less pain than White individuals. Taken together, the previous research provides substantial evidence for racial biases in pain among medical professionals, but does not yet speak to whether these same biases exist in laypeople. Given that time is a valuable resource, our research team was interested in whether differences in pain perceptions based on an individual's race extend to perceptions of the time needed to recover from a medically-related hardship (further defined as "hardship recovery time" or HRT). Because medical recovery time can affect many dimensions of an individual's life, we were interested in whether racial biases exist in how laypeople perceive HRT in non-medical contexts such as employment, education, and sports settings.

1.1 Racial Biases in Interpersonal Evaluation

Findings from previous research suggest that perceptions following a hardship differ based on the race of who has experienced the hardship. Many recent studies^{7,9,10} have examined hardship and pain perception, analyzing whether racial biases exist in perceptions of pain following a hardship. They all provided evidence that participants perceived Black (vs. White) individuals to feel less pain when they have experienced a greater hardship while endorsing the idea "hardship leads to toughness"^{7,9,10}. Similarly, Deska et al. examined whether people perceive Black people to be less sensitive to social pain (i.e., derogation, exclusion, unfairness) than White people¹¹. These researchers found perceivers believed Black (relative to White) individuals

were less sensitive to social pain and therefore, required fewer supportive resources such as counseling and community to cope with the same socially painful events. Considering how interpersonal pain evaluations differ based on race, perceptions of recovery time following a hardship may also differ across similar lines.

In addition to race, previous research findings support the idea that pain perceptions also differ across socioeconomic status (SES) and poverty. Summers and colleagues found both laypeople and healthcare professionals believed that individuals with low-SES were less sensitive to pain and consequently needed less intensive pain management than individuals with high-SES, and these biases even extended to judgments of children⁹. Similarly, Cheek & Shafir found that both laypeople and professionals held the belief that individuals with lower SES would be less harmed by negative events compared to those with higher SES¹². The authors attributed this effect to the perception that negative events are more expected by individuals in poverty and therefore deemed less harmful to them. These findings suggest perceptions of pain are linked to beliefs about how adverse events impact individuals, and that these perceptions differ based on variables of demographic differences such as SES. While these findings all pertain to pain evaluation and perception, no research has extended to look at how similar results may be found in interpersonal prediction of recovery time following a hardship.

1.2 Racial Biases in Interpersonal Empathy

Existing literature supports the idea that there are significant differences between levels of empathy felt for ethnic ingroup and outgroup evaluation targets. Put more clearly, members of one's own ethnic group, their ingroup, will have more empathy for those members compared to people who are not part of their own ethnic group, the outgroup members. Neumann et al. administered images depicting negative (injuries, natural disasters, illness, grief, confinement and assault) and positive (smiling related to a party, and an amusement park) contexts to participants and measured ratings of empathy based on ethnic ingroup and outgroup affiliation to the target in the image¹³. Participants rated significantly higher on three dimensions of empathy (affect, perspective taking, and understanding) for ingroup ethnicity targets than for outgroup ethnicity targets for the negative social contexts. Azevedo et al. additionally examined how race and ingroup versus outgroup affiliation affect empathy-related responses through a neuroimaging approach¹⁴. These researchers presented video clips depicting White and Black skin colored hands, alongside a control group of violet colored hands, being either painfully penetrated by a syringe or being gently touched by a Q-tip. They found

a significant difference in White participants' empathetic processing, as increased activity within the left anterior insula—a brain region associated with empathy—during the observation of White observation targets' pain versus Black pain. Applying these findings, such differences in empathy levels across racial lines may also facilitate different perceptions of recovery time for other racial groups.

Considering these findings, we were interested to see how state empathy, a temporary response of empathy rather than a personality trait, may play a critical role in the relationship between racial differences and perceptions of recovery following a hardship. Drwecki et al. examined the role of empathy in pain treatment disparities¹⁵. A sample of undergraduate and nursing professionals reported their state empathy and treatment suggestions after viewing real videos of Black and White patients showing genuine facial expressions of pain. The participants showed significant pro-White pain treatment biases; however, participants partaking in "empathy-inducing, perspective-taking interventions" (such as being instructed to intentionally imagine how each patient feels while being examined for treatment recommendations) showed 55% less pain treatment bias compared to the control group. These pro-White pain treatment biases may carry over to other aspects of evaluating individuals across different racial lines. Just as state empathy facilitated these treatment biases, it may also facilitate biases in perceived recovery time when White participants predict recovery time for Black versus White targets following a hardship.

1.3 Sleep and Empathy

With an abundance of existing research supporting relationships between empathy, racial ingroup versus outgroup affiliation, and perceptions following a hardship, we were additionally interested in how empathy might change. As a cognitively intensive task, empathy often varies as a function of cognitive load and available resources. One well-studied factor that plays into cognitive load is sleep. Significant previous research has linked empathy levels with sleep quality. Guadagni et al. examined whether sleep deprivation decreases the ability to experience emotional empathy toward others¹⁶. These researchers assigned each participant to one of three groups: (1) before and after a night of total sleep deprivation, (2) before and after a usual night of sleep spent at home, and (3) tested twice during the same day. Participants were administered pre- and post-measurements of direct and indirect emotional empathy. Interestingly, these researchers found the post measurements of both direct and indirect emotional empathy of participants in the sleep deprivation group were significantly lower than other conditions, suggesting that sleep deprivation is linked to lower levels of

empathy. Guadagni and their colleagues replicated a similar version of this study in 2016, finding evidence of a significant relationship between individuals' quality of sleep and their ability to share the emotions experienced by others¹⁷.

1.4 Current Experiment

Existing literature suggests that relationships may exist between White participants' evaluations of White versus Black targets and their subsequent empathy and pain/social perceptions; however, there is a gap in current literature about whether these perceptions extend to hardship recovery time perceptions that are made by non-medical professionals. Current literature related to race and recovery-related perceptions focuses primarily on medical contexts, but medical recoveries affect nearly every dimension of an individual's life; for instance, allocating accommodations at school/work, family responsibilities, and social commitments. The present study aims to see if racial biases exist among laypeople's perceptions of recovery after an individual experiences a common hardship, and whether this relationship is mediated by empathy for the target and/or mediated by sleep quality. This research has implications for employment, education, law, and social settings.

We were interested to see if the racial biases in pain perception found by Hoffman & Trawalter extend to perceived hardship recovery time (HRT), and whether racial biases in resource allocation needs found by Deska et al. extend to perceived HRT, such that people will perceive longer HRT for White targets and shorter HRT for Black targets^{7;11}. We made this association because pain perception, supportive resource needs, and HRT are all judgments that an individual can make about someone who has experienced a hardship and thus may all be influenced by similar biases in evaluation.

Additionally, we were interested to see if state empathy differs based on racial ingroup versus outgroup affiliations. Based on findings from Neumann et al. and Azevedo et al., we predict that participants will have higher state empathy scores for same-race targets than for other-race targets^{13;14}. Further, findings from Drwecki et al. suggest that empathy may be a mediator between the race of the target and perceived HRT¹⁵.

Furthermore, findings from Guadagni et al. and Guadagni et al. suggest that sleep quality directly relates to empathy, such that sleep deprivation is linked to lowering empathetic processing capabilities^{16;17}. Thus, we wanted to account for sleep quality as a moderator between race condition and state empathy. Based on the existing literature, our research team had four hypotheses:

Hypothesis 1:

We predict there will be a main effect of race on participants' perception of hardship recovery time (HRT), such that White participants will indicate longer HRT for White targets than for Black targets.

Hypothesis 2:

Furthermore, we predict that the relationship between race conditions and perceived HRT will be mediated by state empathy for the vignette target, such that participants assigned to the White race condition (in the target's racial ingroup) will have higher state empathy scores and thus predict longer HRT for the target than participants assigned to the Black race condition (in the target's racial outgroup). We predict that perceived HRT for the target's race is determinant on the participant's state empathy for their assigned target and that the relationship between race and state empathy will be significant.

Hypothesis 3:

We predict that the relationship between vignette target race and HRT will be moderated by sleep quality, such that perceived HRT differences between the White and Black conditions will be smaller for participants with a higher sleep quality and larger for participants with lower sleep quality.

Hypothesis 4:

Finally, we predict that the mediation model will be moderated along a path by participant sleep quality, such that the mediation model will be weaker for participants with a higher sleep quality and stronger for participants with lower sleep quality.

The present experiment sought to understand the interplay of race, empathy, and participant sleep quality as they relate to the evaluation of a target's recovery time. Participants were presented with a vignette depicting either a White or Black target undergoing a significant hardship and then were asked to estimate how long that target's recovery would take using a novel measure designed for this study. Following, participants were asked to evaluate how much they were able to empathize with the vignette target using a standard measure of state empathy for the target. Participants were also asked to report the quality of their sleep using an established scale. Including these variables offered a more comprehensive approach than previous research and allowed us to explore potential mechanisms for racial empathy biases while investigating potential points of intervention to mitigate these biases.

2 METHODS AND MATERIALS

2.1 Participants

We recruited 142 American participants for an experiment via Connect, an online recruitment hosted on Amazon's CloudResearch¹⁸. All participants were compensated \$0.50 through Connect for a survey that took approximately 3-7 minutes. We excluded nine participants for not identifying their race as White/European American in keeping with our exclusion criteria. All participants passed our attention check, recalling what happened to the target in the vignette and indicating that their data would be used for research. Our final sample included 133 participants. Participants' sex assigned at birth was 50.4% male and 49.6% female, and participants' gender identity was 48.9% men, 48.1% women, 1.5% nonbinary, and 1.5% declined to share. The final sample was entirely White based on the exclusion criteria for our experiment. The participants' ages ranged from 19 to 75 ($M_{\text{age}} = 39.31$, $SD_{\text{age}} = 11.73$).

A sensitivity analysis in G*Power¹⁹ indicated that this sample size ($N=133$) was powered to detect a small to medium effect (Cohen's $d = 0.43$, $\alpha = 0.05$, $\beta = 0.80$) or greater for an independent-samples t-test with 80% power.

2.2 Materials

Vignette

Participants read one of two vignettes during the experiment. The vignettes included basic information about a target named 'Alex,' including their age, race, and city of residence. The vignettes described an incident and subsequent consequences for Alex. Across both conditions, all information in the story except the stated race of the target (White versus Black) was consistent:

"Alex, a 32-year-old [White/Black] American living in Denver, was sitting at a red light waiting for the light to turn. Their car was rear ended at a moderate speed by another driver who was not paying attention. Alex sustained a concussion, moderate whiplash, and some minor bruising. Alex felt a variety of emotions during this incident and after."

Novel Perceived Recovery Time Measure

After viewing the vignette, participants answered a series of novel questions that were developed for this study that sought to evaluate participants' perceptions of how long it would take the target to recover from the incident in the vignette. The novel measure of perceived hardship recovery time (HRT) included the following four questions: "How much time do you think is reasonable to take off from work following this accident?", "How long do you think it will take this person to get

back to normal daily activities?”, “For how long do you think this event will have a major impact on this person’s physical abilities?” and “For how long do you think this event will have a major impact on this person’s mental health?”. These questions were evaluated using a multiple-choice question ranging from “1 day” to “1 year+” with eight total choices. These were collated into a summed composite variable with higher scores indicating longer expected HRT ($M = 16.29$, $SD = 4.90$). This novel demonstrated strong internal validity within our sample (Cronbach’s $\alpha = .82$).

Individual Difference Measures

State Empathy Scale. Following the experimental manipulation and measurement of the anticipated character recovery time, participants completed two individual difference measures. The first of these was the State Empathy Scale (SE), which evaluates the level of state empathy that participants had for the character they read about in the vignette²⁰. The SE scale has twelve total items and is broken down into three subscales of four questions each: the affective empathy subscale (“I can feel Alex’s potential emotions”), the cognitive empathy subscale (“I can understand what Alex is going through in the story”), and the identification subscale (“I can identify with Alex in the story”). Each individual item is then evaluated on a scale from “Not at all” to “Completely” with five total options. These answers can then be summed into a composite score for the scale in aggregate or for the individual subscales, with higher scores indicating greater state-level empathy for the target ($M = 42.0$, $SD = 9.43$). The total composite scale showed very strong internal validity in our sample ($\alpha = .91$).

Sleep Quality Scale. The second individual difference measure was the Sleep Quality Scale (SQS), which evaluates six domains of sleep quality – daytime symptoms, restoration after sleep, problems initiating and maintaining sleep, difficulty waking, and sleep satisfaction – over the past month²¹. The SQS consists of 28 items and is divided into six “factors” or subscales. Every item in subscales two and five are reverse scored. All items are scored on a four-point Likert scale ranging from “few” to “almost always,” with guidance being given for how to respond based on how many days participants identified with an item in a given week. Sample items from the scale include “I fall into a deep sleep” and “Poor sleep gives me headaches.” These items are then summed for a composite variable with higher scores indicating higher quality sleep ($M = 59.17$, $SD = 16.01$). In our sample, the scale showed very strong internal validity ($\alpha = .94$).

2.3 Procedure

Participants were recruited through the Connect online platform¹⁸ and took the questionnaire via Qualtrics survey software. Participants were first directed to an implied consent form. If they did not consent, they were sent to the end of the survey. Participants who did consent to the experiment were randomly assigned to one of two vignette conditions (White target or Black target). Participants were instructed that in the first part of the survey, they would read a story describing a situation and then would then be asked a series of questions about this situation and the person in it. Participants were instructed to rely on their “gut instinct” when selecting an answer, as there are no “right” or “wrong” answers. Participants were then presented with their assigned vignette condition detailing a minor car accident at a traffic light and made ratings of their perceptions of the target’s recovery time, which were measured through a novel scale. Participants then completed the State Empathy Scale and the Sleep Quality Scale to measure individual differences^{20,21}. After completing both scales, participants completed an attention check question asking what happened to the target in the vignette. After completing the attention check, participants answered a series of demographic questions, including sex assigned at birth, current gender identity, racial identity, age, and education status. All data collection was completed in May 2024.

3 RESULTS

We conducted a series of exploratory correlational analyses to test the connections between our constructs. As shown in Table 1, the relationship between sleep quality and state empathy was not significant, $r(131) = .13$, $p = .141$. The relationship between perceived recovery time and sleep quality was not significant, $r(131) = .13$, $p = .132$. Perceived recovery time and state empathy were significantly correlated with one another, $r(131) = .18$, $p = .039$. This is a weak positive correlation.

	Mean	SD	HRT	SE Scale	SQS	Race Condition
HRT	16.29	4.90	1			
SE Scale	42.0	9.43	.179*	1		
SQS	59.17	16.01	.131	.128	1	
Race Condition	1.51	0.50	.197*	-.129	.039	1

Table 1 Correlation table of individual difference measures and their association with race condition (1 = White, 2 = Black) (* = $p < .05$)

We first tested our hypothesis that there would be a main effect of the race of the vignette target on participant-rated HRT such that participants who saw a Black target would perceive shorter recovery times than those who saw a White target. We conducted an independent-samples t-test comparing the average recovery time perceptions for the two race conditions.

This analysis yielded a significant effect of target race on HRT, $t(131) = -2.31, p = .011$, 95% CI [-0.74, -0.06], $d = -0.40$. People who were in the White vignette condition ($M = 15.31, SD = 4.86$) perceived a shorter recovery time for the target than people who were in the Black vignette condition ($M = 17.24, SD = 4.78$). Next, we looked at our second hypothesis of whether participants' state empathy toward the vignette target differed based on the race of the target. We conducted an independent-sample t-test comparing participants in the White target condition and participants in the Black target condition on state empathy scores. Although the analysis was approaching significance, there was not a significant effect of target race on empathy for the target, $t(131) = 1.49, p = .139$, 95% CI [-0.80, 5.64], $d = .26$. Participants in the White target condition ($M = 43.23, SD = 8.26$) had directionally, but not significantly, higher state empathy scores for the vignette target, Alex, than participants in the Black target condition ($M = 40.81, SD = 10.35$).

To examine the relationship between race and recovery time further, we conducted a moderation analysis to see if sleep quality moderated the relationship between race condition and perceived recovery time using the PROCESS Macro in SPSS²². In the analysis, perceived recovery time was regressed on to race condition, sleep quality, and their interaction. Race condition and sleep quality were mean-centered before conducting the analysis. Although the overall model trended towards significance, it was not significant, $F(3, 129) = 2.52, p = 0.061$. The analysis further indicated the main effect of race condition remained significant, $b = 1.88, t(129) = 2.25$, 95% CI [0.23, 3.53], $p = 0.026$, however, there was no significant main effect of sleep quality, $b = 0.68, t(129) = 0.81$, 95% CI [-0.10, 0.23], $p = 0.421$, nor a significant interaction between sleep quality and race condition on perceived hardship recovery time, $b = -0.02, t(129) = -0.37$, 95% CI [-0.12, 0.08], $p = 0.709$.

To investigate our third hypothesis, we tested whether the relationship between race condition and state empathy toward vignette target was moderated by participant's reported sleep quality, such that state empathy differences between the White and Black race conditions will be smaller for participants with a higher sleep quality and larger for participants with lower sleep quality. We conducted a moderation analysis via PROCESS Macro²² in which state empathy scores were regressed onto race condition, sleep quality scores, and their interaction. Race condition and sleep quality were mean-centered before calculating the interaction term. The overall model was not significant, $F(3, 129) = 1.80, p = .151$. This analysis indicated no main effect of sleep quality, $b = -.06, t(129) = -0.35$, 95% CI [-0.38, .26], $p = .729$ and no significant main effect of race condition, $b = -2.52, t(129) = -1.55$, 95% CI [-5.73, .69], $p = .123$. There was no interaction between sleep quality scores

and race condition, $b = .09, t(129) = .88$, 95% CI [-0.11, 0.29], $p = .383$.

Finally, to test our fourth hypothesis, we conducted a statistical mediation analysis with 5,000 bootstrapped resamples (PROCESS Macro²²) to examine whether state empathy scores mediated the effect of randomly assigned vignette viewing conditions (1 = White; 2 = Black) on HRT. The 95% CI for the indirect effect included zero, $b = -0.26$, 95% CI = [-.85, .08], indicating the mediation model was not significant (see Figure 1 for all pathways).

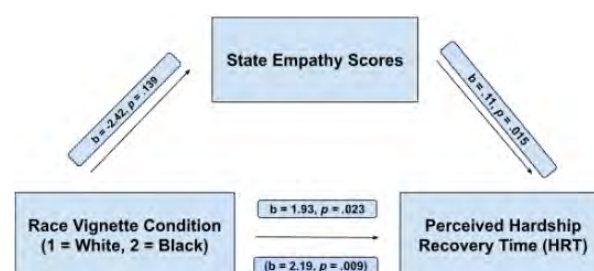


Figure 1. Mediation diagram depicting hypothesis 3 of the study with the individual statistics of each of the pathways of the mediation in addition to the indirect effect pathway.

4 DISCUSSION

4.1 Summary of Results

Our findings suggest that Black individuals are perceived to take longer to recover from a relatively common hardship than White individuals, and that individuals may have more empathy toward people in their racial ingroup than racial outgroup. Our findings contradict our first hypothesis and previous literature. We predicted that participants would perceive longer hardship recovery time (HRT) for White targets than Black targets based on previous research findings that Black individuals have a higher pain tolerance⁸, feel less pain¹⁰, and require fewer supportive resources to cope with socially painful events¹¹ than White individuals. We hypothesized that HRT perceptions would parallel literature regarding perceptions of pain and supportive resource needs, as all are judgments that can be made following a hardship. Instead, we found that participants perceived shorter recovery times for the White targets than the Black targets.

Additionally, our findings suggest that higher state empathy is shown for White targets than Black targets among the White sample, which is supported by previous literature. We predicted that the relationship between race conditions and perceived HRT would be mediated by state empathy for the vignette target, such that participants assigned to the White race condition (in the target's racial ingroup) would have higher state empathy scores and thus perceive longer HRT for the

target. We formed this hypothesis based on previous research findings that people may have higher empathy for those in their racial ingroup^{13;14} and favor White (versus Black) targets in state empathy and treatment biases from pain expressions¹⁵. Our results indicated a slight inclination towards support of this previous literature, but it was not significant. We did not find any relationships between sleep quality and empathy toward the target. This contradicted the third and fourth hypotheses and previous literature suggesting that lower sleep quality is linked to lowering empathetic processing^{16;17}.

4.2 Contradictions Within Literature

Our findings align with some existing literature. For instance, Johnson and colleagues found that people perceived individuals of low socioeconomic status (low-SES) as requiring more coping resources and support in painful social situations compared to their high-SES counterparts²³. The researchers suggested that empathetic concern for low-SES individuals heightened perceptions of their social pain and increased expectations that they would need more support to handle difficult circumstances. This differs from our hypothesis that people would show more empathy towards their racial ingroup. Instead, Johnson and their colleagues found that empathetic concern was associated with those perceived as less advantaged in daily life²³. Given that all our participants identified as White in the present study, they may have perceived Black individuals as less advantaged or underprivileged. This perception could explain why our participants attributed longer recovery times to Black targets, contrary to our initial hypotheses, as participants may have speculated that Black targets lacked resources or faced other societal boundaries which led to longer expected recovery times. In contrast, participants may have perceived White targets as having greater advantages and access to resources, thus needing less time to recover.

The present study addresses a gap in the literature about how laypeople perceive the time needed to recover from a hardship, as current literature about target race and recovery perceptions focuses on medical contexts. Further research is needed in this field to draw further conclusions about the relationships between race, empathy, and HRT.

4.3 Implications

This research makes important contributions to the study of race, empathy, and social perceptions related to hardship recovery time (HRT) and has implications for theoretical and practical contexts.

Our findings in the present study both align and contrast with current literature about pain and hardship

perceptions, which has theoretical implications for the current literature. The variance in findings and interpretations between the present study and existing literature suggest there may be other variables that affect the relationship between race, empathy, and recovery time. For instance, judgments about recovery time may vary across regions of the United States, depending on the type of hardship endured and attitudes about time as a resource. One important implication is that further research is needed to investigate these variables and how they may interact with the findings of the present study.

Practically, our findings have implications across domains where judgments about recovery time among laypeople can significantly impact individuals' lives. In workplace settings, employers making decisions about time off or accommodations following an injury or accident may be influenced by biased perceptions of recovery needs based on an employee's race. In educational contexts, differences may exist among teachers or administrators allocating extensions or accommodations to students recovering from hardships. In healthcare, expectations among medical professionals about recovery time may influence treatment trajectories that differ between racial groups. Ultimately, these biased perceptions of recovery time may contribute to broader racial disparities. For instance, if Black individuals are consistently expected to need longer recovery times following a hardship, this could reinforce stereotypes about being less capable of coping with adversity, potentially leading to reduced opportunities across social and professional contexts.

Our research also has implications for implementing recovery time perceptions in diversity training curriculums. In the present study, we found that individuals perceived longer recovery times for Black targets than White targets; training programs may need to specifically address stereotypes around recovery times and accommodations following hardships across racial groups. One way to address this is for workplace and educational settings to standardize recovery-related accommodations, such as sick time or leave for workers. This will help mitigate the impact of individual racial biases among teachers and employers and create more equitable opportunities for students and employees across racial groups. Additionally, having diverse representation in leadership roles within institutions where decisions about recovery time are made is an important implication of this research, as we found that White individuals tend to perceive necessary recovery time differently for individuals of different races.

The present study makes contributions to the literature on racial biases in hardship recovery perceptions, but emphasizes the complexity of racial biases. Our findings both align with and contradict the current literature, emphasizing the need for further research in this

field. Addressing biases in recovery time perception is important for ensuring equitable treatment across racial groups in domains such as healthcare, employment, education, and social life.

4.4 Limitations

It is important to note that our study has limitations. Although the State Empathy Scale is a validated scale that showed very strong internal validity in our sample ($\alpha = .91$), there were some items that did not fully translate to the vignette scenario²⁰. For example, item 8 asks “Alex’s reactions to the situation are understandable,” but our vignette vaguely states, “Alex felt a variety of emotions during this incident and after.” A few items from the State Empathy Scale required participants to infer Alex’s scenario beyond what was stated in the vignette, which may have been confusing for some participants²⁰.

A second limitation is that sleep quality is more accurate when measured physiologically compared to self-report. While the SQS is comprehensive and showed very strong internal validity in our sample ($\alpha = .94$), using biological measures to index sleep quality yields more accurate results²¹.

A third limitation is that the present study used an all White sample. While this allowed us to have equal representation in both conditions, it greatly limits the generalizability of our results to a racially diverse society.

Furthermore, our manipulations were limited to only Black and White vignette targets. Thus, the results from the present experiment are not inclusive of interracial individuals. Additionally, since Black and White vignette target manipulations are common in the social psychology realm, it is possible that participants may have inferred our experimental conditions and guessed at hypotheses surrounding the relationship between race and recovery time.

Lastly, although we were adequately powered to find a statistical effect, we only found a significant effect from the t-test. Having a larger sample would have made us more adequately powered to detect higher order effects, such as the mediation and moderation effects that we initially hypothesized.

4.5 Future Directions

In future studies, we recommend that sleep quality is measured physiologically rather than self-reported. For instance, conducting an explicit sleep manipulation by having a “sleep deprivation” condition to compare to either a control/“well-rested” condition. Though we recognize that lab studies have limitations, measuring sleep physiologically would allow for a better operationalization of sleep quality. Perhaps, through these

measures, we would find results that better reflect the literature that suggests sleep quality is positively correlated with state empathy¹⁶, as well as our hypotheses from the present experiment that perceived HRT differences between the White and Black conditions will be smaller for participants with a higher sleep quality and larger for participants with lower sleep quality.

Furthermore, we recognize the perpetuated myths and over-exaggerations in the United States regarding racial minorities’ use of social welfare programs and how this may impact perceived recovery time – wherein those who believe racial minorities to struggle is ‘expected’ and that they would need more recovery time and support than someone they can better relate to. In order to parse the relationship of recovery time and the expectation of using welfare programs, we encourage future research to develop a scale looking at the expected use of welfare programs for both conditions and seeing whether that has a relationship with perceived recovery time. A potential hypothesis for this experiment would be that participants who see a minority vignette target would rate them more likely as taking advantage of social welfare programs due to the prevalent view that minority groups, especially Black people, are primary recipients of welfare²⁴. Furthermore, if minority groups are more highly rated as being expected to be welfare recipients, we expect future results to resemble what we found in this study, wherein we believe those who are rated to be higher in likelihood of receiving welfare support would also have longer recovery times. This would be reflective of the literature, where Johnson et al. have found that lower-SES individuals are seen as needing more social support to recover from painful social situations²³. It would also be within our interest to investigate how participants may be conflating race with a target’s SES when thinking about target recovery time, as this relationship could be influencing results outside our predictions.

As the current literature has mixed findings about racial biases in resources needed following a hardship, future research should expand upon why participants perceived longer recovery times for Black targets compared to White targets. Future research should consider racial perceptions in the expected use of welfare or social programs. There are pervasive cultural myths in the United States about racial minorities’ use of social welfare programs; exploring if these myths relate to perceptions of recovery time may shed light on other implicit biases. If participants perceive someone in a racial minority group to take more advantage of social welfare programs, we hypothesize that they additionally will predict a longer hardship recovery time compared to a White counterpart.

Additionally, it is possible that participants in the present study rated Black targets to need longer recovery time due to an overcorrection of implicit racial bi-

ases they have. Some Americans have anxiety about being racist, and, therefore consider that the research study may be testing for racial bias, ultimately over-correcting or overthinking their initial reaction to the survey.

A final direction to explore is how individuals perceive recovery time for targets beyond Black and White identities. Based on findings from the present experiment, we predict similar results for other racial minorities, such that non-White targets would be perceived to have longer recovery times than White targets. Although the effects of state empathy on recovery time were not significant, it was pointing in the direction of significance, so it would be of value to revisit this relationship and further explore the potential behind it.

5 CONCLUSION

The results of the current experiment suggest that while humans do evaluate one another differently on the basis of race following a hardship, there is still work to be done in figuring out why these differences exist and through what different mechanisms they may occur. The findings still have significant implications for fields like management and medicine where individuals may be evaluated in similar contexts to the one in this experiment, and real-life decisions must be made about the logistics of their recovery. Understanding that there are biases in our evaluation of recovery time for others is critical to ensuring equitable practices in these fields. Future research could expound on the mechanisms and reasons why these relationships exist and how the evaluation of hardship recovery across racial groups may differ from other phenomena in the literature, such as pain perception or medical treatment. To conclude, this work furthers understanding of how racial identities impact our evaluation of others. While there is still further research needed to understand these biases and how we might mitigate them in practical application, the present study makes interesting theoretical and practical contributions to the literature, filling a gap in the literature about racial biases in lay persons perceptions of hardship recovery time.

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7 AUTHOR NOTE

Authors contributed equally. We have no conflicts of interest to disclose.

8 EDITOR'S NOTES

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Appendix A

Research Materials

Hardship Recovery Time Index

1. How much time do you think is reasonable to take off from work following this accident?
2. How long do you think it will take this person to

get back to normal daily activities?

3. For how long do you think this event will have a major impact on this person's physical abilities?
4. For how long do you think this event will have a major impact on this person's mental health?

All items were responded to on a scale including 1(1 Day), 2(3 Days), 3(1 week), 4(2 weeks), 5(1 month), 6(3 months), 7(6 months), 8(1 year).

State Empathy Scale

1. Alex's emotional response is genuine
2. I experienced the same emotions as Alex may have when reading this story
3. I was in a similar emotional state as Alex when reading this story
4. I can feel Alex's potential emotions
5. I can see Alex's point of view
6. I recognize Alex's situation
7. I can understand what Alex was going through in the story
8. Alex's reactions to the situation are understandable
9. When reading the story, I was fully absorbed
10. I can relate to what Alex was going through in the story
11. I can identify with the situation described in the story
12. I can identify with Alex in the story

All items were answered on a Likert scale including 1 "Not at all", 2 "A little", 3 "A moderate amount", 4 "A lot", and 5 "Completely".

Sleep Quality Scale

1. I have difficulty falling asleep
2. I fall into a deep sleep
3. I wake up while sleeping
4. I have difficulty getting back to sleep once I wake up in the middle of the night
5. I wake up easily because of noise
6. I toss and turn
7. I never go back to sleep after awakening
8. I feel refreshed after sleep
9. Poor sleep gives me headaches
10. Poor sleep makes me irritated
11. I would like to sleep more after waking up
12. My sleep hours are enough
13. Poor sleep makes me lose my appetite
14. Poor sleep makes it hard for me to think
15. I feel vigorous after sleep
16. Poor sleep makes me lose interest in work or others
17. My fatigue is relieved after sleep
18. Poor sleep causes me to make mistakes at work
19. I am satisfied with my sleep

20. Poor sleep makes me forget things more easily
21. Poor sleep makes it hard to concentrate at work
22. Sleepiness interferes with my daily life
23. Poor sleep makes me lose desire in all things
24. I have difficulty getting out of bed
25. Poor sleep makes me easily tired at work
26. I have a clear head after sleep
27. Poor sleep makes my life painful

Participants were instructed to answer the questions using the following guide: “Rarely: None or 1-3 times per month”, “Sometimes: 1-2 times per week”, “Often: 3-5 times per week”, “Almost Always: 6-7 times per week”

Manipulation Vignette

“Alex, a 32-year-old [White/Black] American living in Denver, was sitting at a red light waiting for the light to turn. Their car was rear ended at a moderate speed by another driver who was not paying attention. Alex sustained a concussion, moderate whiplash, and some minor bruising. Alex felt a variety of emotions during this incident and after.”



The Pop by Dmitri Scal

“In ‘The Pop,’ I aimed to freeze that exact kind of moment—when something mundane suddenly becomes visually striking. The subject and setting come together in a brief burst of energy that might otherwise go unnoticed. The image focuses on a seemingly ordinary scene, yet there’s a vibrant disruption within it—a literal and metaphorical ‘pop’ that grabs the viewer’s attention.”

Exploring the roots of Republican factionalism in contemporary U.S. politics

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Abstract

The Republican Party has experienced significant internal divisions in recent elections, with the 2024 Presidential Primary revealing a party divided between two factions: Donald Trump's followers, often referred to by his "Make America Great Again" (MAGA) slogan; and those that adhere to traditional Republican values that have defined the Grand Old Party (GOP) for decades. While MAGA Republicans still espouse conservative social values, they break away from the party when it comes to their "America First" ideology, another popular Trump slogan. The United States has long been a leader on the world stage, a position that both Democrats and Republicans have found useful to the nation's foreign policy agenda. However, Trump's supporters believe the U.S. government should be more focused on domestic issues and advocate for the country's withdrawal from international treaties and global initiatives. Although this divide points to a difference in financial and political priorities, it fails to explain where such a divide originated. The following paper explores how educational attainment influences ideological leanings and candidate preferences within the party, with a particular focus on the 2024 primaries. Through polling data and historical analysis, I conclude that educational attainment significantly shapes these divisions, finding that recent populist rhetoric has exacerbated this divide. While college-educated Republicans tend to favor traditional GOP values and candidates like Nikki Haley, those with lower levels of educational attainment are more likely to rally behind Donald Trump's brand of populist nationalism and identity politics. This educational divide has broad implications for the future of the Republican Party and the ideological trajectory of American politics, particularly in regard to recent polarization within and between the Democratic and Republican parties.

Keywords: Republican Party, Educational Attainment, Political Ideology, Factionalism, 2024 Presidential Primary, Diploma Divide, Populism, Identity Politics

1 INTRODUCTION

Internal divisions within the Republican Party, or Grand Old Party (GOP), have become increasingly pronounced, with the 2024 primaries making it clear that the party is divided into two factions. The MAGA Republicans, staunch advocates of nationalist policies, overwhelmingly showed out to support Donald Trump at the polls, giving him 2,242 Republican delegates¹. However, a smaller sector of Republicans didn't support the frontrunner, adhering to the party's platform from a decade ago that advocates for limited government, law and order, and an interventionist foreign policy agenda. These voters found Nikki Haley to be a better candidate, giving her 95 delegates. Because Haley dropped out of the race before every state had voted, these numbers do not reflect her true base of support, although they exemplify Trump's position as the Repub-

lican frontrunner. While both candidates maintained a commitment to fiscal and social conservatism, their approaches to key policy issues diverged significantly, and they presented contrasting visions of the party's future.

Education level as a determinant of political behavior is a telling factor in understanding the ideological divisions within the Republican Party. Through an analysis of the 2024 presidential primary, this paper aims to explain disparities in educational attainment as a factor in the current division within the Republican Party. Educational attainment refers to the level of education one has achieved. By examining how educational background shapes attitudes towards policy issues, the paper seeks to provide insight into the underlying forces driving factionalism in modern American politics. The findings reveal that the division within the 2024 Republican Party is significantly influenced by the educational at-

tainment of its members, or a divide between those with and without a college degree. By investigating ideological differences that emerge from the educational divide, the following paper finds that Republican voters with at least a bachelor's degree are more inclined to favor traditional GOP policies, whereas individuals with a lower level of educational attainment support Donald Trump and the policies for which he advocates.

2 RESEARCH BODY

2.1 Understanding Divisions within the Republican Party

The 2024 political landscape reveals a Republican Party divided into two: those who support Donald Trump and those who still adhere to a more traditional GOP political ideology. This phenomenon is reflected in disagreements between party leaders and Trump, and among voters on social media, where Trump's followers are quick to attack anyone they view as part of the conservative establishment. Supporters of the former president are often referred to as MAGA (Make America Great Again) Republicans and have an ideology rooted in the nationalist principles championed by Donald Trump during his presidential campaigns and time in office. This ideology, often referred to as "America first," emphasizes a strong stance on issues such as immigration, trade, and national security, favoring policies that prioritize American interests over global cooperation. MAGA Republicans often advocate for restrictive immigration policies, including extensive border security measures and stricter enforcement of immigration law.

The "America first" ideology is reflected in their economic stance as well, with a prioritization of protectionist trade policies to support domestic industries and create jobs. By focusing on production within the United States, this faction hopes to strengthen the workforce and use American labor to encourage domestic prosperity rather than importing goods from abroad. MAGA Republicans frequently express skepticism towards mainstream media and political elites as well, championing those who challenge the status quo. This distrust leads them to advocate for candidates who lack a well-known political history, as evidenced by their support of Donald Trump, who presents himself as a political outsider and someone with few allegiances inside the government. For many Americans, this means that he will prioritize the people over private political interests. Socially, however, MAGA Republicans are more aligned with traditional conservative values, including opposition to abortion procedures and support for Second Amendment rights (the right to bear arms). Despite this alignment, there is a willingness among elected Republicans to "push back on Trump,

the lies about the 2020 election, and the January 6th insurrection ... [reflecting] a source of division outside the usual ideological parameters"². A significant number of these Republican leaders express concern over the more populist and nationalist aspects of MAGA ideology, particularly its approach to foreign policy issues. Since World War II, the Republican Party has advocated for military dominance on the world stage, a form of "hard power" that emphasizes an interventionist foreign policy agenda. This strategy often brought the US into regional conflicts not directly related to national security or trade interests. Republicans were also interested in building international influence through the use of "soft power," or non-violent intervention that expands a country's influence through humanitarian aid, the creation of treaties, cultural influence, and other non-violent means of engaging with foreign entities. This soft power was particularly popular among Republicans during the Reagan Era, when it was used to fight the expansion of the Soviet Union.

The use of hard and soft power remains a fixture of traditional Republican foreign policy in 2024, particularly when supporting Democratic governance across the globe. Senate Minority Leader Mitch McConnell is just one example of a traditional Republican Party leader who adheres to these principles. In a recent interview with CNN, the senator commented on his support of sending US aid to Ukraine to combat the spread of Russian influence. However, he has faced backlash on this position from the MAGA faction, whose members believe that such resources should be directed towards domestic programs and infrastructure. When speaking to CNN, McConnell said that this is "a political reaction led, obviously, by the likely nominee for president"³. The staunch opposition McConnell has faced from MAGA Republicans on the issue of foreign aid points to a significant policy difference within the Party, although Trump's campaign platform remains a pivotal factor in drawing support away from traditional Republican perspectives.

Despite diverging on certain policy areas, both groups of the Republican Party adhere to fiscal and social conservatism, an ideology that prioritizes limited government spending, deregulation, constitutional rights, traditional family values, and religious influence in the political sphere. These commonalities suggest that additional factors underlie the origins of Republican factionalism. Before Donald Trump entered the political arena, the Republican Party appeared aligned on foreign policy priorities, with "Presidents Ronald Reagan and George W. Bush [putting] freedom and democracy at the heart of their worldview" by supporting "United States alliances and [embracing] free trade"⁴. However, the emergence of "America first" rhetoric has disrupted this previously cohesive stance on foreign affairs. While the two factions may disagree

on foreign policy priorities, the divide seems to be a symptom of the “America First” ideal that MAGA Republicans espouse, rather than the root cause of the division.

The rise of the MAGA movement reflects a shift in the party’s base, where Republican voters without college degrees gravitate towards candidates that focus less on international issues and more on domestic concerns, often connecting with politicians that exhibit populist behavior. Conversely, traditional conservatives, usually with higher degrees of educational attainment and economic resources, continue to support traditional conservative policies, viewing them as essential for national security and international economic stability. Thus, educational attainment can be pointed to as a key factor driving Republican factionalism, influencing perspectives on a range of issues beyond foreign policy. Understanding these educational divides is essential to comprehending the full scope of Republican factionalism in 2024.

2.2 Educational Attainment and the 2024 Republican Primaries

Numerous studies have shown a strong correlation between educational attainment and party affiliation, with higher levels of education generally associated with a greater likelihood of identifying with the Democratic Party. In fact, “between 2000 and 2020, the percentage of a county’s population with a BA is one of the strongest predictors of changes in vote share, with highly educated counties becoming more Democratic and less educated counties becoming more Republican”⁵. Multiple factors have been pointed to as explanations for this trend, such as the emphasis on education and intellectualism within the Democratic Party, exemplified by its support for public education and funding scientific research. This separation is present within the parties and played a significant role in the 2024 election cycle. Donald Trump’s ability to resonate with a segment of the U.S. characterized by lower levels of education has played a crucial role in his political career and contributed significantly to the division within the Republican Party. This influence was notably evident during the 2024 Republican Presidential Primary, where the candidate embodying more traditional GOP values garnered significant votes from college-educated individuals, while Donald Trump remained popular with voters of lower level of educational attainment⁶. Trump’s ability to attract support from voters with lower educational attainment was abundantly clear during the 2024 Primaries, where voters had the option to choose between two candidates who are widely thought to embody the current Republican factions. Nikki Haley, a former UN Ambassador and career politician, holds many traditional GOP values, while Trump is consid-

ered the head of the new MAGA movement within the party.

Donald Trump was widely perceived as the frontrunner of the 2024 Republican Presidential Primaries before the contest began, leaving Nikki Haley with the challenge of attracting supporters away from his camp. This means that, when comparing the votes each candidate received, Trump significantly outperformed Haley with college-educated supporters, as he did with every demographic. Of the 2,349 Republican delegates, 2,242 of them went to Trump, exemplifying his position as the Party’s favorite¹. Because Trump received broad support from the moment he entered the race, Haley had to connect with Republican voters that were looking for an alternative to the frontrunner. She was most successful with college-educated Republicans, indicating that this demographic continues to align with traditional GOP ideology. Not only has this group been the largest to embrace Nikki Haley’s message, but they were also among the last Republicans to accept Donald Trump into the party⁷. Such attitudes towards the political newcomer suggest that Republicans with high levels of educational attainment are at odds with Donald Trump’s brand of populism and proposed policies.

The New York Times’s first poll on the Republican primary was released in July 2023 and found that “a quarter of Republican voters said they were not open to supporting Donald J. Trump,” with the majority of that group being highly educated constituents that support immigration reform and aid to Ukraine, some of the key policy areas of disagreement between traditional Republicans and those that subscribe to the MAGA movement⁸. This data was further reflected on Super Tuesday, with twenty-two percent of the vote going to Haley, whose “strongest performance came in cities, college towns and suburbs”⁹. Furthermore, exit polls across the United States depict Trump as performing well among voters without a college degree, while Haley drew significant numbers of college-educated Republicans, as seen in every state included in Graph 4. Although Trump retained many college-educated voters, he was largely considered to be the Republican frontrunner throughout these primaries, and Haley had to pull voters away from his base of support. The fact that she was most successful in doing so with degree-holding Republicans alludes to a split in the party along educational lines. Such trends underscore the preferences of college-educated GOP voters, suggesting that they are actively seeking alternatives to MAGA ideology that more closely align with their traditional Republican values. Haley’s ability to attract this demographic indicates a demand for such policy priorities and challenges the notion that Trump’s appeal holds firm across all segments of the Republican electorate.

2.3 Historical Perspective: Variables Impacting the Trend

In order to confidently assert that level of educational attainment is a driving factor of 2024 Republican factionalism, it is important to contextualize the current GOP split by looking at the historical impacts of education on ideology. In an interview for an upcoming book on the subject, Joshua Zingher states that “our level of educational attainment says a lot more about how we vote than it did in the past. And to be specific about that, people with college degrees and/or graduate degrees have become much more democratic over the last couple of decades, but in particular the last six to eight years”¹⁰. This correlation between the Democratic Party and higher levels of educational attainment is often referred to as the “diploma divide” and is an indicator of an individual’s political preference. On the political spectrum, MAGA Republicans fall far to the right of center in their beliefs, meaning that they have more policy differences with Democrats than traditional Republicans, who tend to fall closer to the middle. The diploma divide first became a significant indicator of political affiliation in the 1990s and was on display in 2020, when Joe Biden received 15 more points from college-educated voters than Donald Trump¹¹. With the Democratic Party attracting more voters with degrees in recent decades, it is apparent that the diploma divide uncovers real ideological differences between voters who attended at least some college, and those who did not.

Higher levels of educational attainment were not always associated with the Democratic Party, however, and the New Deal core constituencies have shifted significantly since the 20th century. Initially, Democrats attracted low-income and low-education voters, while Republicans attracted the opposite: high-income, high-education voters. However, following ideological realignments since the mid-20th century, some demographics of the Democratic and Republican parties have changed: Republicans now attract high-income and low-education voters, while Democrats attract low-income and high-education voters¹². A substantial factor driving this transition is the Democratic Party’s movement away from a “predistribution” model of economics focused on protectionism, unions, and public employment, and movement towards a redistributive one that emphasizes tax-based welfare programs (Kuziemko et al.). This transition of low-education voters from the Democratic to the Republican Party suggests that the source of this educational divide within the Republican Party is due to the emergence of a new segment within the GOP, one with distinct economic policy priorities that may not align with the political right’s long-established ideology, and run counter to some policies that this traditional base supports in the present day.

One example of these conflicting policies can be found in the GOP’s evolving stance on immigration. For a party that once prioritized business interests favoring immigrant labor, it has dramatically shifted in the past decade to appeal to voters concerned with immigration, particularly from non-European countries. This rhetoric has been at the forefront of many MAGA politicians’ platforms, exemplified by Donald Trump’s 2020 presidential campaign messaging, Florida governor Ron DeSantis’ decision to transport migrants to liberal sanctuary cities (those that limit cooperation with federal immigration enforcement), and Texas governor Greg Abbott’s attempts to finish building a wall along the southern border¹³. Such ideological and demographic changes demonstrate that the Republican Party has evolved in recent years, with a noticeable divide between traditional conservative policies and the new MAGA faction. As the latter grows, understanding the historical causes of this rift is essential for those seeking to predict the future of the Party’s platform and direction.

2.4 Empirical Trends in Republican Primary Voting Behavior

While recent years have witnessed more pronounced polarization along educational lines, exit polls from previous elections reveal that educational attainment has a history of influencing political ideology. The graphs below depict this trend, with the 2008, 2012, 2016, and 2024 Republican primaries illustrating different levels of support for candidates from voters with and without a degree. Only the top two or three candidates are included for the sake of simplicity and, although data was not available for every state across all four graphs, they collectively demonstrate a clear pattern in voting tendencies. These states were chosen for analysis due to their regional diversity and early placement in the Republican primary process, meaning that fewer candidates are likely to have dropped out before voting occurred. For each Republican primary represented, the percentage of votes from non-college-educated supporters was subtracted from the percentage of votes from college-educated supporters. The following variables and equation exhibit this method:

$$P_{\text{college}} = \text{percentage of votes from college-educated supporters} \quad (1)$$

$$P_{\text{non-college}} = \text{percentage of votes from non-college-educated supporters} \quad (2)$$

$$P_{\text{college}} - P_{\text{non-college}} = \text{percentage difference between college- and non-college-educated supporters} \quad (3)$$

This method illustrates the significant difference in support a candidate received from those with a college degree than from those without, or vice versa. For example, in the 2008 Virginia primary, John McCain received 15 percent more votes from supporters with a college degree than from those without, demonstrating that his base is majority college-educated by a significant percentage. Alternatively, votes for Mike Huckabee came from a 17 percent majority of non-college-educated supporters in Virginia, indicating that he has a greater appeal to voters without a degree.

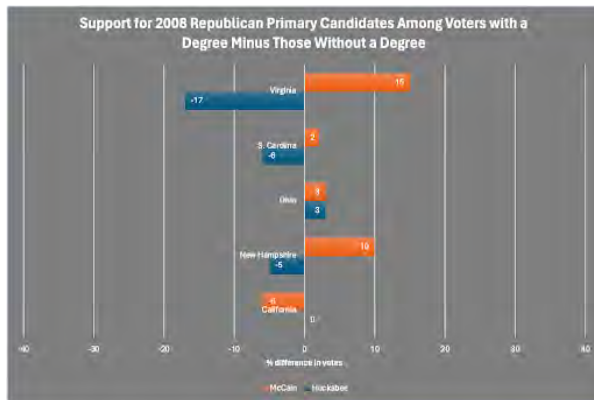


Figure 1. Source: ABC 2008 Exit Polls.

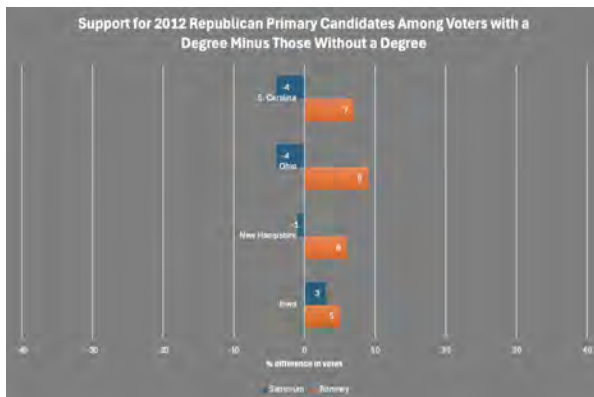


Figure 2. Source: New York Times 2012 Exit Polls

In Graph 1, the difference in support between college-educated and non-college-educated voters for McCain and Huckabee is evident, especially in states like Virginia and California, with the average difference totaling -0.1, indicating that there were slightly more voters without a degree than with one showing up to the polls. McCain garnered significantly more support from college-educated voters in Virginia, whereas Huckabee found more favor with non-college-educated voters in California. By 2012, the divide is similarly apparent in Graph 2 with Santorum and Romney, although the average is 2.63, showing that there were greater numbers of voters with a degree participating in these primaries.

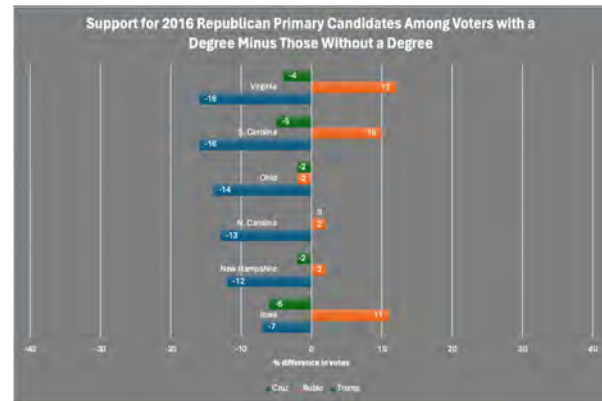


Figure 3. Source: CNN 2016 Exit Polls

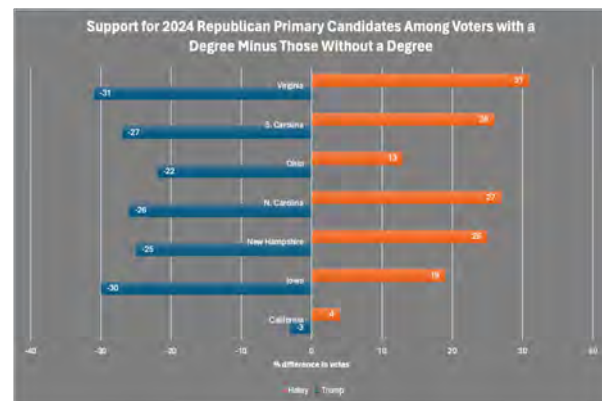


Figure 4. Source: CNN 2024 Exit Polls

Romney, often seen as the establishment-oriented candidate who adhered to the traditional Republican platform, received more support from degree-holding voters in states such as South Carolina and Ohio, while non-degree holders favored Santorum.

Graph 3 further highlights the educational divide through Republican votes for Cruz, Rubio, and Trump, where an average difference of -3.44 indicates that the number of voters without a college degree surpassed those with a degree by a significant margin. Trump received more support from non-degree holders across the board, while Rubio had better performance among voters with degrees. By 2024, Graph 4 shows that the trend has become even more pronounced. Nikki Haley, who espouses traditional conservative ideology, draws substantial support from degree-holding voters. However, Donald Trump continues to dominate among non-degree holders, showcasing an educational split in states like Virginia and the Carolinas. The 2024 average is -1.36, showing that there were more voters at the polls without a degree, but the difference was not as drastic as it was in 2016.

These graphs illustrate that the divide in educational attainment among Republican voters has not only persisted, but has intensified over the last few election

cycles. They also make it apparent that this division did not appear with Donald Trump's entry into politics, as candidates in each primary election tended to receive more support from either the college-educated or non-college-educated group across numerous states. The division along such lines within the Republican Party appear most prominent in America's latest election cycles, however, and illustrate the presence of Donald Trump as an unprecedented factor that has intensified an already existing divide.

2.5 Populism's Appeal to Non-College-Educated Voters

Many of Trump's speeches, both on the campaign trail and in the White House, use populist language to position his audience against the political establishment, rallying support for himself as a candidate who has not been part of this governing structure and is willing to dismantle it if necessary. Populist politicians appeal to the populace and condemn the system that oppresses them, presenting themselves as the solution. During Trump's 2017 inauguration speech, he told the crowd that "what truly matters is not which party controls our government, but whether our government is controlled by the people. January 20, 2017 [inauguration day], will be remembered as the day the people became the rulers of this nation again"¹⁴. While the first sentence seems to be a call for unity, the second makes it clear that he does not believe the Democratic administration before him put the people's will first. Such populist rhetoric can be divisive and has proven particularly appealing to individuals with lower levels of educational attainment. One 2016 study on the correlation found that "there is quite a strong relationship between education and the support for populism; with the less educated supporting populism much more strongly when compared with the higher educated"¹⁵. Spruyt and co-authors explain this correlation as a matter of exposure to perspectives and a voter's self-perceived identity. They argue that institutions of higher learning foster political competency that encourages individuals to vote for policies on paper, rather than the way such policies are presented.

Additionally, the authors state that identity plays a key role in one's affinity for populist candidates and "a stigmatized group will find in the empty signifier, 'the people,' a means to adopt a group perspective to interpret their social position and maintain their self-respect. Thus, the more the specific group position constitutes a core part of their identity, the more people will define themselves as part of the 'common man' and the more they will be attracted to populism"¹⁵. Those without a college degree often fall at the lower end of the socio-economic ladder and, in a capitalist society such as the United States, money is inherently tied to influence, power, and status. For a group that so often feels

powerless, the populist rhetoric present across Trump's speeches brings them together as "the people," providing membership to a formidable political force.

Although Donald Trump has used some of the most populist campaign tactics that American politics has seen in decades, he is not the only one to incorporate such rhetoric. The first populist candidate to impact America's political scene was Huey Long in the late 1800s and early 1900s. By speaking against corporations like Standard Oil and using the slogan "every man is a king," Long positioned himself as a radical reformer and champion of working people¹⁶. Many American politicians have used populist rhetoric since then, with a recent example being Mike Huckabee in 2008, who "articulated a sharp economic populism, criticizing corporations, calling for changes in U.S. trade policies, and charging that Wall Street held too much power over the nation's economy"¹⁷. As evidenced in Graph 1, Huckabee performed better among voters who did not graduate college, supporting the idea that voters without a degree tend to gravitate towards populist candidates.

A smaller, though existent, margin between voters with high and low levels of educational attainment is depicted in 2012, when there was a lack of Republican populist candidates. This correlation further alludes to a connection between populist candidates and voters without a college degree. The trend sees greatest support in 2016 and 2024, however, with Trump's clearly populist campaign winning him overwhelming support from those who did not attend college. The three candidates presented in the 2016 graph depict this trend well, with Rubio exhibiting similar traditional Republican traits as Haley's 2024 campaign, and Cruz borrowing tactics from the populist playbook, albeit not as many as Trump. Across most states, Rubio had a significant hold on the college-educated Republican electorate, while Trump and Cruz appealed to those with lower levels of educational attainment.

2.6 The Influence of Identity Politics

Identity politics are another factor that has impacted the way Republicans without a degree have voted. In a podcast discussing his upcoming paper on the topic, NBC election analyst Will Marble speaks to his recent findings and offers a compelling explanation. When researching political attitudes since the 1980s, Marble found that earlier decades did not show a significant "correlation between vote choice and issue attitudes on cultural issues among non-college educated voters," but this has changed in recent years and "conservative cultural attitudes have become more important for the vote choice of non-college educated voters"¹⁰. Where voters with lower levels of educational attainment have traditionally focused on economic policy, they now place greater weight on cultural issues. As a

result, the cultural attitudes of politicians have become more significant for this group when making their political decisions.

Trump often weaves issues of identity into his populist style of speaking, exemplifying this phenomenon. In a recent speech at an International Christian Media Convention in Tennessee, he told attendees that “the radical left ... want to tear down crosses where they can and cover them up with social justice flags”¹⁸. Appeals to identity and cultural preservation speak to voters who may feel their values and way of life are under attack, particularly for individuals with a white, Christian background. By positioning himself as a defender against the perceived liberal agenda, Trump effectively mobilizes his base through their cultural identity. Such a strategy sets these voters apart from Republicans with traditional GOP beliefs, who have a history of focusing on economic conservatism and limited government over cultural and identity issues. The divergence in priorities highlights the evolving landscape of Republican politics and helps to explain the current rift in the party, where sociocultural issues now play a pivotal role in shaping the political identities and loyalties of voters.

3 CONCLUSIONS

The division within the contemporary Republican Party is complex, but a significant factor driving this division is the level of educational attainment within the GOP. As of May 2024, the party is split between two major factions: those who support Donald Trump and his brand of populist nationalism, and those who adhere to more traditional GOP principles. This paper has sought to explore how the educational background of Republican voters impacts their political actions, and how this phenomenon impacts factionalism within the party. Historical analysis, along with recent data from the 2008, 2012, 2016, and 2024 Republican primaries, shows a consistent trend: candidates’ support is often divided along educational lines. The graphs reveal a rift that predates Donald Trump, although populist rhetoric has amplified the split. Trump’s unique campaign style has been found to resonate with non-college-educated voters, while Republicans with a college degree tend to be less receptive to Trump’s brand of populism and identity politics. This group has been slow to accept Trump and continues to support candidates who embody traditional Republican values, such as Nikki Haley. Data from the 2024 Republican Presidential Primaries exhibit how Haley was able to garner support from college-educated voters, particularly in areas with high numbers of college students. These polls highlight a demand within the Republican Party’s highly educated electorate for alternatives to Donald Trump.

Understanding the educational divide within the GOP has important implications for the future of the

party and American politics more broadly. If Republican candidates become reliant on populist campaign rhetoric, they risk alienating voters with high levels of educational attainment, who could decide that they align more strongly with the Democratic Party. On the other side of the aisle, Democrats seeking to appeal to working-class Americans may have to re-evaluate how their messaging addresses identity issues and economic insecurity among non-college-educated voters, particularly in rural areas. By exploring the causes of shifting voting behavior among educational demographics, both parties can gain important insights that could inform campaign management and outreach in future elections. Should Republicans continue with populist rhetoric these elections are likely to have a greater influx of candidates that reject international cooperation and established institutions in favor of nationalism and identity-based appeals. Such a change could lead to dramatic realignments in the political parties’ constituencies, particularly in regions of high educational attainment such as cities and college towns. For those involved in political strategy and campaign management, examining educational trends in voting behavior is critical when tailoring messaging, as the diploma divide is no longer simply a statistic indicating party affiliation; it is a road map to understanding the voting behavior of the American electorate.

4 FUTURE DIRECTIONS

The analysis presented in this paper displays the significant role that educational attainment plays in shaping ideological divisions within the Republican Party, as was particularly evident during the 2024 Presidential Primaries. However, areas for further study and research remain, offering opportunities to deepen our understanding of the factors driving factionalism in contemporary American politics. Because of the staggered timeline of primaries and inconsistencies in exit polling across states, assembling a dataset that breaks down the entirety of primary voting behavior would be time-consuming and could yield results that are difficult to interpret. This limitation points to a need for greater data collection in future primaries and underscores the value of the graphs presented in this study.

Longitudinal studies tracking the political attitudes and behaviors of individuals over time could supply valuable insight into the relationship between education and political ideology within the GOP. Adding qualitative research methods, such as in-depth interviews and focus groups, could offer a more nuanced understanding of sociocultural factors, including religious affiliations and regional norms, while demographics like age, race, gender, and socioeconomic status would provide a deeper understanding of the intersectional nature of this issue. Finally, conducting comparative

analyses of political parties and systems outside the United States has the potential to uncover information about the nature of factionalism and its consequences for democracy. Pursuing these future directions would allow scholars and political strategists to better understand the forces shaping contemporary political polarization and inform efforts to engage voters across educational and ideological lines.

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6 EDITOR'S NOTES

This article was peer-reviewed.

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Untitled by Lauren Tapper

Massacre vs. shooting: Exploring CNN and FOX's coverage of the Uvalde Robb Elementary School attack

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Abstract

This study dissects FOX News Media (FOX News) and Cable News Network's (CNN) media coverage differences of the Uvalde, Texas Robb Elementary School terror attack (Uvalde shooting). On March 24, 2022, Salvador Ramos perpetrated a mass shooting, killing 19 children and two teachers and injuring 17 others. This paper showcases that the incident qualifies as terrorism and explores how two major U.S. news outlets framed and covered the incident differently in their headlines, images, captions, sources, and tone. While CNN emphasized police culpability, victim perspectives, and presented a somber tone, FOX News downplayed the severity of the attack, highlighted police preparedness, and maintained a more positive tone regarding law enforcement actions. Through analysis of these framing techniques, this study underscores the importance of media literacy, urging news consumers to critically evaluate the biases of their chosen news sources and understand the impact of political ideologies on framing terrorism incidents.

Keywords: terrorism, Uvalde shooting, media coverage, media framing, CNN, FOX News, Robb Elementary School shooting, media perspectives

1 INTRODUCTION

On March 24, 2022, Salvador Ramos shot his grandmother, crashed his vehicle into a ravine near Robb Elementary School in Uvalde, Texas, killed 19 children and two teachers, and wounded 17 others with an AR-15-style rifle. Critical to this incident was the 77-minute time gap by responding officers from when Ramos walked into Robb Elementary School until he was stopped¹. While not commonly regarded as such, under Schmid and Jongman's definition, which states that "terrorism is a method of combat in which random or symbolic victims serve as an instrumental target of violence," the Robb Elementary shooting was a terrorist attack². The primary motive of the attack was an attempt to gain notoriety and fame from the incident³. The shooter leveraged his social media accounts to try to gain fame, sharing disturbing videos of himself holding a clear plastic bag with a dead cat inside and firing BB guns at people, alongside livestreaming a heated argument with his mother on Instagram⁴. This alarming pattern of online behavior and the fact that he was known jokingly as a "school shooter" by some of his classmates, emphasizes how the shooter sought to cultivate a violent persona, ultimately treating his victims as mere tools to achieve his desired infamy⁴. Thus, those

murdered were utilized as "instrumental targets of violence."

News framing of terrorism incidents differs from one source to another. Framing, in this sense, is defined as "select[ing] some aspects of a perceived reality and mak[ing] them more salient in a communicating text"⁵. For U.S. news sources, factors such as the use of bioweapons, higher death tolls, attacks conducted in locations friendly to the U.S., and ISIS-linked attacks increase the probability of terror incident coverage⁶. News reporting on terrorism has also been shown to be a "tactic to influence politics," and thus comports with the dominant political ideology of the news sources that cover the event⁷. For the news coverage outlets covered in this paper, FOX News typically leans conservative and promotes ideals important to the Republican party, while CNN tends to produce more liberal content while promoting values of the Democratic party. These ideological contrasts shape how each outlet reports on news events, particularly on terrorism, aligning with their broader political perspectives.

2 METHODOLOGY

This study employs content analysis to gauge the framing of the Uvalde terror incident by both CNN and FOX News. The two CNN articles analyzed were titled "Gunman in Texas school massacre emerged from closet as Border Patrol agents moved in, source says" and "Uvalde school massacre could have been stopped sooner, DOJ report finds"^{1,8}. The articles examined from FOX News were entitled "Uvalde school shooting: DOJ review faults police for big delays in confronting gunman" and "Uvalde, Texas police hosted 'active shooter scenario training' in March, had session called 'Stop the Dying'"⁹. The five framing variables compared in these four articles are (1) headlines, (2) images embedded within the article, (3) the associated image captions, (4) sources cited within the article, and (5) tone. The first two articles compared were published on May 28, 2022, four days after the attack. The second set of articles compared were from January 18, 2024, containing information on the follow-up court hearings conducted by the Department of Justice (DOJ) against the responding officers. This exploratory study reveals that different political ideologies of the news sources contributed to the differential reporting of the Uvalde terror attack. Presenting the incident as a tragedy for the victims, CNN was more likely to highlight the perspective of victims' families and emphasize that the police were complicit in what had occurred. In contrast, FOX News focused more on absolving law enforcement of responsibility and protecting police credibility by highlighting others' culpability or positively portraying the Uvalde Police Department.

3 FINDINGS

3.1 Headlines

Headline titles reveal the story's significance to the reader and are essential in how the audience interprets the news stories. This showcases how the media presents their news stories to the public, utilizing techniques such as simple messaging, which is effective because it is quickly remembered, or using charged words with more exaggerated meaning to grab the reader's attention¹⁰.

CNN and FOX News' headlines subtly imposed distinct political ideologies. The CNN article published four days after the attack began with the headline "Gunman in Texas school massacre emerged from closet as Border Patrol agents moved in, source says"⁸. This headline alluded to the events that unfolded on the day of the attack and emphasized the police officers' absence at the scene. US Border Patrol agents were the eventual force to end the shooting incident as Uvalde Police Department officers were described to be standing in the hallway taking "no action," waiting for equipment and

room keys⁸. The headline of the January 2024 article by CNN is "Uvalde school massacre could have been stopped sooner, DOJ report finds"¹. In both titles by CNN, the terror incident was labeled as a "massacre," depicting the gravity of the killings and the event as a whole. The second headline also holds the police accountable, citing the DOJ report, indicating that more action could have been taken by responding officers to prevent or minimize the resulting deaths. In other words, CNN approached the attack that presents the police as culpable.

In contrast, FOX News acknowledged law enforcement blame, yet also preserved the image of the police organization and downplayed the severity of the incident. The 2024 FOX News headline reads, "Uvalde school shooting: DOJ review faults police for big delays in confronting gunman"⁹. While placing the blame on the officers for their slow response, the terrorist attack was labeled as a "school shooting." This labeling crucially highlights how the event has been lessened in severity in comparison to CNN's "massacre" label. As showcased by an article written by Helen Taylor in the *Journal of Policing, Intelligence, and Counter Terrorism*, comparing two well-known mass shootings, Dylan Roof's attack in Charleston and Omar Mateen's Orlando shooting, media commentators can "symbolically label" offenses with what aligns with their dominant ideology¹¹. Taylor's article illustrates that despite both attacks meeting the definition of terrorism, Roof's attack was predominantly labeled in the media as a "hate crime" rather than terrorism. In contrast Mateen's shooting was almost always identified as terrorism, with many media reports even linking him to the ISIS terrorist organization¹¹.

The primary FOX News article four days after the attack was headlined: "Uvalde, Texas police hosted 'active shooter scenario training' in March, had session called 'Stop the Dying'"¹². This headline underscored how the police had been preparing for such incidents instead of highlighting their lack of preparedness and their inaction. FOX News thus took a milder approach that still depicted the incident as a tragedy, while also portraying the police as well-equipped to prevent similar occurrences.

3.2 Images and Associated Captions

Many viewers believe they can look at images and read their captions to get the full picture of the story being covered¹³. The media aim to provide graphic videos and images when reporting on terrorist activities to emphasize the high-level threat these groups or individuals pose. However, by continuously broadcasting graphic images, new outlets perpetuate terrorists' messages and goals⁶. Thus, the selection of images within a news story can yield variant interpretations of the same

article by different individuals, leading to a distorted understanding of the covered event.

This concept has been explored in a study conducted in Finland where researchers presented newspaper article images from the COVID-19 pandemic to individuals in different age groups to examine how these individuals would position the context of the pandemic based on the images presented. The study concluded that in varying age groups, media images during the pandemic aligned with specified social representations and identities of the individuals viewing the images. This study proves how newspaper article images and other visual forms of media reinforce viewers' pre-existing values and social identities¹⁴. News sources and outlets utilize this information to shape how their messages are perceived by audiences, strategically selecting images to reinforce specific narratives and emotional responses.

CNN personalized the victims and families of the Robb Elementary attack, opting for an emotional appeal in its visual reporting. Out of the 45 images depicted in the May 28, 2022, article, 60% portrayed the victims' families, memorials, and community mourning (Figures 1-2). Even the images that showed law enforcement officers typically also displayed children who were fleeing the school or victims' families with them (Figure 3), bringing the percentage of these types of images up to 75.5%. Captions for images contained quotes from community members condemning the violence, saying, "We cannot forget what happened, and it needs to stop"⁸.



Figure 1. Choir members who sang in Uvalde on May 27 to support families impacted by the shooting¹⁵.

The follow-up 2024 article from CNN on the Uvalde attack only had two images of people, neither displaying Uvalde police officer presence, alongside six expandable images of highlighted quotes from the DOJ report. The first photo in the CNN article depicted family members of the murdered victims in the Uvalde shooting crying while listening to the testimony given at the DOJ hearing (Figure 4). The caption named the individual in the photo, humanizing her. The second image was of Attorney General Merrick Garland along-



Figure 2. Families gathering in the main plaza in Uvalde to grieve the lives lost on May 28¹⁵.



Figure 3. Students fleeing Robb Elementary School with the aid of law enforcement officers¹⁵.

side other government figures speaking at the news conference in Uvalde directly following the shooting. Garland is quoted within the article, alongside family members of those whose lives were lost in the attack, mentioning no statements of the police department feeling remorse, grief, or taking accountability for their role in the hurt they caused, expressing how "no one wants to take responsibility"¹. In essence, CNN's visual narrative of the Robb Elementary terror attack gave a human face to the tragedy that had unfolded.

FOX News also took an empathetic approach with its images but focused on different actors, such as the Uvalde Police Department. The 2022 article had eight images, 87.5% of which displayed police officers. The one image not including an officer was of the one-pager, created and provided by the Uvalde Consolidated Independent School District Police Department (Figure 5), which outlined the contents of the police training, including how to register and who should attend. The caption for this image detailed that the training encouraged "Peace Officers, School Resource Officers, and campus security officers" to attend¹². The article con-



Figure 4. “Kimberly Mata-Rubio, center, and other family members of the Uvalde shooting victims listen to US Justice Department officials during Thursday’s news conference”¹⁶.

tained no images of the victims or their families. At the end of the article, there was an image of a man placing an object at the memorial site in front of Robb Elementary School (Figure 6). The caption read, “A law enforcement personnel lights a candle outside Robb Elementary School in Uvalde, Texas, Wednesday, May 25, 2022”¹². Rather than displaying those directly impacted by the loss of life of their child or sibling, the person lighting the candle at the memorial is a member of law enforcement, more specifically, a Uvalde Police Department officer. This image and caption further the narrative the audience receives from FOX News that the police officers were well-trained and prepared for the attack and grieving in its aftermath.



Figure 5. “‘Active Shooter for School-Based Law Enforcement’ was the training hosted by the school district’s police department on March 21, and ‘Peace Officers, School Resource Officers, and campus security officers’ were encouraged to attend.”¹⁷.



Figure 6. “A law enforcement personnel lights a candle outside Robb Elementary School in Uvalde, Texas, Wednesday, May 25, 2022”¹⁸.

The 2024 FOX News follow-up still did not depict facial photos of victims and family members directly involved in the attack; however, it showcased two memorial photos (Figure 7). The other stand-alone image was of the former Uvalde Police Chief giving his testimony (Figure 8). Both CNN and FOX News identify and depict through images and captions what the DOJ report stated in terms of police faults in the Uvalde terrorist attack. However, CNN utilized emotional images of those directly impacted by the incident, while FOX News foregrounded the police, which potentially alleviates the blame for slow intervention in readers’ minds.



Figure 7. Memorial photo included in FOX News 2024 article¹⁹.

3.3 Sources

Sources quoted within articles give credibility to the details of events and highlight evidence presented within the article, revealing the dominant framing of terrorism events within news coverage. In the Umpqua Community College shooting, the 2007 Virginia Tech shooting, and the 1991 Royal Oak shooting, researchers examined whether sources were cited or quoted and categorized sources as politicians, journalists, and informal, helping identify how sources contrastingly frame incidents²¹. This type of framing through source choices was evident in Fox News and CNN’s reporting on the Uvalde attack.



Figure 8. Former Uvalde Police Chief Pete Arredondo giving testimony on the Uvalde attack²⁰.

The varying visual approaches by CNN and FOX carried over to their use of sources. Both the 2024 CNN article and each FOX News article directly quoted some number of official government or law enforcement actors. While the 2024 CNN article did provide statements from Attorney General Garland, both CNN articles prioritized the voices of parents whose children lost their lives to the terror attack alongside other children who were in the school while the attack was occurring. They opted for more citations from these individuals than from government officials and utilized direct quotations instead of paraphrasing their words. In contrast, FOX News utilized lengthy quotes from the Texas Department of Public Safety Director Steven McCraw, the Uvalde Police Department, and Attorney General Merrick Garland, purely government and police figures. The absence of first-person account victim or bystander quotes and the excess of police and governmental citations proved that police were not culpable in perpetuating the attack and helped to preserve these figures' reputations. In sum, CNN favored directly quoting affected parents and individuals on the scene, employing a more personal and emotional narrative. In contrast, FOX News incorporated extensive quotes from government and police officials, which authenticated police actions and safeguarded the reputations of the authoritative figures involved in the incident.

3.4 Tone

The holistic tone of a news article factors into the perceived gravity of a particular terrorist incident and varies based on different factors. Comparing the otherwise similar Ft. Hood and Navy Yard shootings, for example, researchers observed tonality framing differences throughout a variety of news articles on the same topic concerning the perpetrator's background, the incident, and other subsequent discourses²². Covering the Uvalde terror attack, the tone varied between CNN and FOX News in terms of sympathy toward victims on the one hand and upholding police reputation on the other.

CNN's articles emphasized the severity of the attack and its devastating impact due to the lack of police presence and highlighted the deaths that affected the lives of victims and their families and friends. The 2022 CNN article described the story of a school student named Miah, who was watching a movie with her classmates when the teachers heard about the shooter. When the teachers went to lock the door to prevent intrusion, the shooter was already there waiting⁸. With no mention of a police presence at this moment, this story suggested police negligence in correlation with the violence that had ensued. The fear was compounded by the quote from a student, Jayden Perez, who stated, "[the shooting] was very terrifying because I never thought that was going to happen"⁸. Perez then stated that he does not want to return to school again telling CNN reporters, "No, because after what happened. I don't want to. I don't want anything to do with another shooting or me in the school. ... And I know it might happen again, probably"⁸. This quote further implied the police's incompetence in protecting students. The article also gave a timestamp guideline of the events that unfolded at Robb Elementary, including when police officers waited to intervene at multiple stages of the attack. Similar patterns were present in the 2024 CNN article, which underscored how the DOJ blamed the police department for the attack.

The FOX News articles presented an opposite tone, maintaining police involvement in the incident and underscoring that protocol was followed. As previously discussed, the initial May 28, 2022, FOX News article focused on describing how the Uvalde Police Department participated in an active shooter scenario training two months prior to the terror incident taking place. More than once, the article stated that many departments were encouraged to attend the training, which frames the police in a positive light and learning preventative techniques. It also aimed to blame other types of officers rather than those in the police department who may have chosen not to attend the training despite being encouraged to go¹². The article also emphasized why there was no police intervention sooner in the attack, stating the officers believed that there were no children at risk and the subject was considered to be a "barricaded subject", something the officers covered in their active shooter training¹². The 2024 article maintained a blameless tone for the police department, making it appear as though it is the fault of one officer (the police chief) instead. Also, before mentioning the pain and tragedy endured by the victims, they noted that the police officers suffered bullet graze wounds. FOX News, in addition to the DOJ report, mentioned a separate private Texas investigation since that report also placed blame on the school administrators for the lack of intervention⁹. FOX News' tone consistently upheld police involvement while placing the responsibility with other

entities and emphasizing the police's training as a positive preventative measure.

4 LIMITATIONS

The limitations of this exploratory study can help inform future research comparing media coverage of mass shootings, terror attacks, and/or hate crimes. While four articles were sufficient to draw the above conclusions, the findings cannot be generalized to the two outlets' reporting. Future research can examine CNN, FOX News, and other outlets' coverage of a range of attacks to better understand their editorial approaches over time. Additionally, researchers can compare how reporting patterns align or differ when the attack is local vis-à-vis international. Another limitation of this research is that there is no simple or all-encompassing definition of terrorism, and terrorism is defined differently for varying attacks²³. For the purpose of this paper, Schmid & Jongman's definition was utilized as its criteria aligned with the details about the perpetrator and the shooting.

5 CONCLUSION AND FURTHER IMPLICATIONS

The dominant political positioning of CNN and FOX News most probably influenced their framing of the Robb Elementary School mass shooting. CNN, a left-leaning news source, incorporated headlines that called attention to the severity of the incident, images and captions that displayed the heartbreak and trauma of victim and their families, direct quotes from more varied perspectives (while prioritizing quotes from firsthand witnesses and those closely connected to the event), and a tone that reflects the sorrow of this terrorist event in conjunction with evidence supporting police's fault. On the other hand, FOX News, a right-leaning news source, admitted police culpability while still conserving and protecting the credibility of most of the police officers involved in the attack. To do so, they used headlines, images, and captions displaying police involvement in preparations for active shooter incidents as well as police testifying and making an attempt at reparations by placing candles at the memorial sites. FOX News further featured quotes mainly from governmental or police-related organizations, and utilized a tone of coverage that reflects positively on what actions were taken by police while employing words and quotes with less intensity and harshness when related to police blame for the terror attack.

The evidence presented demonstrates a bias among news sources holding different political ideologies when reporting on the same incident on the same day. This evidence implies that media consumers should be more critical of the evidence and words they take in and

pay attention to the biases of their go-to sources when reading online news. Depending on where a person gets their news, their understanding and interpretation of an event could differ dramatically. In addition, understanding the distinctions between varying news sources on incidents of terrorism can help us understand why terrorism is so difficult to define. Gathering a wide range of perspectives on terrorist incidents and news, in general, can make for a more well-rounded approach to understanding the everyday stories reported and why these stories receive the coverage they do.

6 ACKNOWLEDGEMENTS

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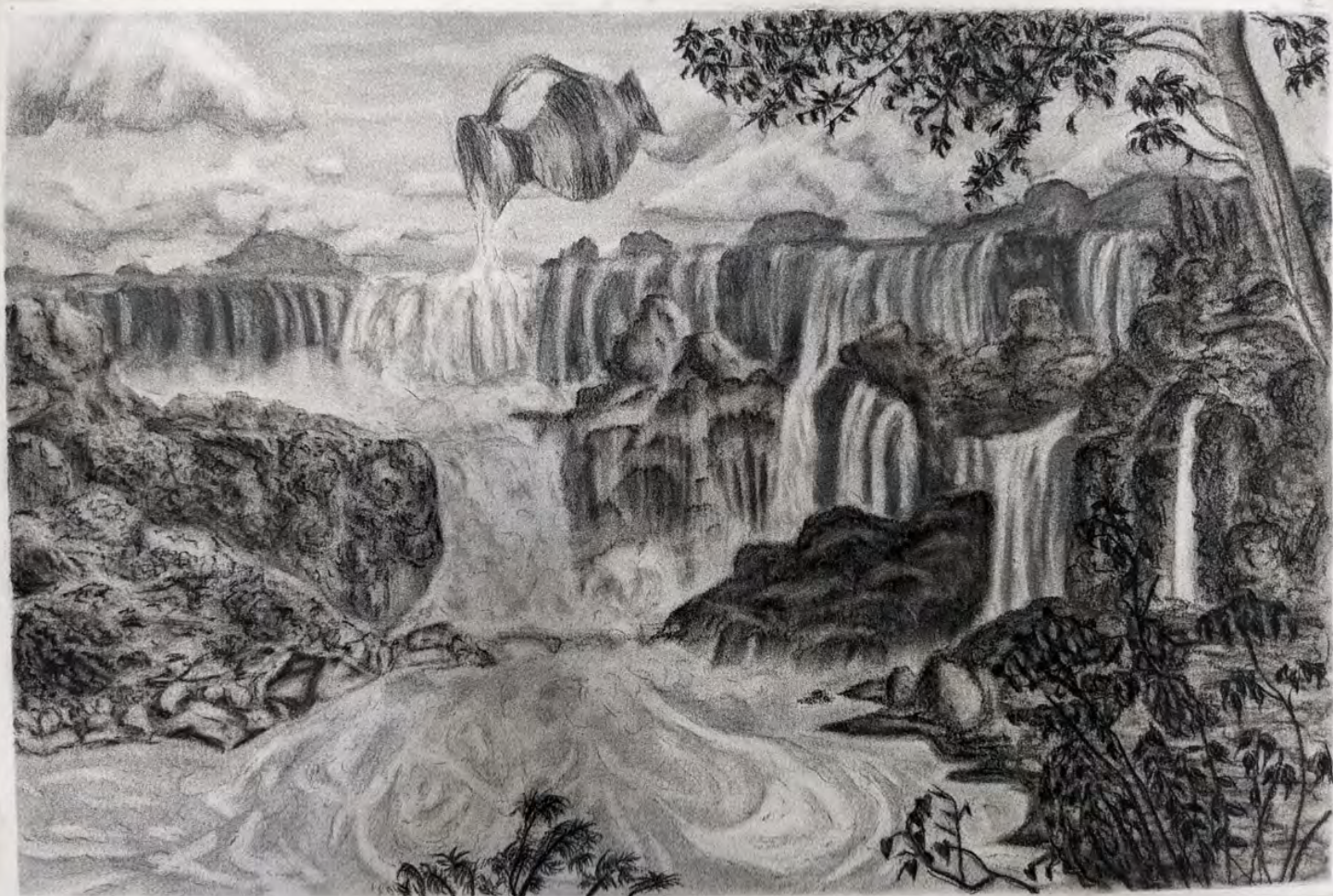
7 EDITOR'S NOTES

This article was peer-reviewed.

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Falling water by Morgan Sirota
Charcoal and Conté on Paper

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Named University Lecturer for AY 24-25

Rachel Jaeger¹, on behalf of the Editorial Board

¹DUURJ Editor at Large, University of Denver



1 TELL ME ABOUT YOUR CAREER TRAJECTORY FROM UNDERGRAD TO BECOMING A PROFESSOR.

I was an undergrad comparative literature and Spanish student at the University of Washington. My goal as an undergrad was to study abroad as much as possible—I studied abroad in Spain and Ecuador—and still finish my degrees as quickly as possible. I was trying to make my undergrad experience as economically painless as I could, so I graduated in three years. Then I didn't really know what I should do. I felt like all I knew how to do was be a restaurant server or a student, so I went to grad school right after undergrad. In one of my study abroad programs in Ecuador, I ended up studying the

Kichwa¹ language, the most widely spoken Indigenous language of the Americas. I found a program at the University of Maryland where they were looking for a graduate student who was interested in Andean studies and Quechua language and culture. That was a little bit niche, and I don't think there were a lot of US-based undergrads with Kichwa language studies, so it worked out well. I ended up getting a Ph.D. in Comparative Literature at the University of Maryland from 2000 to 2006. I fast-tracked the Ph.D. as well, but it worked out, and I got to spend a lot of time researching and studying in South America.

I spent a year researching my dissertation in South America, mostly in Peru, but also in pretty much every other South American country except French Guiana and Surinam. I missed those countries, and I missed Venezuela. Other than that, I was in every other South American country in that year, and I learned a lot about the world and how to manage research sites as a young woman and as an outsider. I spent a lot of time in Quechua communities in highland Peru working on a project that became my first book about representations of Andean food systems in colonial and contemporary contexts. That was what my dissertation research was on, so I spent a lot of time in agricultural contexts in the highland Andes.

I graduated with my Ph.D. in 2006 and needed a job, so I worked in a small town in northwestern Nebraska called Chadron, at Chadron State College. Most of my students were first-generation students and from farming and ranching families. Some were from the Pine Ridge Reservation. I learned a lot in that first tenure track. I was the entire Department of Languages and Literatures. I taught many different classes each semester and actually took my Nebraska-based students to Peru on a study abroad program. It was an unbelievable amount of work to be the entire department, so I applied to a lot of jobs after that first year and came to the University of Denver in 2007. And I've been here ever since. I mostly taught Spanish majors and minors

¹The language is spelled "Kichwa" in Ecuador and "Quechua" in Peru. Kichwa is the northern Andean variety.

in a 3000-level Latin American literature and culture series. In the last few years, I've taught more Advanced Seminars and AI Society classes, so a few classes every year in English.

I was recently named "University Lecturer" for AY 24-25. I'll deliver a lecture sometime next year regarding my Quechua and Andean Studies community-based research projects when the award is formally granted.

2 WHAT WAS LEARNING QUECHUA LIKE?

WHAT IS IT LIKE TEACHING IT TO STUDENTS NOW?

By the time I started studying Quechua, I had academically studied Spanish and Portuguese, and I grew up as a first-language English speaker. Quechua was the first non-European language, that I have studied and to date, the only one in which I have become proficient in. It was also the first agglutinating language that I had studied. All of the suffixes and infixes were so exciting to me—the idea that you could create subtle shifts in meaning by just adding an extra infix. As a literary studies fanatic, it was really exciting for me to translate from Quechua to Spanish or English, because I could play with all sorts of poetic descriptions that were coded in the Quechua verse using these particles of speech we call infixes. It was super challenging. It has a lot of sounds and explosive phonemes that don't exist in any of the languages I already spoke. A lot of my students who speak Hebrew or Russian, or other Slavic languages, can pronounce a lot of those glottal sounds, but it's difficult for first-language English speakers in terms of pronunciation. Quechua is also a primarily oral language, so as someone who had formally studied other languages mostly in a school system with grammar, books, and so forth, Quechua really challenges you to work in the real world very early on. You have to focus on oral proficiency before reading and writing, which was new and exciting for me.

The Quechua class here is Intro to Quechua Language and Culture, so it's taught in Spanish as well. All the students who take that course are already at an intermediate or advanced level of Spanish. That's helpful, because a lot of the lexical values in Quechua, particularly nouns for objects that surfaced in the Andes post-conquest, are just Spanish words with a topical marker. Speaking Spanish is really helpful for understanding some of the lexical varieties of Quechua. Quechua speakers who live in regions of the Andes where there is a lot of Spanish influence, particularly urban Quechua speakers, code-switch often between Spanish and Quechua. Students' previous experience with Spanish is really helpful, but I always find it important to emphasize that these are completely different language families, and it's the history of conquest that has brought Spanish and Quechua into contact. They are mutually unintelli-

gible languages. A Quechua speaker isn't necessarily familiar with Spanish. There are millions of monolingual Quechua speakers. Luckily, teaching Quechua in this day and age, there are a lot of online materials, podcasts, and YouTube channels. It's much easier for students to practice and listen to oral recordings of Quechua. That used to be a challenge.

3 WHAT IS YOUR FAVORITE CLASS TO TEACH?

My favorite class to teach is my Advanced Seminar, *Imagining the Amazon*. I love ASEMs because the students come from various majors. Usually, since you have such a wide variety of ASEMs to choose from, everyone who signs up for *Imagining the Amazon* is interested in the topic. I love having a combination of environmental science students, geography students, Spanish majors, computer science majors, biology majors, marketing majors—everybody comes to this interdisciplinary study of a fascinating region of the world with a lot of beauty and moving artistic production, and also a lot of challenges. It's a great space where we can all learn from each other. I learn so much from students every time I teach that class. It's also always changing, so the materials I teach in the class shift every quarter, which is important for me because I like to keep learning personally.

4 AFTER YOU FIRST VISITED THE ANDES AND AMAZON REGIONS, WHAT WAS SOMETHING THAT STAYED WITH YOU AND MADE YOU WANT TO RETURN?

I was very impacted by care for community members. Individuals were always considering the wellbeing of their families, neighbors, and community members when they were making choices that might seem pretty individual. They were always thinking about the larger context, even the environmental context. Even in communities that were facing a lot of hardship or economic marginalization, there was a sense of community and support that I wasn't experiencing in the United States. I lived in Washington D.C. and commuted to the University of Maryland campus, and I just felt like people who had access to all sorts of material wealth were very hyper-focused on the individual. In the Andean communities where I was spending a lot of time, it was so refreshing to live in a place where there was a real sense of common goals and helping others. The Quechua language itself has terms, vocabulary words, and even a syntactical structure that emphasizes reciprocity. It was so interesting to be able to see daily life practices reflected in the language and vice versa.

5 WHAT ARE YOUR CURRENT RESEARCH PROJECTS? WHAT WAS THE INSPIRATION OR IMPETUS BEHIND EACH?

I have two ongoing projects. One of them is *Musuy Illa*, and it's an online extension of my second book. My idea was to expand the book beyond just an academic audience and create an open platform for sharing contemporary Quechua poetry that could be accessible to folks throughout the Andean diaspora and in the Andes, and that could be useful for teachers and the poets themselves. I'm the editor of it, but it includes the work of poets from principally Bolivia, Ecuador, and Peru, and then writers who live in the diaspora, mostly Europe and the U.S., but who write in Quechua. The collective is fully trilingual in Quechua, English, and Spanish. It has been a challenge but also a beautiful project to try to create a large, sophisticated platform that is also fully accessible in an Indigenous language. It's also important to me that it is audio-accessible, because a lot of elders in Quechua communities have never had access to formal education in their own language, so they didn't necessarily have access to Quechua reading and writing in schools. They're able to hear the poetry in audio form as well. That's fun and important for students as well because they can take home poems from *Musuy Illa* and intergenerational learning can take place. There are also sample activities where teachers can pull lesson plans and students can interview their grandparents regarding some of the topics that are represented in the poem and so forth. Some of my DU students have actually created learning modules that teachers in the Andes can download as already prepared packets.

My other major project is called *The Aspen Archives*. This project is both a museum exhibition and a digital exhibition. It focuses on the history of sheepherders in the Rocky Mountain West, specifically Quechua and Peruvian sheepherders who make up nearly all of the sheepherders working in the United States since about the 1980s to present. It's a large-scale project that studies cultural history and some of the political and economic contexts related to the sheepherding industry in the American West. You have these transnational labor relationships between the highland Peruvian communities and high country communities in rural Colorado and Wyoming. The "aspen" aspect is the physical inscriptions left by generations of these workers on the aspen trees themselves, the aspen carvings. In the Colorado context, the project traces workers from Mexico and New Mexico in the first decades of the 20th century and then shifts to Peruvian workers starting in the 1980s. The time period of the project is 1925 to present. We showed the museum exhibition here in Denver and in a museum in Steamboat Springs near the forest where many of the sheepherders work. It was set to open in May at the Peruvian embassy in Washington D.C., but

that show has been on hold because of concerns regarding an exhibition that describes immigrant communities in the Rocky Mountain West during this particular political climate. We are continuing to work on it on the digital platform, however.

6 YOU'VE MENTIONED THAT YOU TRY TO INCLUDE AT LEAST BILINGUAL, IF NOT TRILINGUAL, MATERIALS IN YOUR DIGITAL PROJECTS. CAN YOU TALK A LITTLE BIT ABOUT WHY THIS IS IMPORTANT TO YOU?

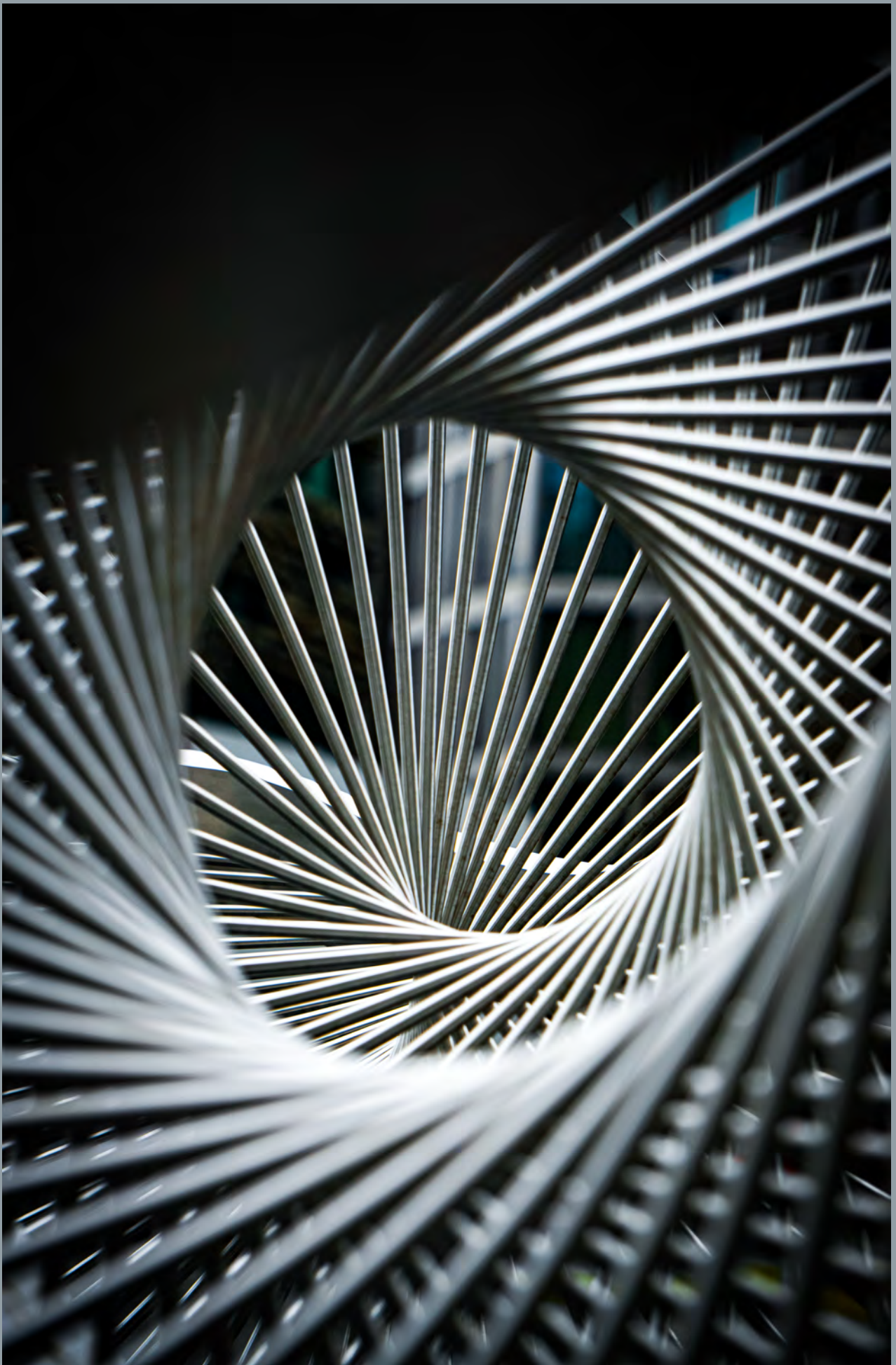
I've taken a good number of social science and anthropology courses, and one of the key points in all of those classes is sharing research with the communities that you work with. Also, for all of the decades that I've spent in Andean communities, the idea of reciprocity is fundamental to the work that any individual or community undertakes. The idea that I would just be producing academic journal articles that are available on databases that require credentials and really expensive subscriptions and are only written in English just seems anathema to everything that I hope to stand for. If I did write an article or a book chapter in English, for many years I would also try to publish it in an open-access journal in Latin America in Spanish. With these latest two projects with Peruvian sheepherders and with Quechua language poetry, I thought I should also try to make it available to a nonacademic public. The number of folks who have the time and access to an academic journal is limited. So, that's why I started working on the web-based options. It's incredibly complicated, especially to make the materials available in Quechua, but the amount of positive feedback that I received from colleagues and from community members has been so nice. It has opened up a lot of opportunities for the Quechua poets, for example, as well, just because when you look up Quechua poetry the site comes up. One of the poets on the site had her work featured in a museum exhibition funded by Prada in Italy because they found *Musuy Illa*. All of these different avenues have opened up because it's digitally available in multiple languages. Quechua language poetry was originally sung in an oral tradition, so not to offer an oral presentation of the verse seems ridiculous when we have access to the technology to provide audio recordings as well. It's nice to use the resources of universities in the Global North to create intellectual communities. Lots of folks benefit from the open-access, multimedia projects in ways that strictly academic articles are limited.

7 WHICH OF YOUR RESEARCH TOPICS ARE YOUR PRIORITIES GOING FORWARD, AND HOW DO YOU PLAN TO DEVELOP THEM FURTHER? DO YOU HAVE ANY NEW AREAS OF STUDY YOU WOULD LIKE TO PURSUE?

That's another thing I like about digital platforms: you can add ongoing research. With these multimedia projects that I'm working on now, new research and new voices can be added much more readily than with print materials. In terms of research going forward...I tend to create giant projects that spin widely beyond what I had first anticipated. My contemporary Quechua poetry book became this massive multimedia platform including dozens of partners and artists from eight or more countries around the world. When I'm envisioning future projects, I have to check in with where I'm going to be able to put my energy because I know that I'm going to make it much more time-consuming, collaborative, and multimedia than I first expected.

I do want to do some work surrounding my interest in practices that involve spending time in forests and open spaces, particularly in alpine contexts, for ritual purposes and practical purposes. For instance, in the Inca Empire, there was a whole system of message transportation, almost like a running relay system, called the chasquis. They were emissaries of Inca rulers centered in Cusco. In order to send messages throughout the vast Inca Empire you would have a relay system of runners who would pass the message from one runner to the next. There's this legacy of using movement across the mountains, of running, for different practical purposes, but also as a spiritual practice. I'm working on a project that traces running and movement through highland spaces for practical and spiritual purposes. I want to look at present-day practices of high-altitude running as community building and bringing attention to particular communities or individuals. A dream coda to this project would be to interview the Bolivian marathon runner Héctor Garibay, who made it to the Olympics and was generally supported by his whole community in that Olympic dream to make it economically possible for him to travel. It's another beautiful example—you would think that an athletic pursuit such as making it to the Olympics would be super individualistic, but instead it turned out to be a whole community behind him. So, the project is a cultural history of highland running within the Andean context, reaching back to pre-Colombian times. I don't know if it'll be a book chapter or an essay, but that's what I'm working on right now. I'm personally a trail runner, so I like to think about some of the psychological and physical reasons why humans like to move themselves through space by running. I was also thinking about the Center for Healthy Aging here on campus and how in highland Andean communities, elders are so active and in-

tegral to the functioning of the family and community. Movement is always what we would call a jog in English. You're never walking to the alpaca pasture or the potato field, you're always sort of trotting or jogging. In terms of physical wellbeing, I think that it helps folks to age healthfully, but I haven't gotten into the science aspect of it yet. In the U.S. we always hear that as you age, weight training is important, but how about high-altitude trail running into your 80s? It's practical and there are certainly positive health benefits. There are all sorts of side pathways into this particular research project, things like healthy aging and use of the coca leaf, so maybe it will become something big. I have to control myself and sometimes just do an article or a book chapter, though.



Spiraling down by Dmitri Scal

Dr. Steven Iona

University of Denver Department of Physics and Astronomy

Rachel Jaeger¹, on behalf of the Editorial Board

¹DUURJ Editor at Large, University of Denver



1 WHAT DID YOU DO BEFORE YOU BECAME A PROFESSOR? WHAT DID YOU STUDY DURING YOUR DOCTORAL PROGRAM?

My college had a program that linked the Department of Mathematics with the School of Education so that I could get two degrees in four years and two summers, and I'd have a teaching credential. I got a job as a math teacher. I was actually a math and science teacher at a middle school, and I did that for a couple of years, and then I got a job as a high school science teacher. I did that for a long time. I had the opportunity to help open a new high school, which was really exciting. Along the way, I was a department chair and did school budgets and data analysis with test scores for the district, and I ran their outdoor education program. I had lots of different jobs with the school district. I didn't know I

would have those opportunities beforehand, but I took advantage of a lot of them.

For my Ph.D., as a high school teacher, I took additional classes—some additional classes were in the sciences, some were in pedagogy, and some were in administration. I had a teaching license and an administrative license, so I could have been a principal. But I gradually acquired a lot of credits and could take a few more classes so I'd have enough coursework to get a doctoral degree. You still have to do some research, so I investigated how students had some physics information organized. I asked them questions and recorded the first things that came to their mind. I was interested in the linkage between the question and this bit of knowledge. By doing some other triangulation—for example, they took a test, they answered some paper questions and some interviews—I could identify how students had physics knowledge organized. So, that's what's wonderful about the university having a teaching professor line. I don't have to have a big lab, graduate students, equipment, and things like that. I can focus on teaching and student learning.

2 DID YOU ALWAYS WANT TO BE A TEACHER?

I had a couple of things that I was interested in. You like things that you're interested in, so you pursue those. Things in science, math, and engineering were among those. I also toyed with some stuff in religion. Seeing an announcement on the bulletin board about a program that I could complete in four years and two summers, and have a job, accelerated that option.

3 HOW HAVE YOU APPROACHED TEACHING GENERAL PHYSICS WHEN IT'S A SUBJECT THAT CAN INTIMIDATE A LOT OF STUDENTS?

Probably by acknowledging that. I tell people that I am so lucky that I have good students, because they're all science students, and they've taken multiple science classes by the time they see me. We start there—

acknowledging that students are smart, they're doing well, they can do physics! If they can do some of these other biology classes that I think are way harder, they can do physics. So there's that kind of positive mindset and approach that I have, and I try to help students see that. Also, they know a lot of this stuff already. They may not have liked it in high school with trig or more algebra or graphs, but there's not a lot that's just brand new. Some of the content, maybe, but the structure is not brand new. We do graphs, we do calculations, we do word problems. I try to build on what students already know how to do. And then for the physics part, because lots of students didn't have physics in high school or didn't like physics in high school, I try to just break it down so that "Hi, you can do this and you'll have success". Then I tweak it a bit, and we'll do the next one. My teaching is a lot of scaffolding, or building. We say, "Alright, this was easy, wasn't it! Now let's do it when there's some initial speed, and now let's make the acceleration negative, and now let's add a force and a different direction." So it's a sequential building, and students nibble away and it's all okay. Suddenly, at a midterm, we think, "Gosh, we did a lot of stuff, didn't we, and it was all okay."

4 WHAT PROGRAMS OR RESEARCH ARE YOU INVOLVED IN OUTSIDE OF TEACHING?

Okay, programs. When I was working in the school district, I did a lot with science fairs. I was director of the Metropolitan Science Fair and that kind of thing. I didn't have that many students that I shepherded through a science fair, but I was the one who directed and hosted the fair. I've continued doing that. I've done Scientific Review Committee for the state Science and Engineering Fair, and I still do that. I have been heavily involved with the American Association of Physics Teachers. I was on their Board of Directors for more than a decade as their secretary, treasurer, and president. I still do things with the physics teachers. While I've been at the university, I've helped sponsor Physics Day at Elitch Gardens and taken students down to do demonstrations there. There are other leadership positions that I've been part of, kind of under the broad category of service, both here on campus and with other organizations like the American Institute of Physics. I'm not so involved in research or publishing. Every test that I give, I'm doing some research! More of my time has been spent in organizational and leadership roles.

5 WHAT DO YOU LIKE TO DO OUTSIDE OF YOUR PROFESSIONAL LIFE?

I'm trying to make this sound not boring...I guess it comes under the broad category of problem-solving. It might be with the upstairs toilet, or it might be with

the humidifier in the basement, or other things around the house. So whether you call it tinkering or problem-solving or trying to fix things, that is something that I enjoy doing. Sometimes that means it's a computer program, and sometimes that means it's a physical thing.

6 YOU WILL BE ENJOYING SABBATICAL NEXT QUARTER. WHAT PLANS DO YOU HAVE?

I have a couple of things that I want to write for the physics teacher organization. It's not a position on the board, but I'm their historian, so I've got some history things I want to write. Also, for a long time, I've been interested in helping students pick careers. In the general physics class, most of those people are biology majors, and lots of them have aspirations to be in medical school or PA school or something like that. Like I say, I've got good students and I write a lot of letters of recommendation, but not all of them are going to get into PA or medical school. Not because they aren't good students, but just because. I've worked with different groups on campus to help students try to think about, for example, healthcare, more broadly. It's hard because for lots of students, at four years old, they wanted to be a doctor, and here they are at twenty-four years old and it's not working. So they've kind of narrowed their scope instead of expanding it. In healthcare, for example, there are lots of things that someone who has biology, chemistry, and that kind of coursework could do. They could do pharmaceutical work, they could do imaging, or they could work with medical devices. They can even work in sales. If you know some organic chemistry and some biology, you can talk to a doctor about selling things. So I'm trying to have people broaden some career ideas.

I worked with the alumni group, and we started Mentor For A Moment. It's where we have alumni who are available for discussion with students. They can't offer a job, but they can talk about what they did since they graduated, and that's where you find out about careers that you hadn't thought about. You hear that somebody who, two years ago, was sitting in the same seat you're in now has a job. What I'd like to do is work with the university to identify alumni in the United States in cities like Houston, Seattle, LA, New York, and Chicago. I'd like to expand on this idea of broadening your perspective about jobs. Maybe during spring break, winter break, or the summer, if we can connect students with an alumni in their hometown who's doing something in healthcare, that's another way to start building a network. It's not designed to get an internship or a job, it's just to learn more options. So, that's something I'm trying to promote. We have alumni, we have students—you'd think we can bring these together to give students more options.

**7 WHAT ADVICE DO YOU HAVE FOR
UNIVERSITY STUDENTS, WHETHER THEY
ARE JUST GETTING STARTED WITH THEIR
DEGREE OR CLOSE TO GRADUATION?**

There are two things. One is, when things aren't going so well—whether it's with a class, a friend, some relationship, or political situations—it's worth asking, "What role am I playing in how things aren't going well?" It's easy to blame somebody else or to complain, but what is it that I'm doing or could do differently that could improve this relationship or this situation? And, the other is kind of related. It sounds cruel or corny, but *you are not the most important person*. It's easy to put yourself first: what I need, what I want. Even when you're trying to be empathetic or inclusive...it would be wonderful if you have a good friend who can hold up a mirror and say "Thank you for seeming to care, but it really seems to be about you". Sometimes you need to do that for yourself. You need to do some self-reflection on how things are going and whether you talked too much or made all the decisions. That's not necessarily being a good friend or partner. You know, we can talk about the usual ones—study hard—but those are lessons that I only learned later and the hard way.



The fury of flora by Kat Seale
Acrylic Paint, Special K Collage

Dr. Luc Beaudoin

University of Denver Department of Gender, Women's, and Sexuality Studies

Rachel Jaeger¹ and Nicole Doris², on behalf of the Editorial Board

¹DUURJ Editor at Large, University of Denver

²DUURJ Editor in Chief, University of Denver



1 TELL US ABOUT YOUR ACADEMIC JOURNEY AND WHAT LED YOU TO FOCUS ON GENDER STUDIES.

My academic journey has always been language-related. I'm from a background of having lived in at least two or three different languages when I was little. I was fascinated by the way the world was described differently for different people, and how they understood the world differently. I'm simplifying it, but that is something I thought about when I was young. By the time I got to high school, and then later on, university, I wanted to continue trying to figure out how people understand the world. The languages I was going to do were mostly incidental to that. They were based on my schedule and what I could afford in terms of textbooks. Originally I had applied to do German in Montreal at McGill University, but my sister called me up and said I would never get a job that way, so I switched to human genetics, which was more in line with what she wanted me to do. While I thought it was interesting, I had a

relationship, I forgot to do final exams...I had all sorts of issues, and honestly, my heart was not in it. So, I went back to languages.

Languages allowed me to experiment with questions of gender and sexuality. An example is that in German, language classrooms are resolutely heterosexual, or they were in the 1980s, at least. I would refuse to play along, and professors would get angry. They would question what I was doing and why, and that just made me want to do it more. Eventually, by the time I got into Russian, which is my primary area, I was also fascinated by what I considered a culture and society in the Soviet Union that erased its queer citizens. People didn't talk about it, and yet, they were there. When I studied in the Soviet Union for a year, I made some gay friends and got to know people. That framed how I did my research and my teaching through the 90s. Even at DU, I taught a class called Alternative Sexualities in Russian Literature. That's when I started getting involved in the Gender and Women's Studies program. My research, as a result, has always looked at those erased queer voices that didn't get appreciation and didn't have a language to express themselves. They were erased, sometimes violently and physically, from history. They were airbrushed, literally, out of photographs in the Soviet Union. I tried to reclaim who these people were and their importance, which leads directly into gender studies. To approach that topic I had to become familiar with the new area of queer theory at the time and its intersection with language. It speaks to me perfectly. I accumulated languages as I went, so I expanded my field of research.

2 WHAT ARE SOME CENTRAL THEMES IN YOUR RECENT RESEARCH, AND HOW DO THEY CONTRIBUTE TO CONVERSATIONS IN GENDER STUDIES?

Right now, my personal research is looking primarily at gay, male, Russian-language exiles—Russophone writers who are exiled from their own country and living abroad. It's accidental that it happened at the same time

as the full-scale invasion of Ukraine and the consolidation of Putin's power, as well as the making illegal of queer expression and queer identities in Russia. Although it's accidental, it certainly has pushed me down this path, because there's no way I'm ever going to go back to the Russian Federation and do research. I can't. My presence is illegal and the work I do is illegal. I have to shift to highlight the voices here, instead. I study primarily Russian, but I also look at writers in Brazil, writers in France, artists, and photographers. The importance of it in gender studies is thinking about how people create a queer identity at the juncture of different cultures, expectations, and languages. For example, if you are a Russian emigrate, a queer exile, and you land in New York City, you're expected to adapt immediately to U.S. gay culture. You might have a good familiarity with it, because you might have seen things on television or on the internet, but it's not your culture. Your own culture, the Russian émigré community in Brighton Beach, doesn't accept you because you're gay. So, you're stuck. You have to reinvent how your identity functions, how you express yourself, how you live, and how you understand yourself between two cultures, neither of which really gets who you are. That is really important because we tend to appreciate the gender studies as having a lot of fluidity and movement, but we forget how much even that movement is defined by language and terminology, defined by the experience of someone in a certain political or social situation.

3 WHAT PEDAGOGICAL STRATEGIES DO YOU USE TO FOSTER INCLUSIVE AND CRITICAL DISCUSSIONS AROUND GWSS IN THE CLASSROOM?

GWSS as a program is already made up of unique individuals who are trying to understand the world and themselves from a new framework. It's a very personal program, in that regard, because it has to do with people's personal experiences, now matter how they identify. To me, the best pedagogical approach to that is to let people speak for themselves. I don't force them into thinking any particular way, even about controversial topics, in the hopes that their own reflection, their own participation in class discussions, allows them to relate and project their experiences onto the topics, people, movements, and ideas that we discuss. Students take away the things that help them better understand themselves and their place in the world. That requires critical thinking, because you need a certain amount of distance to be able to do that, but you also need empathy. You need to be able to relate to people whose backgrounds and cultures may be entirely different from your own experience and see where the commonalities and differences are. It's not just learning a huge amount of facts about how depressing the world is—often we

lean towards that direction, but there is more from it that we can take away. That's where the inclusiveness comes from, automatically. The classes are entirely non-judgmental. Everyone has their own unique thing to contribute, their own experience, their own identity.

4 WHAT ADVICE WOULD YOU GIVE TO STUDENTS WHO WANT TO PURSUE FUTURE STUDY OR CAREERS IN GWSS?

That's a really important question. It's trickier to answer to that question right now because of what people might want out of the field. It's not a field that people traditionally think of as stand-alone. It's not something you go into that gives you the opportunity to change the world by itself. It's usually in conjunction with something different—medical school, for instance. My husband and I were watching *Mythic Quest* on Netflix, and there's a character that they gently make fun of, but in a good way. She has a women's studies degree. It made me smile because they're making fun of it, but at the same time, they were trying to show that she is really good at organizing and moving forward because she has a set of critical thinking skills that they don't have. She can call things into question that they don't even think about. That's one of the tricky things about GWSS, is that you don't want your studies to be isolated. The whole point is integration with the world. The whole point is understanding yourself. Typically, it's about applying it as a framework to something different, say, medical school or law. Although, people can go to graduate school and eventually become professors and scholars and affect a whole new generation of people. In that sense, it's very similar to Russian. You don't typically go into a language and then, *poof*, that's your job. You apply it, and it allows you to perceive things differently. I see them as pretty related.

5 IN YOUR VIEW, WHAT ARE SOME OF THE MOST URGENT QUESTIONS SCHOLARS IN GWSS NEED TO BE ADDRESSING TODAY?

I think, personally, it's the relevance of the field. Given the current political climate and backlash worldwide, nothing is easy about this. Scholars need to reiterate how important these questions are and how they apply universally, however you identify. This sort of research and this sort of thinking can only benefit humankind. It's super difficult to do without being defensive. The attacks are political and academic. Judith Butler, major queer theorist, has been tackling this head-on. She's looking at why it is that gender is being demonized everywhere. Where is this coming from? What kind of societal control do people want to oppose by demonizing questions of gender? That's the kind of thing GWSS scholars have to keep in mind. I think everyone is, you

know, keeping it in mind, but there's always the fear of losing your job. Depending on what university you're at and what's going on, if your job doesn't survive, you can't do very much but think about trying to survive yourself. It's in flux, at the moment. And this means, by the way, that every kind of research is important. It doesn't have to change something right away. It's about questions of knowledge and understanding.

6 WHAT KEEPS YOU MOTIVATED IN YOUR SCHOLARSHIP AND TEACHING?

The teaching is easier because, on occasion, a student will come up and talk about how the classes they've taken in GWSS, or my classes specifically, have transformed the way they understand themselves and who they are. There can be nothing more important than that. I know my own professors transformed who I am, but no one ever did it in a way that speaks closely to my identity, and I would have wanted that desperately. So, I created it myself as best I could. That's easy. The experience of teaching and making people ask questions—that's the most important thing I could possibly think of.

My scholarship, though, is more difficult. I write about writers, and I sometimes doubt myself and think, "Well, if people are interested, they could just read the writers and figure it out themselves. What am I doing, interpreting this?" What I forget, in moments like that, is that someone has to be able to contextualize and articulate the writers' experiences in a way that helps create a greater understanding of the human condition. The writers can't do it themselves. It takes someone who can articulate things from a different vantage point to advance knowledge and understanding of how these artists got to where they are and how that has impacted their own identities. It's important to have the perspective of someone who may share certain elements of identity with them, but is able to translate it to someone else. It reminds me a little bit of when I wrote my most recent book. The first editor, Terry Ann White from the University of Western Australia, said "I want a typical, heterosexual man to understand why reading your book is important to him. I want it to change his perspective of the world." That's exactly how she put it. It struck me, because I never thought of my book as doing anything like that. She really wanted it to be able to create an understanding of people from a vantage point that never had to think about these things before. That's still what drives me.

I'm going to a conference in two days. I'll be presenting on a Russian poet who lived in Brazil. While he's super important, no one ever talks about him, partially because he was publically gay and the Russian diaspora rejected him. Yet, every time I talk about him, people will come up and say how moving and important it was

to hear about his life and his work and what it means, to have the analyses, because they had never thought about it before. Then, they're going to go back and approach their own work differently. Sure, if they're in the audience then they are probably interested anyway, but not exclusively.

7 ANY FINAL REMARKS?

I teach undergraduates. I have occasional graduate students, but because we don't have a graduate program, everything that I'm talking about in terms of teaching and research is in an undergraduate context. I've had amazing work, research, independent studies, senior theses, and capstone projects done by undergraduate students. The nature of Gender and Women's Studies is that, sure, you accumulate knowledge by reading all these theorists, but it's still fundamentally centered on your own experience. Expression of that is valuable, from the beginning of college if not before, and throughout your life. The most important thing is to get people to engage with who they are. I wasn't encouraged to do that when I was that age. I was told to be quiet.



Arma-tea-lo by Abi Newell
Ceramics

“This piece is a visual tribute to the concept of selflessness and quiet heroism. It captures a man in the solemn act of drawing a katana from its sheath—a moment charged with tension, purpose, and restraint. The image is not about violence, but rather the weight of choice and responsibility.”



Noble sacrifice by Dmitri Scal

DU Undergraduate Showcase: Research, Scholarship, and Creative Works

Abstracts

STORYTELLING IN REAPPRAISAL: HOW NARRATIVES CAN CHANGE AFFECT

Kabe Aberle¹, Nadia Kako², Kateria McRae²

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The question of this project was to understand how narratives can be used as short-term interventions to repair mood after a stressor. This research has implications for clinical applications and everyday emotion regulation practices. We designed a correlative study with participants recruited online collecting a variety of qualitative and quantitative data. We found that there was a relationship for some participants between higher quality narrative production and better emotional outcomes. There were also a variety of other factors that influenced emotional outcomes and semantic characteristics that differentiated reappraisal from stressor narratives.

CONNECTED IN CARE: MINORITIZED HEALTH MATTERS

Brooke Agulnek¹, Sky Palmon¹, Yasmine Ramirez¹, Francisca Aguirre Beltran¹, Ashley Juarez¹, Bridget Kim¹

¹Student Contributor, University of Denver

How can we best support and connect Denver communities that are working towards combatting healthcare inequities? We first researched our issue and met with various community members. We then developed a plan to address these issues and implemented it. Students and community members now have better access to resources that will help them succeed.

DO NOVEL MALE CRICKET MORPHS MOVE DIFFERENTLY THAN ANCESTRAL MALES IN THE WILD AND THE LAB?

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A challenge in animal behavior is that scientists often study animals in captivity and rely on the assumption that measures of traits in the laboratory reflect their expression in nature. Pacific field crickets encounter an acoustically hunting lethal parasitoid fly in Hawaii, which has facilitated the rise of novel male morphs, like purring, that sing attenuated songs and are protected from the fly but still able to reproduce. It is possible that quieter purring males use an alternative mating tactic like increased locomotory behavior to increase their chance of encountering mates. We asked if ancestral and purring males differ in their locomotory behavior in the wild, whether this result is maintained in the lab, and whether behavior depends on test substrate (natural grass or artificial foam). Using a population that contains both purring and typical males, we conducted focal follow experiments in the wild and parallel experiments in the lab on natural and artificial substrates. In the wild, we found that the two male morphs did not differ in the time spent walking on the grass, but purring males spent more time stationary while typical males spent more time under the grass. In the lab, we similarly found that the two morphs spent the same amount of time moving, however they traveled significantly further and faster on the artificial substrate compared to the grass. Unlike in the field, morphs did not differ in movement under the grass, which is interesting since crickets are subject to parasitism in the field and may be protected under the grass.

READ ALL ABOUT IT: USING OBITUARIES TO INVESTIGATE HOW CO-VICTIMS OF MINORITIZED MURDER VICTIMS MEMORIALIZE THEIR LOST LOVED ONES

Lily Baeza¹

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The news media tends to neglect everyday homicide stories in favor of sensational murders and members of the police tend to divide murder victims into “good” versus “bad” victims. These practices are exclusionary to those who do not fit this standard and can render the vast majority of those most likely to be affected by urban violence as “unworthy victims.” The Philadelphia Obituary Project (POP), an innovative non-profit, seeks to create an opening to allow co-victims to offer a counter-narrative and discuss their loved ones as complex people whose lives should be remembered more than their deaths. A team of researchers and I conducted a content analysis of nearly 300 POP obituaries to determine what minoritized co-victims of murder want us to know about their lost loved ones. Importantly, because the literature has almost solely focused on mothers’ perspectives, this study adds in the perspectives of non-mothers and assesses whether there are any differences in portrayals between the two. The results show that mothers and non-mothers were not substantially different in their portrayals of their murdered family members. Both primarily highlighted positive characteristics (e.g., “he was a family man and protector). As a subset of non-mothers, spouses and partners appeared to paint the most nuanced pictures (e.g., suggesting that their spouses had troubles, but were overall good people). In conclusion, this study situates these co-victim perspectives within a larger hierarchical understanding of “ideal victim” framing and argues that all murder victims deserve respect and justice, not just the ones we deem worthy.

THE CASE FOR SOCIAL EMOTIONAL LEARNING

Chloe Beers¹, Julia Coakley¹, Whitney Kelsey¹, Sydney Gainforth¹, Gabi Wing¹, Audrey Martin¹

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Our project asked: How can Social Emotional Learning (SEL) be effectively integrated into public school environments to support student well-being and success? This question is important because SEL fosters critical life skills—such as emotional regulation, empathy, and relationship-building—that are essential for both academic achievement and personal development. To explore how SEL is implemented in schools, we partnered with an innovative public school in Colorado: Compass Academy. We conducted on-site visits, observed classrooms and community spaces, and spoke directly with students and staff. We also reviewed research on the benefits of SEL and gathered quotes and reflections from school community members to better understand the real-world impact of these practices. Our observations at Compass Academy showed that intentionally incorporating Social Emotional Learning (SEL) into the school day led to stronger relationships between students and teachers, improved emotional well-being, and increased student engagement. Students shared that SEL activities helped them feel seen, heard, and better able to manage stress, while teachers noticed more positive classroom behavior and deeper connections with their students. These real-life examples, combined with our research, helped us create a proposal with practical recommendations for integrating SEL into other Denver public schools.

COLOR OF WATER IN COMMERCE CITY

Aaliyah Amore Berry¹, Brooke Watley¹, Kiruthika Venkatesan¹

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This project investigates the intersection of environmental justice and public health by examining water quality violations in Commerce City and Northeast Denver, Colorado, from 1980 to 2025, with a focus on the Latinx/e community. We employed a mixed-methods approach, integrating qualitative and quantitative analysis to identify patterns of environmental harm and systemic inequity. Archival newspaper articles were reviewed using targeted keyword searches (e.g., “water quality,” “environmental racism,” “EPA”), and findings were cross-referenced with publicly available violation data from the Colorado Department of Public Health and Environment (CDPHE) and the U.S. Environmental Protection Agency (EPA). To visualize spatial trends, we manually mapped violations. Our mapped data was further verified through county-specific data visualization of violations across Denver. While this phase of research does not isolate specific contaminants, Commerce City and Northeast Denver are frequently exposed to pollutants such as 1,4-Dioxane, various trihalomethanes, chromium (hexavalent), and PFAS. Together, these sources are being used to develop qualitative memos that align specific violations with corresponding news coverage, allowing us to assess how water contamination issues are recorded, represented, and addressed over time, particularly in minority-centered areas. Our findings indicate a disproportionate concentration of water quality violations in Commerce City compared to surrounding regions, a pattern further verified through county-specific mapping. These results highlight the need for deeper scrutiny of regulatory enforcement, media visibility, and the long-term health impacts of environmental and water injustice in Colorado’s Latinx/e communities.

TRANSITIONAL JUSTICE UNDERSTANDING THE IMPACT OF VARIOUS INITIATIVES IN BOSNIA-HERZEGOVINA AND GUATEMALA

Rachel Bienstock¹

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This thesis examines the impact of transitional justice initiatives on reconciliation and healing in regions that have experienced mass atrocities, with a focus on Guatemala and Bosnia and Herzegovina (BiH). While transitional justice processes aim to address the legacies of human rights violations and foster sustainable peace, their impact varies significantly depending on the context and the mechanisms employed. By analyzing existing scholarship and using a case study methodology to gather in-depth data about each instance, this research explores how different approaches to transitional justice can serve a diverse group of communities and how different factors contribute to their success. It is often not the fully funded international commissions that serve the needs of victim populations, but rather locally-focused, bottom-up strategies. Ultimately, this thesis seeks to contribute to a nuanced understanding of transitional justice, emphasizing the importance of integrating local perspectives and practices in the pursuit of justice and healing.

OPTIMIZING LMS FOR ADHD STUDENTS IN HIGHER EDUCATION

Annabella Brotherston¹

¹Student Contributor, University of Denver

You might not guess that aesthetics could change your grade—but for students with ADHD, it might. This literature review explores how the design of learning management systems (LMS) can affect cognitive load and learning outcomes for neurodivergent students, particularly those with ADHD. Proposed evaluation methods include self-reports of task complexity and mental effort, eye tracking to measure fixation and scanning patterns, and time-on-task analysis. One study found that enhancing the aesthetics of an e-assessment environment led to reduced mental effort, increased user satisfaction, improved task performance, and more time spent on self-assessment. Another study noted that in online learning environments, students with ADHD faced greater challenges due to extraneous cognitive load and felt overwhelmed by unclear instructions and the volume of scattered resources. These findings underscore the need for accessible, thoughtfully designed digital learning platforms.

EXPLOITING VULNERABILITY: HUMAN TRAFFICKING AS A TOOL OF GENOCIDE

Madison Bryant¹

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This thesis examines the relationship between human trafficking and genocide, arguing that when trafficking is used with the intent to destroy a targeted group, it should be understood and prosecuted as an act of genocide. While international law traditionally treats genocide and human trafficking as distinct crimes, historical and contemporary evidence reveals significant overlap in their mechanisms, motivations, and outcomes. Through a thematic analysis of three case studies, this research demonstrates how trafficking has been systematically employed to further genocidal objectives, including displacement, exploitation, cultural erasure, and the destruction of communities. The case studies are the genocide of Indigenous peoples in North America during the colonization and founding of America; the genocide of Bosniaks in Bosnia and Herzegovina during the Bosnian War; and the ongoing Russian invasion of Ukraine. This thesis concludes with a call to action to expand the legal interpretation of genocide to include human trafficking when used as a mechanism of group destruction.

LINE V.S. CONTINUUM POLARIZATION: A POLARIZATION STUDY OF STAR SYSTEM WR42

Mia Burgener¹, Emma P. Lieb², Rachel A. Johnson², Jennifer L. Hoffman²

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This research aims to find how much mass is transferring between the stars and how much, if any, is being carried out of the system by the stellar winds. Analyzing polarization data will provide information on the location of the mass, which will also help form a better picture of the system's structure. I used Python coding to plot graphs of the observed polarized spectra and the polarization of different spectral regions as a function of orbital phase (position of the stars in their orbit). According to the polarization data as a function of orbital phase, the emission line and continuum polarizations behave differently. This tells us about the system's colliding winds, and further analysis will give an improved understanding of the wind collision region's geometry and ionization structure.

KEYSTONE REBIRTHS: PENNSYLVANIA'S WHITE NATIONALIST MOVEMENTS IN THE LATE 20TH CENTURY NEWSLETTERS

Kania Campbell¹

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How have white nationalist movements evolved recruitment, communication, and political mobilization strategies in Pennsylvania during the late 20th century? What recurring motivations and goals are shared between different nationalist groups in the state? I answered these questions by conducting a close reading and qualitative analysis of documents held in archives at Duke University and the University of Pittsburgh. The criteria in my selection process were for my sources to be newsletters written and published by white nationalist groups during the 1980s-2000s. Throughout hundreds of pages in these newsletters, there is a consistency in intense paranoia concerning the spread of immorality, particularly behaviors and identities that challenge traditional foundations in American institutions of Christian religion. White nationalists across Pennsylvania were radicalized into strong far-right nationalist political groups, with many becoming incarcerated, finding solace through these newsletters.

ANTHROPOGENIC PARTICLES AND FLUVIAL SEDIMENT TRACING

Kiena Campbell¹

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Understanding the sources of suspended sediments in rivers and reservoirs is an important step in developing mitigation strategies to improve water quality and reduce sedimentation. How can elemental analysis be used in the process of determining sources of suspended sediments? I completed elemental analysis of samples collected by the University of Kansas using inductively coupled plasma mass spectrometry (ICP-MS), then interpreted the normalized data. The results showed certain patterns in the concentrations of characteristic elements (like tungsten, lead, and strontium) can be used to infer whether the source of a suspended sediment sample is anthropogenic (ex: road runoff or construction runoff). This information is useful in identifying mitigation strategies and best management practices for urbanizing areas and construction sites to reduce suspended sediment loading of water bodies.

PREVENTION POSSE: YOUTH SUICIDE PREVENTION COMMUNITY CHANGE INITIATIVE PROJECT

Courtney Cassidy¹, Sage Krzyzkowski¹, Maddox Jones¹, Skylar Abookire¹, Luke Hawkins¹, Sunnah Yoon¹

¹Student Contributor, University of Denver

How can youth identify signs of mental health decline, support friends in need, and properly address the topic of suicide within their community? We met with a variety of stakeholders in the Denver area (such as Wellpower, the Second Wind Fund, Thrive, and more) to gain a better understanding of community needs surrounding this topic. Then we became trained in the American Foundation for Suicide Prevention's "It's Real" curriculum and are planning on presenting this curriculum to students at high schools in and around Denver to better equip them to deal with topics of mental health and suicide. Once our presentations are complete, we hope to make lasting change within the schools we present at through education about stress management, suicidal thoughts, and other mental health related topics. Our goal is to foster an environment where youth understand how to properly address mental health issues and know where to locate resources for both themselves and their peers.

ENHANCING THE SENSITIVITY OF RZNP1 FOR INTRACELLULAR ZINC MONITORING

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Zinc is an important nutrient in cells, and its imbalance can lead to cell dysfunction and neurodegeneration. Current sensors aren't sensitive enough to track its dynamics, which is why optimizing the RZnP1 sensor could help researchers study new treatment targets or learn new information about Zinc. I created different versions of the zinc sensor by carefully changing specific parts of its structure, then tested about 96 bacterial samples at a time to find which versions glowed brighter and responded better to zinc changes. To do this, I compared how the sensors reacted when zinc was removed versus when extra zinc was added. I've found 5 modified versions of the zinc sensor that appear to work better than the original. Currently, I'm testing these in cells to verify how much stronger their zinc-detecting signals are.

EXPLORING EMOTIONAL WELL-BEING AMONG GROUP FITNESS INSTRUCTORS

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What are group fitness instructors' perceptions of emotional experiences in regard to their work? This study uses 15 qualitative interviews to explore group fitness instructors' emotional experiences. Interviews were 30-60 minutes long and conducted via Zoom. The study's findings revealed that group fitness instructors' job demands fall into three main categories: Instructing, which includes experiences during class instruction; Group Fitness Instructor Occupation, which encompasses job-related experiences outside of actual teaching time; and Life, which covers personal life experiences influenced by their profession. Emotional experiences within each category were further classified as having either a positive or negative tone based on interview interpretations, highlighting the complex interplay between work and personal life in shaping instructors' well-being.

THE ROLE OF GENDER AND RACE/ETHNICITY IN THE FREQUENCY AND CORRELATION OF DEPRESSION, HOPELESSNESS, ANXIETY, AND EXHAUSTION IN FIRST-GENERATION COLLEGE STUDENTS

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The study examines the mental health of first-generation college students at Santa Clara University, with a focus on depression, hopelessness, anxiety, and exhaustion. This analysis is based on secondary data derived from a previous survey conducted by Santa Clara University. Of the 1,681 total respondents, 1,036 participants ages 17-69 were included in this study based on relevant inclusion criteria. Findings indicate that first-generation female students report higher frequencies and a stronger correlation between depression and hopelessness compared to male students. While female participants also show a higher correlation between anxiety and exhaustion, the relationship remains weak, and both genders report similar frequencies of anxiety. Racial and ethnic comparisons reveal that African American/Black, Latino/Hispanic/Spanish, and Asian students exhibit a stronger correlation between depression and hopelessness than Caucasian/White students, despite reporting similar frequencies of depressive symptoms. Regarding anxiety and exhaustion, African American/Black students show a stronger correlation than other groups, who demonstrate weaker associations. Additionally, Caucasian/White, African American/Black, and Latino/Hispanic/Spanish students report higher anxiety frequencies compared to Asian students. These results emphasize the varied mental health challenges that first-generation students face across different genders and racial/ethnic groups. Furthermore, the results highlight the importance of inclusive mental health services that reflect the diverse experiences of first-generation students and point to an opportunity to strengthen mental health support by considering the unique needs of different student populations.

SUPPORTING THE LOCAL MUSIC COMMUNITY THROUGH RECORDING SMALL UNDERREPRESENTED ARTISTS

Grady Dionne¹

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How can we make professional recordings accessible to artists who do not have the time, money, or pre-existing platforms to make that possible? Over the course of 11 weeks, I recorded 9 bands in the New Hampshire seacoast music scene. I set up all audio and video recording equipment for each group, with each video taking about 4-5 hours total. Post production involved mixing and mastering all the audio using Pro Tools, and editing the videos using Premiere Pro. The project was overall extremely successful. The recordings, which were made available on YouTube now total over 1000 streams. The outreach to people who had never heard this music was incredible to see, and most importantly the bands were happy with the product. One of the most important things in modern times is to have music that is easily shareable, and this project made that process incredibly easy.

MOTHERING SICKLE CELL DISEASE: NEW FRAMEWORKS FOR THE CAREGIVING ROLE

Nicole Doris¹

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Sickle Cell Disease (SCD) is a chronic, hereditary blood disorder that disproportionately affects individuals of African descent. While existing research primarily focuses on the medical aspects of SCD and the experiences of those diagnosed, this study highlights the often overlooked burden placed on caregivers—particularly mothers. Using a combination of SocioFeminist Health and Womanist Disability approaches, this paper explores how the intersections of race, gender, and systemic neglect shape the caregiving experience. Mothers of children with SCD navigate a healthcare system rife with racial bias, inadequate provider knowledge, and stigmatization, all while shouldering immense emotional and physical labor. By centering caregiver narratives and proposing novel theoretical approaches, this paper advocates for a shift in healthcare and research priorities that recognize caregiving as both a public responsibility and a site of systemic inequity. Addressing these gaps is essential for improving health outcomes for both individuals with SCD and their caregivers.

INVESTIGATING THE EFFECTS OF PATIENT-DERIVED EXOSOMES ON NUCLEAR RELOCALIZATION OF TAU IN NEURONS

Nicole Doris¹, Lyndsie Salvagio², Yan Qin², Ann-Charlotte Granholm-Bentley³

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Alzheimer's Disease (AD) is a devastating neurodegenerative disorder characterized by the presence of amyloid beta plaques, tau tangles, and disrupted autophagy. Current research has found a strong correlation between the cytoplasmic to nuclear relocalization of tau and AD pathology. We explored the use of patient-derived exosomes to analyze AD pathology within primary neuron cultures. Patient plasma and CSF can be analyzed for AD biomarkers such as A β plaques or tau antibodies and used for early disease detection. Furthermore, new findings have shown the appearance of tau in exosomes, suggesting that exosomes might be involved in the spread of hyperphosphorylated tau between neurons. To test this, we examined the subcellular localization of tau in both primary hippocampal and cortical neurons and fibroblast-like COS-7 cells using exosomes isolated from patient brain tissue. Our results showed that AD patient-derived exosomes from cerebral tissue significantly enhanced the nuclear localization of tau in both cell types. Our results not only established a primary neuron model to study the pathological mechanisms of AD, but also provided strong evidence that exosomes carry cargoes that can transform normal neurons, thereby affecting neuronal functions.

N TERMINAL TAGGING OF YEAST INTERMEMBRANE PROTEINS

Anna Dymov¹

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We aimed to improve the current technique used to N-terminally tag genes by providing a novel protocol. We went through PCR to gene edit, plate on various selection plates, and genotyping and imaging for confirmation. We have a way to now easily N-terminally tag any gene of our interest quickly and easily for future use.

WHO'S YOUR DADDY?: A STUDY MEASURING FITNESS IN THE WILD

Hannah Eckert¹, Gabrielle Welsh², Robin Tinghitella², and Erica Larson²

¹Student Contributor, University of Denver

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The question addressed by this project is how natural and sexual selection interact as conflicting forces to influence the evolution of novel signals in response to environmental pressures. Exploring this interaction enhances our understanding of the dynamics of evolutionary trade-offs and adaptive behavior in changing environments. To answer the question, I utilized a mesocosm experiment in which equal numbers of purring and ancestral male crickets were released into enclosures with females, where all crickets were exposed to parasitoid flies and females could mate with any of the available males. I then used genetic parentage analysis to assess the reproductive success of each male morph by genotyping both adults and nymphs to determine the paternity of the offspring. My findings show that females produce more offspring with the ancestral cricket morph than with the purring cricket morph, but that the ancestral cricket also experienced much higher rates of parasitism. This indicates that while certain traits—such as the cricket's song—may enhance reproductive success, they can simultaneously increase risks to survival.

NEIGHBORHOOD OPPORTUNITY AND SLEEP HEALTH: UNEXPECTED PATTERNS IN FAMILIES FACING ADVERSITY

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This research explored links between neighborhood opportunity and child and parent sleep in families experiencing significant adversity. Understanding these links can inform policies and interventions to promote health and well-being in families experiencing low income, as sleep is often linked with physical and mental health outcomes. I analyzed previously collected data from families experiencing significant adversity, including geocoded census tract data to evaluate neighborhood opportunity and questionnaire data assessing parents' perceptions of both their own and their children's sleep quality. To examine the hypothesis that lower neighborhood opportunity correlates with poorer sleep quality, I conducted linear regression analyses using SPSS. Increased neighborhood opportunity was not associated with maternal sleep quality, but was significantly associated with poorer child sleep quality ($\beta = -.31, p < .001$); poorer sleep quality was associated with more internalizing ($\beta = -.20, p = .03$) and externalizing symptoms ($\beta = -.30, p < .001$). For families facing significant adversity, there may be increased stress and social pressures in the context of living in higher opportunity neighborhoods, which in turn may negatively impact child sleep.

AN ANALYSIS OF THE ROLE OF MOTHERHOOD IN SOCIETY OVER THE LAST 100 YEARS – A COMPARISON OF GERMANY AND AMERICA

Larissa Fedorovich-Klein¹

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How society expects women to handle motherhood and the reality of motherhood often do not cooperate. This is reflected historically in Nazi Germany and currently in the United States, specifically in the restriction of reproductive healthcare towards women and mothers. I looked at the political climate of modern-day America as well as Nazi Germany to conclude the effects of restricting reproductive health care as both societies became more extreme. As societies become more right-leaning and conservative, there is a change in access to reproductive health care for women, as their role in society is changed to that of the mother and homemaker once again.

THE PAWS PORTRAIT PROJECT

Georgie Fields¹, Kimberly A. Guevara¹, Aven McCall¹, Ben Peltier¹, Feruz Yahia¹

¹Student Contributor, University of Denver

Our project addresses how to support animal shelters facing overpopulation, with a focus on the Denver Animal Shelter—the only open intake shelter in the city. We explore how media and community engagement strategies can alleviate strain on the shelter by increasing adoptions and public awareness. We interviewed staff and volunteers at the Denver Animal Shelter, analyzed their social media presence, and researched successful outreach strategies from other cities to design a targeted plan for boosting adoptions. We also photographed adoptable and stray dogs and cats to feature them in engaging social media posts that increase visibility and connect with potential adopters. We conducted interviews before and after the photo updates, asking our stakeholder if they observed improvements in shelter operations or higher adoption rates for dogs featured in the new photos. The project is still ongoing, so final results are yet to be determined.

ILLUMINATING MITOCHONDRIAL Zn^{2+} DYNAMICS VIA TRPML1 USING A FLUORESCENT Zn^{2+} SENSOR MITOGZNP4S

Patrick Flores¹

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Can a sensor be developed with a high enough affinity to detect Zn^{2+} transport into the mitochondria from other intracellular compartments that may contain Zn^{2+} ? We introduced mutations into a genetically encoded Zn^{2+} sensor to enhance its sensitivity and selectivity for Zn^{2+} and targeted it to the mitochondria, and characterized it in vitro. Then, we overexpressed this sensor, along with TRPML1, in HeLa cells and activated TRPML1 with its agonist and measured Zn^{2+} uptake into the mitochondria over time. We successfully created a high affinity mitochondrial Zn^{2+} sensor that is selective for Zn^{2+} and used this sensor to show that Zn^{2+} is transported from lysosomes to mitochondria via TRPML1. Our data suggests that Zn^{2+} ions can be transported between organelles, which may be relevant to MLIV disease, which is caused by mutations in TRPML1.

THE SHIELD OF FEMININITY: WOMEN'S ROLES IN NAZI GENOCIDE AND THEIR ESCAPE FROM ACCOUNTABILITY

Jadyn Floyd¹

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This research investigates societal perceptions of female perpetrators of the Holocaust in postwar Germany and examines how these perceptions led to the denial and minimization of their involvement in Nazi crimes. By analyzing gendered narratives of violence, I argue that the widespread belief in women's inherent nonviolence led to the obstruction of both social and judicial accountability. Through case studies such as Irma Grese and Leni Riefenstahl, alongside a range of primary and secondary historical sources, my research demonstrates how gendered assumptions influenced legal proceedings and shaped collective memory in the aftermath of World War II in Germany. My project calls for a critical reassessment of women's roles in the Holocaust and challenges dominant historical narratives that have long undermined women's participation in Nazi atrocities.

HOW TRYING FEELS: INTEROCEPTION'S ROLE IN THE EXPERIENCE OF EFFORT DURING DECISION MAKING

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When faced with mentally demanding tasks such as decision making, how does awareness of bodily sensations (interoception) influence the deployment of cognitive effort? This study explores whether individuals who are more attuned to their internal bodily signals experience cognitive effort more intensely, shaping how and when they exert effort during decision making. In a two day in-person study, on the first day we quantitatively estimated participants' risk preferences, and then used those estimates to create individually-tailored choice sets with choices that were easy and difficult for that person. Effort was indexed by decision times. In the second session, participants completed a heartbeat detection task in which they judged whether sequences of tones were in-sync with or delayed from their heartbeat across 160 trials, enabling the robust calculation of their accuracy in that judgment. Hierarchical linear regressions found that interoceptive ability shapes effort exertion as indexed by decision time globally and on a per-trial basis. Globally, good interoceptors decided more quickly on average than poor interoceptors, consistent with an overall reduction in effort perhaps due to increased sensitivity to effort's affective consequences. Good interoceptors' effort was additionally more tightly calibrated to current choice difficulty and less calibrated to recent choice difficulty, indicating that effort was somewhat more precisely exerted by these individuals. These results indicate that individual differences in interoception may shape effort exertion during decision making at multiple levels, including globally over the entire task, and moment-to-moment in response to fluctuating task demands.

JANTHINOBACTERIUM LIVIDUM AS A POTENTIAL INFECTION MODEL FOR STUDYING IMMUNE DEFENSE IN THE FRESHWATER SPONGE EPHYDATIA MUELLERI

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Sponges are aquatic invertebrates that feed by phagocytosing bacterial prey, a feeding strategy with a high risk of infection by intracellular pathogens. Although they clearly distinguish between prey, parasitic, and beneficial microbes, the cellular and molecular mechanisms underlying this discrimination remain unknown. A major barrier to mechanistic studies of sponge immunity is the absence of experimentally tractable systems that reliably induce authentic immune responses. To overcome this, we are seeking natural bacterial pathogens capable of eliciting reproducible and physiologically relevant host responses. A Gram-negative *Janthinobacterium* species (strain SLB01) was recently identified in Lake Baikal, Russia, as a natural pathogen of freshwater sponges. However, this isolate is currently inaccessible for laboratory study. Notably, unlike many pathogenic bacteria that rely on a type III secretion system (T3SS) to infect host cells, SLB01 encodes a type VI secretion system (T6SS), suggesting a distinct virulence mechanism. To experimentally model this interaction, I screened three commercially available strains of *Janthinobacterium lividum*: two encoding T6SSs and one encoding a T3SS. For each strain, I conducted growth assays to correlate optical density with colony-forming unit (CFU) counts and used these data to standardize inoculum concentrations for experimental infections in the model sponge *Ephydatia muelleri*. Infection dynamics were monitored over time using eubacterial fluorescent *in situ* hybridization (FISH) combined with DNA and actin counterstains and confocal microscopy. Preliminary results indicate that *J. lividum* can bypass the canonical phagolysosomal feeding pathway and enter the sponge body cavity—behavior consistent with either pathogenic or mutualistic strategies. I am currently characterizing host responses to the T3SS- versus T6SS-encoding strains, with the expectation that T6SS-bearing strains may more accurately recapitulate the infection strategy of SLB01. This system may ultimately provide a tractable and ecologically relevant model for studying innate immunity in sponge-microbe interactions.

EXPLORING THE MARTIAN PALEOCLIMATE THROUGH RIVER-VALLEY NETWORK PATTERNS

Camryn Gunter¹

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This project explores what ancient Martian river patterns can tell us about the climate that formed them. It aims to expand the knowledge of extraterrestrial river-network analysis and the climate history of Mars. By evolving the river-valley network backwards in time, we collected climate information about the entire history of its growth and calculated a growth exponent. This growth exponent will inform us about the climate of Mars during the time of formation, a value of less than one indicates an arid climate and more than one indicates a humid climate. With our analysis, we found that one Martian network likely formed in an arid climate.

NAVIGATING EDUCATION: A RESOURCE GUIDE FOR PARENTS AND FAMILIES

Kendal Hengst¹, Charlie Bednarz¹, Issy Garside¹, Addison Baker¹, Rachel Mina¹

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Our project addresses the ongoing issue of education inequity in Colorado by focusing on one of the most vital, yet often overlooked, stakeholders in the system: parents. Through conversations with teachers, administrators, and education advocates, we identified a need for accessible, family-centered tools that support parents as they navigate their children's education. In partnership with the Bueno Center, we developed a bilingual parent guidebook that provides practical resources, answers to common questions, and guidance on how to build stronger relationships with schools. Rather than offering one-size-fits-all solutions, the guide is designed to be adaptable—giving families the tools to advocate for their own needs and empowering schools to meet families where they are.

HOW DOES ANIMAL PERSONALITY RELATE TO EVOLUTIONARY CHANGE

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Do personalities differ between newly evolved cricket morphs with different evolutionary histories? We analyzed previously developed assays of behavioral trials for crickets. We then created our own to develop assays specifically measuring exploration, neophobia, and predation. Our results were the types of assays developed. We had to wait to test them in the field, and began trials in the summer for lab crickets.

NARRATING THE NEW COLD WAR: INVESTIGATING CHINESE CYBER PROPAGANDA AND SINO-AMERICAN TENSIONS ON BILIBILI

William Highfill¹

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How does Bilibili, as a digital platform targeting international and diasporic Chinese audiences, construct and disseminate New Cold War narratives that critique Western systems and promote China as a stable alternative, what ways do these narratives draw from or diverge from historical Cold War propaganda, and what implications do they have for understanding the evolving role of digital platforms in shaping global geopolitics? Through a qualitative digital ethnography, I immersed myself in the platform's algorithmic environment, analyzing politically charged content, remix culture, bullet comment threads, and patterns of engagement surrounding reuploaded Western media. My research demonstrates that Bilibili does not function as a top-down propaganda machine, but rather as a hybrid ideological space where users co-produce nationalist narratives through symbolic reinterpretation, emotional discourse, and selective critique of Western institutions. Drawing on comparisons with Cold War-era propaganda, I argue that Bilibili exemplifies a new model of participatory digital nationalism; where nationalism is reinforced not just through direct government messaging, but through user participation. This makes it more resilient than traditional state-controlled media, as users feel that they are actively shaping the discourse, rather than being passively indoctrinated.

EXOSOME ISOLATION FROM BRAIN TISSUE OF THE 3XTGAD MOUSE MODEL FOR ALZHEIMER'S DISEASE

Sydney Jaques¹

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Alzheimer's disease is a neurodegenerative disease that occurs with the accumulation of amyloid-beta plaques and tau protein in the brain. Exosomes, small, cargo-carrying vesicles released by cells, have been thought to be possible contributors to the spread of these pathogenic proteins throughout the brain. This study begins to explore the role of exosomes in the neuropathology of Alzheimer's disease by establishing a protocol for exosome isolation from 3xTgAD mice brain tissue. Four immunoaffinity-based isolation techniques were used, followed by transmission electron microscopy (TEM), dot blotting, nanoparticle tracking analysis (NTA), and Western blotting to validate the isolated extracellular vesicles (EVs) as exosomes. Out of the four methods explored, sequentially isolating astrocyte-derived exosomes (ADEs) using streptavidin-bound magnetic beads and biotinylated GLAST antibody from Invitrogen yielded the comparatively purest and most populated sample of isolated exosomes. Deriving exosomes directly from brain tissue allows for close study of their role in the spread of pathogenic amyloid-beta and tau proteins through the brain. This protocol opens the door for downstream biomarker analysis of exosomes, particularly with biomarkers indicative of neurodegeneration and neuroinflammation, and extends the applicability of known exosome isolation techniques from biological fluids to brain tissue. Furthermore, the capacity to directly isolate exosomes from brain tissue is highly relevant to understanding how these vesicles contribute not just to Alzheimer's disease, but also to other types of neurodegenerative diseases with neurologically localized pathologies.

METABOLOMICS ANALYSIS OF ASTROCYTE ACTIVATION IN NEUROLOGICAL LONG-COVID AND MILD TRAUMATIC BRAIN INJURY

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The neuroinflammatory responses in COVID-19 infection are similar to those observed in mild traumatic brain injuries (mTBIs), including activation of glial cells in the brain and the release of pro-inflammatory cytokines; however, the complete mechanisms of these neuroinflammatory responses are not fully understood. The purpose of this study was to explore the metabolic changes associated with glial activation in vitro caused by exposure of primary human astrocytes to astrocyte-derived exosomes (ADEs) from patients with a history of COVID-19 and mTBI using metabolomics. Following recruitment of participants with histories of COVID-19 infection only, mTBI only, both COVID-19 infection and mTBI, or neither COVID-19 infection nor mTBI, ADEs were isolated from patient plasma samples. Primary human astrocytes were incubated with pooled ADEs from each group, and UHPLC-MS metabolomics was performed on the astrocyte lysates. The LC-MS data were analyzed to identify significant differences in metabolite levels between groups using an online metabolomic analysis platform, MetaboAnalyst. Fold change analysis revealed differences in metabolite levels in astrocytes exposed to ADEs from patients with a combined history of COVID-19 and mTBI compared to control patients, including metabolites related to oxidative stress, glycolysis, and fatty acid oxidation. Pathway analysis of the metabolites identified by UHPLC-MS revealed several significantly represented pathways, including glutathione metabolism, purine metabolism, amino acid metabolism, and energy production pathways. These results offer a unique metabolic perspective of astrocyte activation due to neuroinflammatory conditions and support further investigations into the underlying mechanisms of these metabolic changes.

DESIGNING APP FOR MATLAB REAL-TIME APPLICATION

Ethan Lim¹

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How can software be applied to a real-time system to improve the functionality and user control of a robotic system during operation? Designing a Real-Time app that can control motor functions and display data through graphs can make controlling and understanding a robotic system easier. Provides users with data that's constantly being updated and allows to control machine functions while operating. Designing an app for a real-time application with a Speedgoat Target Machine is relatively new because there are limited number of resources available. It is important to research and study the functions that support Simulink Real-Time to build a functioning app.

PLP - LEAD THE WAY CCI PROJECT PRESENTATION

Jagger Livengood¹, Owen Mantelli¹, Gabby Pappas¹, Abby McDonald¹, Madeleine Dierking¹, Eve Miller¹

¹Student Contributor, University of Denver

Our project addressed lacking leadership and soft-skill education in local high schools. We became involved in school systems, teaching courses on leadership and soft skills weekly. We educated around 30 students on these tactics and hosted an event at DU where students interacted with leadership professionals and activities.

TENSIONS IN THE ARCTIC: AVOIDING CONFLICT AMIDST CLIMATE CHANGE AND MILITARIZATION

Emma Loeber¹

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My project sought to find a way for the Arctic states to increase their collaboration and transparency in order to prevent a conflict from happening over resource competition, insecurity, and militarization. I analyzed the published Arctic Strategy documents of the Arctic states and China in order to determine each state's goals for the region and how those could be fulfilled while also taking action to reduce political tensions. My analysis resulted in the two recommendations: that the Northeast and Northwest Passages be declared international straits under the governance of Russia and Canada respectively and that the Arctic Council expand its mandate to include military security issues so that the states can better communicate. I believe that these recommendations would be acceptable to all of the relevant states and successfully reduce the likelihood of a conflict in the region.

EXAMINING THE IMPACTS OF THE MT. ST. HELEN'S ERUPTION ON TREE GROWTH

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Following the eruption of Mt. St. Helens, there were large amounts of ash distributed across the United States. Tree core samples were collected from forests near Enumclaw, Washington – roughly 100 miles from the eruption site – that were analyzed using the tree rings to examine how different tree species grew year to year. Charts were created in order to show the changes in growth following the eruption in 1980. The project determined that the nutrients in the ash promoted growth within the trees. The tree rings became complacent following the eruption, indicating that the nutrients allowed for the trees to thrive even in dry years.

VISUALIZING OZONE POLLUTION IN THE DENVER METRO AREA USING A BIOINDICATOR GARDEN

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Since the industrial revolution, widespread fossil fuel combustion has significantly increased atmospheric pollution. The combustion of fossil fuels releases nitrogen oxides (NO_x) and volatile organic compounds (VOCs), which form tropospheric (ground-level) ozone when exposed to sunlight. Ozone directly harms plants by disrupting their ability to absorb carbon dioxide, release oxygen, and carry out photosynthesis. Bioindicator species are plants that have visible responses to environmental conditions, such as ozone, and can act as “canaries in the coal mine,” indicating the health of their environment. In this study, I use a garden of ozone bioindicator species (ozone garden) as a cost-effective tool for monitoring and visualizing the effects of anthropogenic ozone pollution. My goal was to understand the damage tropospheric ozone has on plants in Denver using two varieties of beans: a common ozone-sensitive variety and a modified ozone-tolerant variety as a control. For a full growing season, I monitored the temperature, ozone concentration, and leaves for ozone damage. I found that the ozone-sensitive cultivar exhibited significantly more foliar injury compared to the tolerant cultivar ($p < 0.05$) in response to tropospheric ozone. I also found evidence that ozone-sensitive snap beans experience a latency period in their response to foliar injury. All foliar injury data were added to a nationwide database of ozone gardens to contribute to understanding the relationship between ozone concentration and damage severity across different locations.

DEVELOPING RESEARCH METHODS FOR MEASURING AND IMPROVING USER ENGAGEMENT WITH LARGE LANGUAGE MODELS

Khadija Mohamed¹

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This project focuses on developing a framework for studying how users engage with content generated by large language models (LLMs). It aims to guide future research on how elements like tone, personalization, and structure may influence trust and perception. The project will begin with a review of existing literature on user engagement and LLMs to identify current research approaches. From there, I will organize key themes into categories and subcategories to help build a flexible framework that future researchers can use to study how users interact with LLM-generated content. While the research is ongoing, the goal is to create a foundational framework that can be used and adapted by future researchers. As LLMs continue to evolve, this work can help guide more effective and consistent methods for studying user engagement with these emerging technologies.

EXPANDING AWARENESS AND SUPPORT FOR NEURODEGENERATIVE DISEASES IN THE VIETNAMESE REFUGEE COMMUNITY

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After conducting a thorough literature review, we identified systematic barriers that hinder the understanding and diagnosis of neurodegenerative diseases. To better support Vietnamese communities—especially immigrants and victims of the Vietnam War—we plan to provide easily accessible and comprehensible materials to address cultural and linguistic gaps. Our goal is to create a culturally sensitive brochure that informs Vietnamese individuals and families about symptoms, available resources, and support options. This tool is designed to bridge communication gaps and raise awareness within the community.

DATA-INFORMED DECISIONS: CONCORDANCE OF APPRAISAL FROM MULTI-INFORMANT REPORTS ON LIVING SITUATIONS (LS) OF OUT-OF-HOME-CARE (OOHC)

Gabri Notov¹

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In 2022, the Adoption and Foster Care Analysis and Reporting System (AFCARS) estimated that there were 369,000 children in foster care as of the Federal Fiscal year (FY) with 187,000 of those children having just entered that year (U.S. Department of Health & Human Services, 2024). Given the importance of utilizing multi-informant forms for surveys about placement and abuse (Ren et. al., 2024; The Center for Human Services et. al., 2008; Fang et. al., 2023), I used this subsection of the Living Histories Project for my micro credential in data-informed decisions in order to investigate the moderating effect of attachment on concordance and discrepancies across multi-informant forms. Data was acquired from the original R01 longitudinal study conducted by Fostering Healthy Futures (FHF), a mentorship intervention for preteens and teens in out-of-home-care (OOHC) (Taussig et. al., 2012). The primary goal of the micro-credential was to use a variety of statistical software— R, SPSS, REDCap, and Excel— to establish the main association between concordance of living situation (LS) appraisal at timepoint 1 (T1) and the number of subsequent living situations at T2. Concordance was measured at 2 levels using Pearson's R and 3 levels using a one-way ANOVA. Results came out marginally significant for the Pearson's R, $t(251) = 0.78$, $p = .089$, and the one-way ANOVA, $t(251) = 0.78$, $p = .089$. A sensitivity power analysis at 80% power was conducted based on the sample $n = 160$, resulting in a small effect size, $f^2 = 0.039$. Thus, while there is a possible inverse relationship between concordance and placement stability, there was not enough power to rule out alternative explanations for these results. We plan to further investigate this using the other waves of data from FHF to increase power and analyze the child's attachment to their caregiver.

CULTURING, BLEACHING, AND EXOSOME EXTRACTION FROM CAENORHABDITIS ELEGANS MODELS FOR PARKINSON'S DISEASE

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My project addresses how exosomes derived from *Caenorhabditis elegans* contribute to the spread of α -synuclein aggregation, a hallmark of Parkinson's disease. Understanding this mechanism is important for identifying potential therapeutic targets that could interrupt the progression of neurodegeneration. To investigate exosome-mediated α -synuclein aggregation, I cultured transgenic *C. elegans* expressing human α -synuclein, performed synchronized bleaching to obtain age-matched populations, and extracted exosomes using ultracentrifugation and filtration techniques. These vesicles were then analyzed to assess their role in protein aggregation and intercellular signaling. Through culturing, bleaching, and exosome extraction from *Caenorhabditis elegans* models of Parkinson's disease, I successfully isolated exosomes containing α -synuclein aggregates. Confocal imaging revealed the localization and progression of these aggregates, particularly in the head region of the worms. These findings suggest that exosomes may play a role in the propagation of neurodegenerative pathology, offering insights into potential therapeutic targets for Parkinson's disease.

POLLEN ANALYSIS FROM A LOW-ELEVATION FEN IN COLORADO'S FRONT RANGE AND IMPLICATIONS REGARDING CLIMATE CHANGE

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Peatlands serve as valuable paleoecological archives through preserving long-term records of climate and vegetation change. While most studies in Colorado have focused on high-elevation fens and lakes, little is known about the paleoecology of lower montane systems, despite their sensitivity to environmental changes. This thesis presents a fossil pollen analysis from Todd Gulch fen, located at approximately 8,460 feet in Colorado's Front Range – making it one of the lowest elevation fens in the region. Through microscopic identification of stratified pollen preserved in a sediment core, this study reconstructs vegetation dynamics over the last 10,000 years, offering insights into Holocene climate variability and vegetation dynamics. Results indicate distinct shifts in pollen composition corresponding to known Holocene climatic phases, including early Holocene warming, mid-Holocene aridity, and Neoglacial cooling. These findings not only contribute a new paleoecological record for a spatially underrepresented zone, but also emphasize the ecological sensitivity of montane fens to climatic and hydrological fluctuations. Understanding these long-term patterns provides critical context for anticipating future ecosystem responses under projected climate change in the Southern Rocky Mountains.

VULNERABLE POPULATIONS AND COASTAL HAZARDS

Anna Paradiso¹

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This project aimed to determine what demographics in Gulf Coast cities are most at risk of coastal flooding hazards and what locations would require the most support in an emergency flooding situation. Using data from the US Census Bureau and the Federal Emergency Management Agency for the Houston, New Orleans, and Tampa regions, I created a database in PostgreSQL and a geodatabase in ArcGIS. I then used PostgreSQL to run queries to determine the most vulnerable locations based on demographic factors and used ArcGIS Pro to display these areas alongside flood risk areas. Cross-referencing this data with case studies, I determined that there are several areas where elderly populations are concentrated along the coast and in high coastal flood risk areas. Elderly populations in particular can have increased difficulty evacuating in emergency situations and often require more assistance. I produced several maps displaying these case studies, showing where vulnerable populations are most exposed.

INVESTIGATING THE REGENERATION OF ZEBRAFISH SWIM BLADDERS

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The zebrafish swim bladder is an air-filled organ that plays a critical role in buoyancy control and is developmentally and evolutionarily related to the human lung. Both organs originate from the foregut endoderm and share structural and functional similarities, including the presence of epithelial cell layers, gas exchange functions, and signaling pathways. Given this homology, the zebrafish swim bladder offers a unique and accessible model to study processes relevant to lung biology and disease. Understanding whether the swim bladder can regenerate after injury is important because it could reveal fundamental mechanisms of epithelial repair, fibrosis, and functional recovery—processes that are directly relevant to human lung diseases such as asthma, pneumonia, bronchitis, and chronic obstructive pulmonary disease (COPD). Despite the swim bladder's potential, its regenerative capacity remains largely unexplored.

To investigate this, we developed a mechanical injury model in adult zebrafish by puncturing the swim bladder through the body wall with a 30-gauge needle. We collected swim bladder tissues at various time points post-injury and analyzed them using immunofluorescence microscopy and Western blotting to assess cell proliferation and remodeling responses. Immunofluorescent staining revealed a transient increase in proliferating cells between 3 and 7 days post-injury, as indicated by PCNA expression, but this was not sustained over time. Fibronectin, a marker of tissue remodeling and fibrosis, remained consistently expressed at the injury site through 60 days post-injury. Western blotting supported these observations, suggesting that while a limited proliferative response occurs, the swim bladder does not fully regenerate. Instead, the tissue exhibits signs of chronic remodeling and scar formation. Notably, swimming behavior returned to normal within 24 hours of injury, despite the persistent structural damage to the swim bladder. These findings highlight a disconnect between functional recovery and true tissue regeneration and suggest that the swim bladder may undergo a fibrotic, rather than regenerative, healing response. Further studies are needed to understand the molecular signals that limit regeneration in this organ and to explore how these mechanisms may relate to human lung repair and disease.

PREDICTING PREECLAMPSIA TO REDUCE BLACK MATERNAL MORTALITY USING MACHINE LEARNING AND COMMUNITY-CENTERED DATA APPROACHES

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Black maternal mortality in the United States remains a public health crisis, with Black pregnant individuals facing rates of death and complications that far exceed those of their White counterparts. A major contributor to this disparity is preeclampsia, a life-threatening hypertensive disorder that disproportionately impacts Black women, often earlier and more severely in pregnancy. This research explores how machine learning can support earlier identification of preeclampsia risk to improve outcomes. Drawing on publicly available maternal health datasets, I built and evaluated a proof-of-concept predictive model in Python, adapting techniques involving Naive Bayes classifiers. My preeclampsia model, trained on features like blood pressure, age, and urine protein levels, was assessed not only for accuracy but also for fairness across racial groups. Findings revealed the model's predictive potential while highlighting deep limitations in data representation for Black patients. These results underscore the need for equitable, community-centered data collection practices and ethical safeguards in health AI. This work contributes to ongoing conversations at the intersection of data science, health equity, and systemic bias in clinical outcomes.

COMPARING PATH PLANNER COMBINATIONS FOR AUTONOMOUS ROBOTS

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To determine an optimal combination of local and global path planners for a specific robot to optimize navigation. Using the robot's LiDAR sensor and mapping capabilities to create a map of a space and testing different combinations of implemented path planning algorithms to determine which ones are most effective for different situations. The results of my data analysis were inconclusive, as I ran into compatibility issues with certain algorithms and only determined working algorithms toward the end of my time researching.

ENSURING ACCESS TOGETHER: INCREASING SNAP CAPACITY AT COLORADO FARMER'S MARKETS

Juliana Ramirez¹, Casey Doherty¹, Ella Kestner¹, Teagan Weindel¹, Cate Billings¹, Pablo Torre-Walter¹

¹Student Contributor, University of Denver

How can we fill the gap between farmers seeking to accept SNAP at farmers' markets and ensure they have both the necessary training and sufficient devices to accept SNAP payments? We reconstruct the curriculum to train farmers on SNAP certification and usage, a host workshop, and use our grant funding to supply transaction devices and do onboarding days. While also using feedback from farmers and partners to guide our process and improve future training. Success will be measured by the number of farmers trained, SNAP certifications obtained, increased transactions, and participant feedback on the new curriculum guide, adoption numbers and market impacts, however we have yet to fully complete the project as our timeline is set to complete in May.

IMPROVING ACCURACY OF SUPER RESOLUTION IMAGING: FINDING CENTER OF LASER BEAM

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The purpose of this project is to use super-resolution imaging in deep tissue, specifically the brain, which is important because it can be applied to study the structure-function of neurons regarding the process of learning. Resolution of deep tissue imaging is limited by how well the vortex is centered, and this project focuses on refining the imaging technique by using a different method for centering the beam on the vortex than the one used in the original demonstration of this imaging technique. To find the center of the beam, this project will use an interferometric technique that allows for the measurement of phase and intensity. In the previous demonstration of this imaging technique, intensity fitting was used to center the beam, which only relies on intensity. When both phase and intensity are used to determine the center of the beam, instead of just intensity, it is predicted this will output a more accurate reading. This project was not completed fully, but the results so far have shown aspects of the program that codes the vortex that are crucial for stability and resolution of the hologram, and can be used when continuing this project to optimize the future result.

LETS TALK IMMIGRATION: FACILITATING EMPATHETIC CONVERSATIONS BETWEEN FIRST-GENERATION AND HIGH SCHOOL STUDENTS

Khadeeja Rashid¹, Laine Satterlee¹, Piper Heilbronner¹, Lily Pound¹, Ben Whitehurst¹

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This project focuses on fostering psychologically safe, collaborative dialogue surrounding the topic of immigration. Given the current political climate, these types of verbal and written exchanges are becoming increasingly dangerous and stigmatized, yet these very challenges underscore the urgency and necessity of creating spaces where open and authentic conversations can thrive. This project employed a combination of quantitative/qualitative surveys and reflective in-person and virtual discussions to understand the student perspective on immigration and how to best address the needs of those involved. While the trajectory of this project shifted from discussion-based facilitated workshops to a holistic guide for future implementation due to the safety concerns of the current political climate, we strongly believe this project is a step towards a more empathetic community through a continued partnership with the Ambassador Foundation and the students that make it possible.

DSFYA: YOUTH TACKLE CAPITOL LOBBYING

Anna Respet¹, Lizzie Lesoing¹, Sydney Hertel¹, Aya Saad-Masri¹, Brooke Ballenger¹, Max Proske¹

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How can we empower high school students across Colorado to advocate for themselves and their peers in the political and public policy realms? Upon consulting our community partner and coach, we decided we can best leverage our capacity, resources, and connections as a team by organizing a lobbying day at the Colorado state capitol for Colorado Youth Congress high school members. This will empower these students by both educating and training them on how to lobby, contact their elected officials, and make meaningful political and public policy change while applying these skills to specific contemporary issues they care about. We anticipate that this experience will be transformational and highly beneficial for the youth that attend, as it will further aid them in their skills in and passion for public policy and political advocacy. We will measure the success of this project by debriefing with attendees and sending out surveys, conducting interviews, and following up with the impact made both in the legislature and among those involved.

FOSTER FORWARD

Hannah Rosenberg¹, Ellia Nakahara¹, Sophia Espinoza¹, Ivan Woolhouse¹

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How can we assist foster youth members who are aging out of the system? We wanted to prepare members of the foster care system by connecting them with resources that aid them in the aging out process. We met with a variety of stakeholders to get insight into how our help would be most useful. Additionally, we gained support to compile research on the most helpful resources that are needed to transition into adult living. We established that foster youth need resources before they age out, so we created a resource booklet to provide easy access for them to view. It will be given to our community partner, Hope and Home, to receive feedback on how helpful the booklet was for foster youth.

RECURRENT PROCESSING OF LUMINANCE AND ILLUSORY VISUAL CONTOURS

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The visual brain stitches together luminance contours (boundaries between light and dark) to detect illusory contours (partially occluded surfaces). Can the visual brain detect illusory contours with linear, feedforward communication alone, or is recurrent processing necessary? The answer could shed light on the brain's architecture and on the construction of neural networks designed to parse visual scenes. Object substitution masking is a noninvasive tool believed to disrupt recurrent processing, and thereby detection, of an object by overwhelming recurrent communication with new stimulus-associated activity. If luminance contours prove to be more resistant to masking than illusory contours, then we may have evidence that luminance contours are less reliant on recurrent processing. Though we found overall effects of masking and contour type on visibility of visual objects, we did not find that luminance contours were more resistant to masking than illusory contours. As such, we have evidence that recurrent processing may be necessary for awareness of contours broadly, regardless of type.

BRUSH-E BOT: MAKING TOOTH BRUSHING FUN AND EASY FOR KIDS THROUGH ROBOTICS

Melaku Saketa¹

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How can we make daily tooth brushing more engaging for children to encourage better oral hygiene habits? We designed and tested multiple versions of a kid-friendly robot using 3D modeling software and 3D printing. Each prototype was evaluated for functionality, usability, and its potential to make brushing more engaging for children. We developed and refined multiple working prototypes of the Brush-E Bot, focusing on ease of use, interactive features, and educational potential. While the robot was not tested on children, internal evaluations showed improvements in design functionality and user engagement elements.

WATER INEQUITY IN THE DENVER METROPOLITAN AREA: TRUST BUILDING BETWEEN COMMUNITIES AND GOVERNMENT ENTITIES

Michela Schenk¹, Maren Lynch¹, Madi Hamm¹

¹Student Contributor, University of Denver

How has historical instances of environmental injustice in marginalized communities led to a lack of trust in government solutions to water inequity? How can we bridge the gap between these community organizations to support initiatives around water equity and sanitation? Utilizing interviews with a wide variety of stakeholders, we gained perspective on the multi-faceted nature of water inequity and the compounding social, legal, and environmental factors that have created the public health situation that is present today. In our partnership with Denver Water, we ideated various routes of action that could sustainably benefit the affected communities. Ultimately, we directed our project towards building relational trust between community organizations and governmental agencies that have the resources to solve the infrastructural issue. Through a partnership with Denver Water's Lead Reduction Campaign, we aided in the expansion of Denver Water's network of community partners. We hope through this project to strengthen the trust between marginalized communities and Denver Water. This trust will be crucial in solving decades of infrastructural issues of the low-income and predominantly immigrant areas of Denver and will in turn solve the resulting public health issues that stem from water inequity.

PSYCHOPHYSIOLOGICAL REACTIVITY AND ANXIETY IN YOUTH: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Research studies have shown mixed findings for the association between psychophysiological arousal/reactivity and anxiety, with some studies showing a significant positive association and others showing no association, necessitating clarification. This systematic review involved two meta-analyses of eligible studies examining psychophysiology and anxiety in youth. A systematic literature search was conducted in PsycINFO, PubMed, and Web of Science for peer-reviewed English language papers using stem abstract search terms relating to youth, anxiety, and psychophysiology. Full text of articles were then reviewed for inclusion, and eligible study data was then meta-analyzed in Comprehensive Meta Analysis V4. The overall effect size for single sample study correlations between psychophysiology and anxiety symptoms was small, positive, and statistically significant, indicating that overall higher anxiety symptoms are significantly associated with higher psychophysiological arousal at resting baseline. The overall effect size for psychophysiology between diagnosed anxiety/high symptom versus no anxiety diagnosis/low symptom groups was not significant, indicating that youth with anxiety diagnoses/elevated symptoms do not significantly demonstrate higher psychophysiological arousal at resting baseline than non-anxious peers. Together, these results suggest that the association between psychophysiological reactivity and anxiety may not be particularly robust, at least not with the sample sizes and included studies.

REDESIGNING NYKU'S BASE ROTATIONAL MOBILITY MECHANISM AND SOFTWARE

Rana Seif¹, Jackson Hall¹

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How can the current base-mobility mechanism and software on Nyku be altered in order to maintain functionality and reduce unnecessary external peripherals in order to produce a more life-like base that is easier to transport? We approached the problem by selecting some options for the redesign, then ultimately deciding on the simplest version of the base redesign which we then fully simulated the mechanism in SOLIDWORKS. We then wrote software that could independently run each motor, and finally, the system was prototyped using subtractive manufacturing and 3D printing. A base was successfully designed and prototyped to be enclosed within the penguin base and was able to still provide 3 degrees of rotational freedom with some added limits to the rotational angles dictated by built-in hardware and software restrictions. The updated mechanism faced less issues with traction than the older design because it relied on solid joints held together by screws rather than frictional elements.

BRAIN HEMORRHAGE ASSOCIATED BLOOD BIOMARKERS USING CAPILLARY ZONE ELECTROPHORESIS

Marisela Simental¹, Daniel Paredes², Aaron Mena²

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What are the concentration patterns of common biomolecules present in the blood samples of brain hemorrhage patients? This research project involved running and processing of blood samples through the CZE, acquiring data in the form of electropherograms, and analyzing the collected data. As well as data analysis via concentration calculations from the electropherogram data and calibration curves of standard solutions. The results include electropherograms of actual patient blood samples and all standard dilutions of the biomolecules we are interested in analyzing.

TRPML1 KNOCKDOWN USING SHRNA RNA INTERFERENCE

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Mucopolipidosis type IV (MLIV) is an extremely rare neurological disorder that is linked to the loss of function of the MCOLN1 gene, which encodes the protein TRPML1, a lysosomal channel permeable to Zn^{2+} and Ca^{2+} . MLIV is characterized by neurodevelopmental and ocular impairment. Currently, there is no cure for the disease but it is known that the impairment caused by the disorder is due to the dysfunction of the TRPML1 channel. My goal in this project was to create a shRNA construct that would knockdown TRPML1 and stimulate a cell affected by MLIV. Through transfection of the shRNA plasmid and fluorescence imaging it was ultimately found that one of the transcripts, shRNA 1079, was successful in knocking down TRPML1 expression. Furthermore, the finding that there was no Ca^{2+} spike in wildtype hela and astrocytes indicates that there could be higher endogenous levels of TRPML1 in neurons as opposed to other cells.

THE RECONSTRUCTION OF THE AMERICAN JEWISH IDENTITY POST-OCTOBER 7TH

Evelyn Stovin¹

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The goal of this project was to determine if a Jewish national identity was forming post-October 7th. If a national identity is forming, this project also aimed to determine why this is happening and what this could mean for the future of the Jewish community. I decided to do surveys and interviews to gain insight into how Jewish students at the University of Denver are defining their Judaism and Jewishness, what their perception of Israel is and its relationship to their identity, and whether they feel they belong to the Jewish community, while factoring in social media. For the social media portion of this project I followed the ADL, Jewbelong, Jewish on Campus, and Rootsmetal on Instagram in addition to liking and sharing what Jewish students liked and shared in order to see what these posts did to my algorithm. There is a national identity forming. However, there is a disconnect between Jewish leadership and the Jewish community. Jews are being asked to make a decision on whether to support their community when neither political wing really acknowledges the American Jewish experience, or compromise their identity in order to stay true to their values.

OPTICAL VORTEX STABILIZATION AND MODELED TURBULENCE

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Can we test and develop a method to reduce the effects of turbulence acting on vortices within a laser beam? How can we simulate turbulence in the lab? Using models of turbulence theory in holography to simulate turbulence in our lab to be able to test the counteract the affects of turbulence on a laser beam. Using models of turbulence theory in the field of holography, i developed a way to emulate turbulence using a spacial light modulator on a laser beam. This is a way we are now able to effectively enact scales of turbulence on a laser beam in our laboratory .

CONSTRUCT SUSTAINABILITY HUB DATABASE A STORAGE TO LARGE SUSTAINABILITY DATA SOURCES

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Sustainability Hub is a project focus on gathering data on Colorado Sustainability. This research aim collect large data source to perform information extraction in assisting LLM to generate response given user question. Large Language Model (LLM) is a model used to generate response base on pre-trained knowledge.

Sustainability Hub have a chatbot, also called as Sustainability Engine, in which LLM is critical model to run conversation between user and computing system. This correlates to sustainability data collection with intention to help community members to learn more about sustainability data in their own area to Colorado as a whole. In my research, building a SQL database help storage this large database that assist the Chatbot.

The Sustainability Hub Database is constructed to store large sustainability data sources using PostgreSQL with SQL primarily handling table structure setup. The PostgreSQL engine extension in VSCode facilitates database creation and data insertion while ensuring well-organized output. To automate database connectivity, the psycopg2 Python package is implemented, allowing parsed data to be directly inserted without manual intervention. Within the Python script, a parser processes incoming data using an algorithmic structure. To execute the INSERT INTO operation, a variable with placeholders (%s) is declared to dynamically accept and store values efficiently. The PostgreSQL extension in VSCode enables efficient table visualization, with the first 1,000 rows used to verify data insertion. Successful entries appear as expected, while "null" values indicate missing data requiring attention. SQL structures relevant categories, though fields like organization names remain in development due to storage challenges. For complex data extraction, LLMs can interact with APIs to retrieve missing information. The parsing method lays the foundation for future data sources, with potential for a reusable library. This structured storage will help LLMs extract keywords, find relevant data, and generate sustainability-related summaries.

PYTHON-BASED MACHINE LEARNING FOR ANALYZING DEER MICE MUSCLE AT HIGH ALTITUDES

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My proposal will use Python-based machine learning approaches to provide an improved, effective, and automatic quantification of oxidative fibers and capillaries from stained histological images of deer mouse skeletal muscles. My work intends to illustrate the efficacy of offering a reliable and straightforward way to examine tissue physiology and cellular metabolism in mouse models by comparing it with previous research. I will use Python and OpenCV to develop a computer vision tool that isolates and quantifies skeletal muscle oxidative fibers and capillary density through image segmentation and machine learning. The model's accuracy will be validated against 150 hand-quantified images, and once optimized, it will be applied to analyze the full 3,000-image dataset. The goal is to accurately quantify capillary density and oxidative fiber count, validating the model by comparing its results to 150 hand-quantified images using correlation analysis. If needed, the model will be adjusted to ensure statistical significance.

DENVER ISSA STUDENT AMBASSADOR PROGRAM

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How can we address the growing cybersecurity workforce shortage in the U.S., where nearly 470,000 unfilled positions leave organizations vulnerable to rising digital threats, financial loss, and reputational harm? We partnered with Denver ISSA to develop a Student Ambassador program aimed at addressing the cybersecurity industry's talent shortage and job vacancies. Our project achieved its goal by connecting students with cybersecurity professionals and mentors through networking events, while also enhancing their resumes and engagement in the field through the Student Ambassador role.

ECONOMIC WARFARE AGAINST IRAN'S NUCLEAR PROGRAM

Zoey Weiss¹

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This study evaluates the effectiveness of economic sanctions imposed on Iran's nuclear ambitions, with a particular emphasis on the Joint Comprehensive Plan of Action (JCPOA) and the Maximum Pressure Campaign (MPC). Using the Economic Coercion Trilemma framework, this research analyzes the impact of these sanctions regimes on Iran's nuclear program through the lenses of efficacy, political feasibility, and unintended consequences. Ultimately this study explores the question: Could sustained sanctions have constrained Iran's access to critical resources, effectively halting its pursuit of nuclear weapons? The findings suggest that while both the JCPOA and MPC had varying degrees of success, neither fully achieved their desired objective of halting Iran's nuclear development. This analysis contributes to the broader discourse on the limits of sanctions as a tool for nuclear non-proliferation and offers insights into optimizing future sanctions strategy.

RELATIVE FITNESS OF NEWLY EVOLVED CRICKET MORPHS IN REALISTIC SOCIO-SEXUAL SETTINGS

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What's the relative fitness between purring and ancestral males in the field? This is important because the fitness of a species determines if their traits will be inherited over another trait. We used field mesocosms in Wailua, Hawaii and there were 20 replicates and deployed adult animals for 1 week, before collected. Then we collected tissue samples from all adults and females laid eggs for fitness calculations. The average time to parasitism is 10 days for ancestral males vs. 66 days for purring. Currently determining parentage using microsatellites and the parents have been sequenced, now sequencing 16 offspring/mom and the mom's spermatheca.

ASSOCIATION BETWEEN BODY MASS INDEX AND EMOTIONAL EATING BEHAVIORS AMONG THREE-YEAR-OLD CHILDREN

Keely Wright¹, Kena Riveria², LillyBelle Deer², Jena Doom², Elysia Davis²

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Greater frequency of emotional eating is associated with a higher body mass index (BMI; kg/m²) in 7-12-year-old children (Webber et al., 2009). However, few studies have examined the emotional eating-obesity relation in preschool-aged children and instead use parent reports such as the Children's Eating Behavior Questionnaire. We aimed to examine whether specific behaviors during an objective emotional eating task were associated with BMI at three years old. Based on the existing knowledge, we hypothesized that a higher engagement with food and puzzles would be associated with a higher BMI. This study utilized data from an ongoing longitudinal project called the Care Project. As part of the study, mother-child dyads came into the lab for a 3-year visit where an emotional eating task took place. During the task, kids had to do a puzzle but a piece was missing. When the evaluator went to look for the piece, the kids were left alone for 5 minutes and could either eat the snacks or play with the toys given to them. Behavioral coding of the task took place in The Observer XT. The behaviors coded were the duration of engagement of food, toys, and the puzzle. The engagement was coded as any time the child looked at or touched the objects. Additionally, the frequency of eating for every bite was also coded. At the same visit, 3-year-old BMI data was collected using child height and weight objectively measured by trained research assistants. We only have preliminary results right now and will have updated data by the time of the presentation. For the first aim of evaluating the emotional eating behavioral codes, we ran correlations of the behaviors with each other. Engagement with food was negatively correlated with engagement with toys ($r(142) = -.65, p = <.001$), and positively correlated with engagement with puzzles ($r(142) = .28, p = .006$), and frequency of eating ($r(142) = .69, p = <.001$). Engagement with toys was also negatively correlated with engagement with puzzles ($r(142) = -.41, p = <.001$) and frequency of eating ($r(142) = -.55, p = <.001$). For the second aim we examined correlations between child behaviors and child BMI. There was no significant association between child BMI and engagement with food ($r(142) = -.08, p = .383$), engagement with puzzle ($r(142) = .16, p = .123$), or frequency of eating ($r(142) = -.04, p = .676$).

PHOTOCHEMICAL KINETICS OF ANTHRACENE DERIVATIVES IN THE PRESENCE OF HUMIC ACID

Isabelle Yaremenko¹

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Anthracene is a polycyclic aromatic hydrocarbon, which is formed from burning organic fuels and is correlated with a range of health problems including cancer and respiratory diseases. When anthracene interacts with electrophiles in the ocean, such as bicarbonate, it forms the carcinogen anthraquinone. Anthracene can also be photodimerized. Humic acid is formed during the decomposition of and is known to increase the rate of solubility of anthracene in aqueous environments. This research focuses on the effects of humic acid on the photolysis and solubility of anthracene in a bicarbonate buffer as well as on the pH of the anthracene-bicarbonate system. This research showed that after the addition of anthracene, the buffer became more basic by about 0.8 pH, photolysis had no effect on the pH. The rate of dissolution of anthracene was significantly increased with the addition of humic acid upon photolysis and in unphotolyzed samples. As hypothesized, the anthracene derivatives, including photodimers, formed from the interactions with electrophiles occurred more frequently and had a higher formation rate than those reported in past literature, which was due to the addition of both bicarbonate and humic acid.

USING GIS AND LIDAR TO SUPPORT COMMUNITY ARCHAEOLOGY IN SURPRISE VALLEY, CA

Caitlyn Young¹

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The first Indigenous Traditional Ecological Knowledge (ITEK) Field Day in Surprise Valley was held in June 2023 and was supported by the Northern Paiute Gidutikad Band of the Fort Bidwell Indian Community, the Kosealekte Band of the Pit River Tribe, Lomakatsi Restoration Project, Bidwell Canyon Farm, and community residents. This event illustrated the importance of traditional land management practices in shaping local ecologies and developing community relationships. This poster explores how LiDAR and 3D printing, implemented through community archaeology workshops, reveal the innovations, strategies, and embedded histories that can be leveraged from ITEK perspectives.

EDITOR'S NOTES

These abstracts have not been peer-reviewed.



Lanse Hay Bales by Abi Newell

Oil on Canvas

“This piece was my first oil painting. It was painted en plein air after hiking a few miles from my grandparents’ house with my easel strapped on my back. Bugs got stuck in my paint, I used blades of grass a few times when I lacked a clean brush, my neck got ridiculously burnt. It is still my favorite painting experience to date.”



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