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Dear Reader,

There is a unique type of courage involved in publishing your first piece of academic research, especially as an undergraduate. Work often begins as a question a student might not be sure is worth asking, or one they believe they are underqualified to explore. With bravery and support from mentors and institutions, these questions can be shaped into an argument and analysis, and offered to unfamiliar readers on platforms like ours. Each paper in this volume represents that act of courage by undergraduates at our university.

Undergraduate research occupies a distinctive place in the academic landscape. It is sometimes treated as preparatory, a rehearsal for the real work that comes later. At DUURJ, we disagree. The studies, analyses, and arguments gathered here are not practice for future scholarship; they are real academic works produced by researchers who bring fresh perspectives, passion, and genuine curiosity to the questions explored. This issue presents a variety of works. Articles include investigations of the perceptions of mothers running for political office; the effects of modern finance “influencers” on Generation Z’s financial literacy; social vulnerabilities that come with AI-generated content; environmental geopolitics in El Mirador, Guatemala; long-term effects of gentrification in the Auraria neighborhood of Denver; eating disorders and their relation to comorbidity and stigma; access to urban greenspace in metro Denver; consequences of ozone pollution on various plant species; and the intricacies of learning to construct mathematical proofs.

The works presented here reflect the dedication of authors, their faculty mentors, an institution that encourages undergraduate inquiry as a serious undertaking, and every individual who submitted work this cycle, including those whose papers were not included in the final publication. I am incredibly grateful to have such a skilled and committed team of board and associate members of DUURJ, whose efforts helped make the publication of this volume not only possible, but enjoyable.

For this volume in particular, there is one message I would like to highlight: do not wait for opportunity. Instead, create it yourself. Small steps in inquiry and ambitious thinking about topics you are passionate about can lead to great outcomes you may have never expected. I encourage you to view each article in this volume as a significant step for authors in pursuit of their passions and goals, reflecting their willingness to create opportunities for themselves through publication with DUURJ.

Thank you,



Alexandra Choudhury
Editor in Chief



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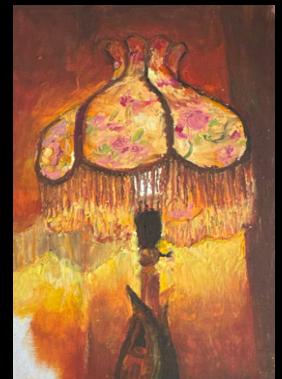
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A symbolic model of proof acquisition in ACT-R

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Abstract

Learning to construct mathematical proofs—formal arguments demonstrating the truth of a mathematical statement using logical deductions and previously established facts—is one of the most challenging skills in STEM education. This research aims to build the foundations for a symbolic cognitive model, using the ACT-R cognitive architecture and implementing in Python with the pyactr package, to explore how different proof strategies can be thought through with only symbols and rules. The model observes simple proofs, and its abilities are assessed based on its generalization capabilities, efficiency, and error patterns. By developing and analyzing such a model, this research provides new insights into how symbolic reasoning skills are acquired, offering a detailed case study of proof acquisition within a cognitive architecture.

Keywords: cognitive architecture, mathematical proof, symbolic learning, educational psychology

1 INTRODUCTION

Learning to construct mathematical proofs—formal arguments demonstrating the truth of a mathematical statement using logical deductions and previously established facts—is one of the most challenging yet crucial skills in STEM education. Students on the cusp of advanced mathematics and computer science can find the mental switch from applied to abstract reasoning difficult^{1,2,3}. While the task of proving may appear simple, the mental gymnastics required to logically flow from statement to conclusion can be tricky, especially at the beginning of such study². This reality raises the following questions: How can proofs be distilled down from the learner’s perspective? How can proof acquisition be modeled within a cognitive architecture—a framework designed to model human cognition—, so as to gain insight into both the mind of the student and the optimal strategy of the instructor? This work begins prodding such questions.

In some sense, proofs can be viewed as purely symbolic tasks, made up of a set of symbols that can be manipulated with a set of rules. That is, proofs are often syntactic and procedural. This view translates well into the modeling of proof acquisition in a cognitive architecture. Cognitive architectures are computational implementations of a theory of human cognition. They define, within software, the structures for systems like memory and learning that align with their underlying theory. Unlike more targeted forms of artificial in-

telligence, cognitive architectures are designed to exhibit broad and flexible intelligence. Indeed, the goal of cognitive architectures is “to find the mechanisms and representations that specify a formal foundation for a unified theory of cognition”⁴. In particular, the cognitive architecture ACT-R attempts to best simulate human cognition by combining a declarative memory, which stores factual information like symbols and their definitions, with a procedural memory, which stores rules as if-then statements. ACT-R therefore provides the foundation to model the incremental acquisition of mathematical proof strategies from both a symbolic and cognitively plausible perspective.

There has been little prior exploration of the symbolic modeling of proof acquisition in cognitive architectures, ACT-R or otherwise. However, research regarding the pedagogy of proof, theorem provers, and other tasks posed in cognitive architectures provides some footing.

To start, the steep learning curve associated with mathematical proof is well-documented^{2,3}. Though students may possess “a factual knowledge of a mathematical concept,” the task of using the concept in a proof, or proving the concept itself, does not easily follow². For instance, Knobelsdorf and Frede³ emphasize a sense of confusion among undergraduates in their first proof course: Students “were confusing [emphasis added] premises with conclusions and frequently asked what was given and what they were supposed to prove” and “were using wrong mathematical nota-

tions and seemed to be uncertain or confused [emphasis added] about what information they already had and what they had to prove". Knobelsdorf and Frede³ successfully diminished students' confusion by supporting students with the theorem prover Coq, which offered proof scaffolding and immediate feedback.

Coq, now rebranded as Rocq, is representative of a larger group of interactive theorem provers (ITPs), also known as proof assistants, which are capable of proving involved mathematical theorems and verifying complex software systems⁵. ITPs like Coq define type systems and proof languages capable of mechanizing mathematical reasoning with human guidance⁶. ITPs, and their automated theorem prover cousins that minimize the role of the human prover, testify to the possibility of formalizing mathematical proof structure and syntax, although they do so in a way that does not attempt to mimic the human learning process.

Prior experiments in cognitive architectures seek the cognitive realism that theorem provers do not, though none have examined the acquisition of mathematical proof strategies. For example, ACT-R has been used to model diverse domains such as driving behavior^{7,8,9}, pilot performance¹⁰, and solving puzzles like the Tower of Hanoi¹¹.

Despite an intense focus on tangential topics, from the educational psychology of mathematical proof to theorem provers and other ACT-R experiments, no investigation into the cognitive modeling of proof acquisition exists—an investigation with broad implications for learners, teachers, and the fields of education, psychology, and mathematics. The present work lays the foundation for such an investigation. To follow, I discuss the topic of mathematical proof, the ACT-R cognitive architecture, and an overview of the development of a model within ACT-R to simulate the acquisition of proof strategies. I then evaluate the results of the model in its current, primitive state. Finally, I suggest steps for further developments in this area.

2 BACKGROUND

2.1 The Pedagogy of Mathematical Proof Productions

Proving in mathematics is a difficult skill, involving "a complex interaction between rigorous and intuitive thought"². In pedagogical research, proof techniques are split into procedural proof productions, syntactic proof productions, and semantic proof productions. Procedural proof productions involve the rote application of a procedure. This repetitive, algorithmic approach requires little engagement with the proof content on the part of the prover. Syntactic proof productions involve manipulating definitions and symbols. As such, syntactic proofs are often dubbed as simply "symbol

pushing." While these types of proofs can be involved, they tend to require more effort to keep track of syntactic details than to massage an abstract representation of the concept at hand. Moreover, the number of proofs that can be constructed procedurally and syntactically are limited, and their convincing power can be weak².

Semantic proof productions are a more dynamic form of proof, and their use has been shown to distinguish high-level mathematicians from undergraduate students^{1,2}. Semantic proof productions require the prover to first intuit why a statement is true before harnessing such intuition to formalize a proof. This necessitates spontaneity, instinct, and an ability to translate between the informal and the formal—qualities that less experienced mathematicians may not yet possess¹. For this reason, mathematics education typically places an early emphasis on procedural and syntactic proof productions. Procedural and syntactic productions familiarize students with foundational reasoning patterns, build skills in proof writing, and provide a basis for more sophisticated mathematics, including a natural shift toward semantic proof productions.

Given that the cognitive model to come concerns learners' initial acquisition of proof strategies, it is constructed to focus on procedural and syntactic proof productions and not on semantic ones. However, it is important to recognize that educational psychology research reveals what Weber deems a "pedagogical problem"¹. That is, "There is a danger that if undergraduates only write" procedural and syntactic proofs "and do not reflect on their proofs and proving processes, then the act of proving may not be effective at promoting understanding"¹. In sum, the procedural and syntactic proof productions examined within the present cognitive model serve as sound introductory methods into proof crafting, though it should be noted that semantic productions play a critical part in reaching mathematical maturity.

2.2 Cognitive Architectures and ACT-R

Cognitive architectures emerged as part of research into artificial general intelligence in the 1950s, seeking to model the human mind and thereby step closer toward a computational replica of human-level intelligence¹². Cognitive architectures chase cognitive realism, which distinguishes them from other intelligent systems like theorem provers and large language models.

Not all cognitive architectures agree upon the mechanisms that most accurately model human intelligence, however. Cognitive architectures divide into three categories: symbolic architectures, emergent architectures, and hybrid architectures. Symbolic architectures represent cognitive processes as manipulations applied to symbols. The mechanistic rigidity of symbolic systems makes them well-suited to planning and reason-

ing tasks but limits their ability to adapt to a changing environment¹². Emergent architectures provide the adaptability that symbolic systems lack via a network of parallel models where information propagates through signals, akin to neural networks¹². These systems are easier to design, but they require (expensive) training and can lack transparency¹². Hybrid architectures seek the middle ground by merging elements from both symbolic and emergent architectures, though “there are no restrictions on how the hybridization is done and many possibilities have been explored”¹². According to Kotseruba and Tsotsos’s review, hybrid architectures are the most abundant¹².

ACT-R, which stands for “Adaptive Control of Thought—Rational,” is one such hybrid architecture. ACT-R is the result of over 40 years of computational and empirical research and was developed and is maintained by members of Carnegie Mellon University’s Department of Psychology¹³. The ACT-R framework centers around the integration of two memory modules: procedural memory and declarative memory. Procedural memory holds skill-based knowledge encoded as if-then pairs, while declarative memory contains factual knowledge implemented as chunks, i.e. slot-value pairs. In addition to these two memory modules, ACT-R includes an imaginal module, which holds temporary internal representations, a goal module, a motor module, and a visual module¹³. With the exception of the perceptual memory module, which is not explicitly accessible, ACT-R accesses its modules via dedicated buffers, each capable of holding one representation at a time¹⁴. At any given moment, the content of these buffers “represent the state of ACT-R at that moment”¹⁴.

To progress from state to state, ACT-R relies on pattern matching and production execution. The pattern matcher first searches for production rules held in procedural memory that match the current state of the buffers¹⁴. Only one matching production can fire at a time. If multiple production rules match, conflict resolution takes place. All matching production rules are ordered based on their expected utility, which measures the likelihood and associated costs of completing the current goal after executing the production in question¹⁵. The production rule with the highest utility is not always the rule chosen, however. ACT-R adds noise to explore more of the solution space, ultimately better approximating human cognition. Once a production rule has been selected, ACT-R fires the chosen rule in production execution.

Another critical process, called production compilation, may occur during production execution, as well. Production compilation involves the creation of new or the combination of existing production rules. ACT-R’s production system, which monitors the sequence of production rules, enacts production compilation in scenarios where the model repeatedly fires the same

sequence of rules. In essence, production compilation reflects psychology’s Hebb’s law: “Neurons that fire together wire together.” Through the process of pattern matching, production selection, and production execution—including production compilation—, cognition in ACT-R “unfolds as a succession of production firings”¹⁴.

It is important to distinguish between the cognitive architecture and the model that implements it. Cognitive architectures “supply a general theory of cognition that is independent of particular phenomena, to which the modeler adds representations to perform a specific task. The architecture is then simulated on a computer to produce behavior” through the model⁴. The architecture’s results are therefore reliant upon the model, which is reliant upon a given knowledge base and any necessary inputs. The model to come, for instance, is given several worked training proofs and definitions to learn from.

3 METHODS

3.1 Model Setup

Before implementation, I first selected training proof tasks and outlined the model’s design. I chose training proofs with the goal of testing a range of reasoning strategies and utilizing a range of concepts, all at a level suitable for an undergraduate student in an introductory proof course. The training proofs are summarized in Table 1.

After selecting five training proof tasks, I developed annotated steps for each proof. For example, the annotated proof for the fifth induction proof task is as follows:

1. Base case: $n = 1, 1 = \frac{1(1+1)}{2}$.
2. Inductive hypothesis: Assume true for $n = k$.
3. Show for $n = k + 1 : \frac{k(k+1)}{2} + (k + 1)$.
4. Combine using common denominator: $\frac{k(k+1)+2(k+1)}{2} = \frac{(k+1)(k+2)}{2}$.
5. Therefore holds for $n = k + 1 \rightarrow$ holds for all n .

The next setup step surrounded the model’s design. I began by defining the model’s goal structures and declarative memory chunks, including the chunk types and slots. Goal structures, or goal chunks, indicate the current problem-solving state and are held within ACT-R’s goal buffer. Each goal structure represents an individual task or subgoal, guiding the model’s behavior by specifying its current objective and strategy. The model’s general goal structure is given in Figure 1.

In terms of declarative memory, I identified a need for three chunk types: definitions to encode formal definitions of a concept, rewrites to represent algebraic identities, and lemmas to store general and learned results. The slots for these chunks are shown in Figure 2.

Training proof task	Strategy	Key concepts
If n is even, then n^2 is even.	Direct	Definition of even, algebraic substitution
$\sqrt{2}$ is irrational.	Contradiction	Rational numbers, properties of divisibility
If n^2 is odd, then n is odd.	Contrapositive	Definition of odd, logical equivalence
Every integer is either even or odd.	Cases	Modular arithmetic, mutual exclusivity
$1 + 2 + \dots + n = \frac{n(n+1)}{2}$	Induction	Base case, inductive step, hypothesis application

Table 1 Selected training proof tasks.

```
(isa goal
  type      <type>          ; kind of task (e.g., prove, apply-rule, etc.)
  target    <statement>     ; main statement to prove
  method    <proof-method>  ; approach (e.g., direct, contrapositive, etc.)
  context   <givens>        ; known assumptions or givens, will evolve dynamically
  status    <state>        ; current state (e.g., in-progress, completed, etc.)
```

Figure 1. General goal structure.

I accordingly defined the declarative memory chunks needed for the training proofs. These included definition chunks for the definition of even, odd, and rational; a rewrite chunk for the square of a product; and lemma chunks stating that “if an integer n is even, then n^2 is even” and its converse. Further chunks should ideally be added as the model learns new patterns and generalizations.

```
(isa def
  name      <definition-name>
  definition <definition>)

(isa rewrite
  expression <initial-expression>
  result     <rewritten-expression>)

(isa lemma
  name      <lemma-name>
  assumption <assumptions>
  conclusion <conclusions>)
```

Figure 2. Chunk types and slots for definition (def), rewrite, and lemma declarative memory chunks.

The final model setup step involved developing the production rules for the model’s procedural memory. These if-then style rules drive the model’s problem-solving behavior. As previously mentioned, ACT-R is capable of creating new or combining existing production rules through production compilation. To begin with, however, I initialized the model’s procedural memory with a set of tailored production rules emerging from the annotated training proofs; each logical step in the training proofs became an explicit production rule.

3.2 Initial implementation

After determining the model’s training tasks and initial goal chunks, declarative memory, and procedural memory, I followed Dotlačil and Brasoveanu’s (2018) pyactr workflow to showcase how such a model could be implemented.

1. Create chunks

The first task in Dotlačil and Brasoveanu’s (2018) workflow requires creating chunks. I did so for both goal and declarative memory chunks. I defined the chunk types with pyactr’s chunktype method and then used the chunkstring method to define specific chunks, following the types and slots outlined previously.

2. Create model

Dotlačil and Brasoveanu’s (2018) second task involves creating the model and its modules. This meant first instantiating an instance of pyactr’s ACTRModel class. Several subtasks follow:

2.1 Store chunks in declarative memory

I then added the declarative memory chunks defined in step one to the newly instantiated model’s declarative memory using pyactr’s decmem.add method.

2.2 Create extra modules and buffers

This step was not applicable, as I am only using the memory modules and goal buffer.

2.3 Create production rules

To create production rules, I used pyactr’s productionstring method and defined production rules following each of the five annotated training proof tasks.

2.4 Create environment process

An environment process, or simulation, is required to run the model¹⁶. I created an environment process with pyactr’s ACTRModel class’s simulation method.

3. Run the model with parameters of interest

In the case of the present model, the parameters of interest included the five training proof goals, added to the goal buffer. I completed 20 trials of each training proof, recording the step count and elapsed time for each trial. It is important to note that I repeated the 20 trials in the same session

to avoid disturbances caused by ACT-R’s native accumulation of symbolic learning.

4. **Read off behavioral data from the simulation**

Dotlačil and Brasoveanu’s final workflow step involves gathering behavioral data from the simulation¹⁷. In this model’s case, the behavioral data included the step counts and elapsed run times for each of the training proof tasks. Results from the simulations are discussed in the following section.

4 RESULTS

I propose three pillars upon which to evaluate the model both now and with future progressions. The first pillar concerns the model’s generalization capabilities: Can the model solve novel but structurally similar proofs using learned strategies? The second concerns the model’s efficiency: Does the number of cognitive steps or total time required to complete a proof decrease with training? The third concerns the model’s error patterns: What kinds of mistakes occur, and how do those mistakes change over time? Given that the model outlined above serves as a starting point, it scores poorly across all three pillars.

4.1 Generalization capabilities

In its present “setup state,” the model’s generalization capabilities are poor. Production rules are hyper-specific to each training proof. The only general production rule, in fact, is that of clearing the goal buffer once a goal’s status has been marked as complete. Additionally, declarative chunks are added to the retrieval buffer manually. These characteristics result in an inflexible model.

4.2 Efficiency

The model shows no efficiency improvements on any of the five training proofs in terms of step counts, which would ideally decrease with training as the model learns to “chunk” productions together in production compilation. However, as exhibited in Figure 3, the elapsed times for four of the five training proofs show downward trends, as measured across the 20 trials. The contradiction proof was the outlier, resulting in an upward trend. Notably, the contradiction training proof has the highest elapsed time generally, as well. A potential reason for this proof’s increasing elapsed time trend could be its retrieval-heavy nature, as the contradiction proof requires the most retrievals out of the five training proofs (Figure 4). Another important observation regarding the model’s efficiency is the significant noise in elapsed time across trials for all five training proof tasks (Figure 3). This noise likely results from ACT-R’s native subsymbolic characteristics that seek to simulate

human-like variability.

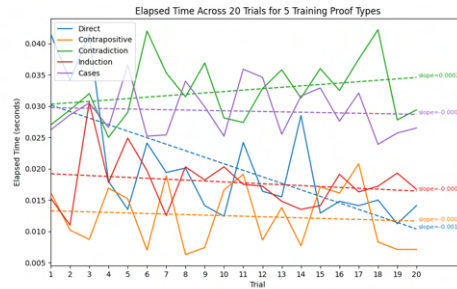


Figure 3. Trends in elapsed times for each training proof.



Figure 4. Training proof retrieval counts.

4.3 Error patterns

No errors currently occur, which does not imply that the model is perfect. Rather, since all given proofs are worked examples with explicit production rules and predetermined chunks, the model does not yet have the workings or opportunities to commit errors during the learning process.

5 DISCUSSION

This research outlining a symbolic ACT-R architecture aims to delineate how symbolic reasoning skills, as demonstrated in mathematical proof productions, are acquired and can be modeled within a cognitive architecture. At this stage, the model has been trained and run on five worked example proofs: a direct proof, proof by contradiction, by contrapositive, a case analysis proof, and an induction proof. Beyond completing the worked examples, the model establishes a scaffold for encoding syntactic and procedural proof productions within ACT-R’s architecture. This work represents the first unified demonstration that ACT-R can be configured to execute complete mathematical proofs across multiple proof genres. The implementation also clarifies the cognitive operations and representational commitments required to symbolically step through formal

arguments, providing the design and foundation for future, more autonomous models. It further shows how proof states can be treated as dynamically evolving cognitive configurations, making explicit the sequence of attentional shifts, goal creations, and memory updates that a learner might make themselves. By articulating such mechanisms, the model sheds light upon the minute symbolic processes that shape the arguments of even basic proofs.

Though the current model demonstrates progress in this new area of modeling proof acquisition in ACT-R, it exists in an extremely primitive state that is not meant to complete this line of research. Several limitations exist. First, the production rules are not generalizable but instead “hard-coded” to walk the model through the training proofs. Second, the retrieval of chunks from declarative memory occurs explicitly as opposed to automatically. While these are characteristics of training, they do not support the model’s self-driven acquisition of proof techniques through trial and error.

Future research should overcome such limitations by addressing the generalization of production rules, implementing automatic retrieval from declarative memory, and running the model on novel but nearby proofs, thereby building off of the present work to achieve active learning. To further probe the symbolic acquisition of proof strategies in these ways, I suggest the development of a progressively less constrained model by relaxing the explicit guidance provided by worked examples. This might involve: (1) replacing fixed, proof-specific productions with parameterized rule schemas that can be instantiated in multiple contexts; (2) enabling ACT-R’s utility learning and chunk-strength mechanisms so that the model can select among competing steps rather than following a single predetermined path; and (3) introducing impasse-driven subgoaling to enable the system to reformulate its reasoning when progress stalls. Any of these pathways would enhance the current model with more autonomy to acquire and refine proof strategies.

The present work offers an initial account of how symbolic mathematical reasoning skills can be represented and acquired in a cognitive architecture. By distilling proofs into goal structures, memory operations, and incremental inferences available in ACT-R, the model demonstrates how formal arguments can be reconstructed from the learner’s point of view rather than that of a trained logician or cognitively implausible intelligent system. The model further exhibits how proof acquisition can be modeled as a sequence of cognitive commitments, strategic choices, and representational constraints, providing insight into the developing mind of the student and the instructional interventions most likely to support them. For example, the model’s progress highlights that choosing the appropriate strategy is pivotal, and perhaps more difficult than execut-

ing the strategy itself. The method slot is included in the goal chunks deliberately, after all. Knowing what needs to be proven is of little use if the learner does not understand how to execute the proof. While a statement can be proven via multiple techniques, success depends upon a well-chosen strategy. The model’s progress also demonstrates that definitions and intermediate claims operate as essential retrieval cues and that impasses might signal missing definitions or productions rather than failures in understanding. Although preliminary, this work establishes the foundations needed to study proof acquisition at a level of cognitive realism, opening a pathway toward models that can autonomously improve their strategies and ultimately illuminate the psychological mechanisms that underlie formal mathematical reasoning.

6 ACKNOWLEDGEMENTS

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7 EDITOR’S NOTES

This article was peer-reviewed.

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Fall Plant by Riley McCarthy
Photography

Visualizing ozone pollution in the Denver Metro Area using a bioindicator garden

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Abstract

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, we used a garden of ozone bioindicator species (ozone garden) as a cost-effective tool for monitoring and visualizing the effects of anthropogenic ozone pollution. Our 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, we monitored the temperature, ozone concentration, and leaves for ozone damage. **We found that the ozone-sensitive cultivar exhibited significantly more foliar injury compared to the tolerant cultivar ($p < 0.05$) in response to tropospheric ozone.** We also found 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.

Keywords: Ozone garden; ozone pollution; bioindicator species; ozone garden; snap beans

1 INTRODUCTION

Since the industrial revolution, widespread fossil fuel combustion has significantly increased atmospheric pollution¹. Emissions from these combustions include nitrogen oxides (NO_x) and volatile organic compounds (VOCs), which form tropospheric (ground-level) ozone when exposed to sunlight². Although stratospheric and tropospheric ozone are chemically identical, stratospheric ozone shields earth from harmful UV rays while tropospheric ozone is a dangerous air pollutant (hereafter, ozone pollution refers to tropospheric ozone). High ozone concentrations are prevalent in urban areas due to vehicle emissions and industrial activity³. Even moderate ozone levels can have consequences on animals, plants and ecosystems, that include worsening respiratory conditions, inhibited plant growth, and reduced biodiversity and carbon sequestration⁴.

Ozone directly harms plants by disrupting the plant's ability to absorb carbon dioxide, release oxygen, and carry out photosynthesis². These processes are essential for plant growth and the presence of ozone greatly reduces agricultural productivity⁵. The U.S. loses \$500 million in crop production annually due to ozone pollution⁶. Ozone enters plants through tiny pores called stomata, which are crucial for photosynthesis as they control the rate of intaking carbon dioxide and releasing oxygen. Once inside the plant, ozone damages the leaf cells that produce the sugars necessary for plant growth, leading to slowed growth, and weakened defense mechanisms, increasing plants' susceptibility to disease, bug damage, and damage from extreme weather⁷. Due to the cumulative impact of ozone damage on the cellular and structural components necessary for photosynthesis, the damage is often irreversible under prolonged exposure⁴. Given the direct impact on plant health, active measures are

needed in high-risk areas such as the Denver metro area, which frequently surpasses ozone pollution safety thresholds.

While the Environmental Protection Agency's (EPA) 70 PPB ozone standard protects human health, under the National Ambient Air Quality Standards (NAAQS), plants are vulnerable at levels as low as 40 PPB⁴. Days above 70 PPB trigger Ozone Action Alert Days, where open burning is prohibited and sensitive groups are advised to limit outdoor activity. The EPA monitors state's ozone concentrations to determine their attainment status with the NAAQS as either "attainment" (below standard) or "nonattainment" (exceeds standard) which is organized by severity as marginal, moderate, serious, severe, and extreme (US EPA, 2024). Denver's sunny conditions and high traffic volume make it particularly susceptible to elevated ozone levels, and as of 2022, the city was reclassified as a "severe" nonattainment area⁸. In the 2023 summer growing season (June to October), the Denver metro Area issued 35 Ozone Action Alert Days and nearly 95% of the season had ozone concentrations above 40 ppb. This reveals the necessity to monitor ozone concentrations, raise awareness about the damaging effects of ozone in the Front Range, and increase public education on how to avoid contributing to the problem.

Ozone gardens are a useful and cost-effective tool for monitoring and visualizing the effects of anthropogenic pollution using bioindicator species (plants that have visible responses to environmental conditions). Plants differ in their sensitivity to ozone pollution, as their susceptibility to damage is influenced by stomatal uptake and antioxidant defenses². As a result, certain species consistently exhibit ozone damage and are used as bioindicators. Bioindicator species act as "canaries in the coal mine" as they can indicate the health of their environment⁹. The USDA's Agricultural Research Service developed snap bean (*Phaseolus vulgaris*) bioindicators for the purpose of detecting ozone pollution¹⁰. Through many controlled fumigation trials, sensitive (S-156) and resistant (R-331) varieties were produced. Other ozone bioindicators include common milkweed (*Asclepias syriaca*), cutleaf coneflower (*Rudbeckia laciniata*), and le chipper potato (*Solanum tuberosum*). The effects of ozone pollution are clear on the sensitive snap beans in the forms of chlorosis (yellowing of leaves and stems), necrosis (cell death), and stippling. Stippling is solely a symptom of high ozone exposure and manifests as dark spotting on the leaves, caused by the plant's defensive production of anthocyanin pigments². Ultimately, using bioindicator species to monitor high-risk areas is crucial for understanding how geography affects plants' response to ozone stress.

In this study, we test the hypothesis that elevated tropospheric ozone levels in the Denver metro area cause significantly greater foliar damage in ozone-sensitive snap beans compared to ozone tolerant cultivars, demonstrating the value of ozone gardens as tools for environmental monitoring and public education. While the ozone garden is located at the University of Denver, the data was used to extrapolate to the broader Denver metro area. This was due to the distance of the temperature and ozone concentration monitoring stations, and the lack of other established ozone gardens with available data around Denver at the time of the study. In collaboration with faculty from the Departments of Geography and the Environment and Biology, we developed an ozone monitoring garden for the University of Denver campus. We established perennial species for long-term monitoring of ozone and we investigated the impacts of ozone pollution on snap beans by comparing a sensitive (S156) and a tolerant cultivar (R123). We added the plant monitoring data to the National Ozone Garden Network to contribute to the broader understanding of how ozone pollution varies across geographic regions. Here, we present the results of leaf damage and productivity for a single growing season, combined with monitoring of daily temperature and ozone. We found heightened damage to the sensitive cultivar when compared to the tolerant cultivar. We discuss how visible foliar damage helps contextualize the impact of human activities and provides an accessible method for both measuring ozone levels and raising public awareness. The establishment of the ozone garden has allowed for the creation of a yearly Ozone Pollution Lab, where Environmental Science students at the University assess damage to the species. Through studying these plants, we gain important insights into the pervasive threat of ozone pollution, which can help spread awareness about the issue.

2 METHODS

2.1 Creation of the DU Ozone Garden

The ozone garden has two goals: annual monitoring of snap beans and long term monitoring of bioindicator perennials such as coneflower and milkweed. In spring 2023, we obtained tolerant (R123) and sensitive (S156) cultivars of snap beans (*Phaseolus vulgaris*) from the Ozone Garden Network, based at the University Corporation for Atmospheric Research in Boulder, Colorado. We started the season with 42 seedlings in total, using 20 tolerant cultivars as the control group and 22 sensitive cultivars as the experimental group. We planted the seeds the first week of May in the

University of Denver's (DU) green room, located on the top floor of Olin Hall. We began hardening the plants in the last two weeks of May to prepare them for transplanting outside. This process involved taking the seedlings to the ozone garden (located behind DU's community garden as seen in Figure 1.) daily for increasing periods of time. We started with one hour every other day, then increased the duration by 30 minutes on alternating days. After the two-week hardening period, we transplanted the beans into the ozone garden and labeled each plant with its cultivar and plant number. We hung a shade cloth over the beans intermittently throughout June to ease their transition into full sunlight. At the end of June, we marked a leaf from each plant's bottom, middle, and top layers to ensure consistent monitoring throughout the season. To promote optimal growth, we watered the garden daily for the first month, then reduced watering to every other day, and weeded weekly. Proper watering and care of the snap beans ensured reliable ozone damage data.

In the 2023 season, we also prepared milkweed seeds in the greenhouse, but they did not survive being transplanted into the garden. In the 2024 growing season, we transplanted 13 milkweed sprouts that we had started in the greenhouse and hardened to adjust to full sun. Additionally, we transplanted two established milkweed plants (both about 1 year old) from the University of Colorado Denver Ozone Garden. Using perennial milkweeds allows the ozone garden to be a long-term project. This is advantageous because the cumulative nature of ozone damage means that its effects on these plants will become more evident with each passing year⁴. We analyze only the 2023 season snap-bean data in the following sections.

2.2 Environmental Monitoring 2023

In order to provide a thorough environmental context for the ozone garden experiment, we collected daily data on temperature (°F), and ozone concentration (PPB). We placed a standard rain gauge on the fence behind the ozone garden and checked and emptied it daily to ensure the measurements were accurate. We used the National Weather Service's online data to obtain Denver's daily high temperatures, which are measured by the Denver Water Department located at 1600 W 12th Ave, Denver, CO 80204 (approximately 4.7 miles from the ozone garden). We acquired the daily high ozone concentration from the Colorado Department of Public Health and Environment's (CD-PHE) Air Quality Summaries. We used the Highlands Monitoring site (located at 8100 S University Blvd, Centennial CO 80122, approximately 7.5 miles from the



Figure 1. Ozone Garden Location. This image (courtesy of Google Earth) shows the ozone gardens location on S Vine St between the DU Bridge Community Garden and DU's Boettcher West. The ozone garden is highlighted in a red box.

ozone garden) because it is in a mixed use area similar to the environment around DU. Additionally, we noted all ozone action alert days. This environmental data allowed us to monitor how variations in temperature impact ozone concentrations in the summer months.

2.3 Garden Monitoring 2023

Consistent and thorough data collection was essential for determining the effects of ozone damage, and was achieved through a structured monitoring process that included visual assessment and yield measurement. Before transplanting the seeds, we completed NCAR's ozone damage training to ensure that we could discern between ozone damage and other forms of plant damage. We randomly chose one leaf from the bottom, middle, and top of each plant to tag with a pipe cleaner to ensure consistent monitoring. From July 13th, 2023 until October 24th 2023, we monitored the garden every other day for ozone damage using NCAR's 1-6 leaf damage rating scale (Table 1.).

On each monitoring day, we observed two plants from each cultivar. To account for minor environmental variations, we selected the first and last plants of each cultivar's set for assessment (e.g., plants 1 and 20 on the first day, 2 and 19 on the second, and so on). We thoroughly observed the pipe cleaner-marked leaves from each layer for dark stippling, and then ranked their ozone damage from 1 (0% damage) to 6 (76-100% damage).

Each monitoring day, we entered this data into the Ozone Garden Network's "data entry" portal,

Table 1 Ozone Damage Classification. Classification of ozone damage on leaves based on the percentage of affected area. Damage severity is ranked from 1 (least damage) to 6 (most severe). The accompanying images were sourced from the NCAR Ozone Garden Data Entry portal.





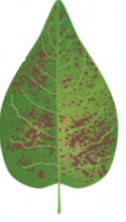

Class	1	2	3	4	5	6
Damage %	0%	1-6%	7-25%	26-50%	51-75%	76-100%
Picture						



Figure 2. Ozone Damage on Sensitive Plant. Example of ozone damage on a bioindicator sensitive snap bean cultivar. This image was taken on October 8, 2023 of sensitive plant #8, and would be classified as level 6 damage. Characteristic symptoms include chlorosis (yellowing), particularly visible on the upper leaves, necrosis (drying) of the bottom leaves, and stippling (dark spots avoiding leaf veins) across all leaves.

contributing to their nationwide study of ozone pollution effects. Additionally, we counted all bean pods 1 inch and longer on the plants being monitored. We recorded the leaf damage and number of bean pods into a spreadsheet. After the bean pods reached maturity on the plant and dried, we harvested and stored them in separate paper bags for each plant. We collected bean pods from the plants until they died in late October. Then, we removed all beans (seeds) from their dry pods and placed them on paper towels to dry for two weeks, keeping them separated by plant. After this two-week period, we counted and weighed every

plant's dried beans and calculated the average number produced and average weights for both varieties. This data provides insight into the physiological reactions of sensitive and tolerant snap bean cultivars under high ozone conditions in Denver, CO.

2.4 Data Analysis

We completed all statistical analysis in R v4.2.3¹¹ and RStudio v2024.12.1+563¹¹, and used the readxl (v#1.4.5) package to format our data. To test for a relationship between daily temperature and ozone concentrations, we used the function `cor.test()` to conduct a Pearson's correlation between the daily temperature and ozone concentrations. We used the function `t.test` to conduct a Welch Two Sample t-test (unequal variance t-test) to test for differences between sensitive and resistant bean cultivars in average ozone damage and reproductive output estimated by number of beans produced and bean mass.

3 RESULTS

As ozone concentrations peak on hot, sunny, and stagnant days, it was crucial to record the temperature daily (Figure 1). The data reveal a general trend of increasing temperatures from June to July, followed by a gradual decline through November. The substantial interquartile range in October highlights a period of significant temperature fluctuation.

Obtaining the daily ozone concentrations was also necessary to see how it varies depending on the temperature from June 2023 to October 2023. We confirmed that temperature and ozone concentration are highly correlated (Pearson's correlation $r = 0.6$, $p < 2.2e-16$). From June to October, ozone varied from

Ozone pollution

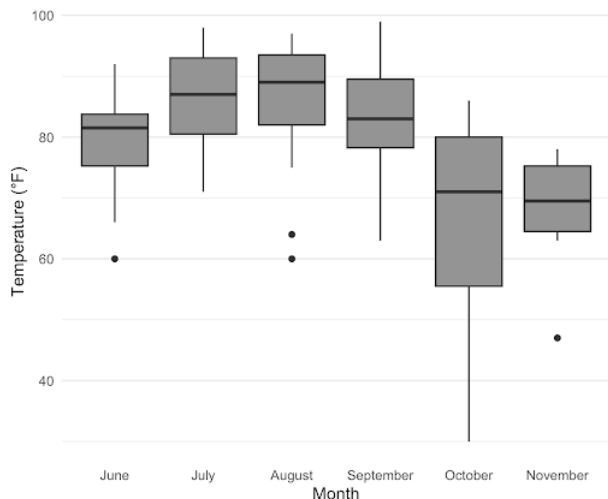


Figure 3. Time series of temperature (orange bars) in Denver, 2023. This data shows the distribution of daily temperatures from June to November.

10 PPB to 83 PPB (Figure 4). Within this time frame, 94.6% of days were above 40 PPB (when physiological damage begins), 11.8% of days were above 70 PPB (EPA standard), and there were 35 ozone action alert days issued by the Colorado Department of Public Health and Environment.

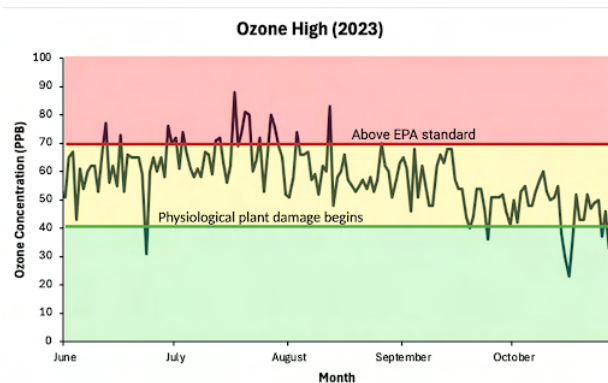


Figure 4. Time series of ozone high concentrations in Denver, 2023 growing season (June to October). The green horizontal line at 40 PPB indicates the threshold at which physiological plant damage typically begins. The red horizontal line at 70 PPB represents the National Ambient Air Quality Standards (NAAQS) set by the EPA for ground-level ozone; concentrations above this line exceed the standard.

We plotted both cultivars' average damage throughout the season (Figure 5), revealing that the sensitive cultivar reached higher levels of damage by the end of the season.

We plotted the overall range of damage for both cultivars to visualize how much more damage the sensitive cultivar experienced (Figure 6). We found a

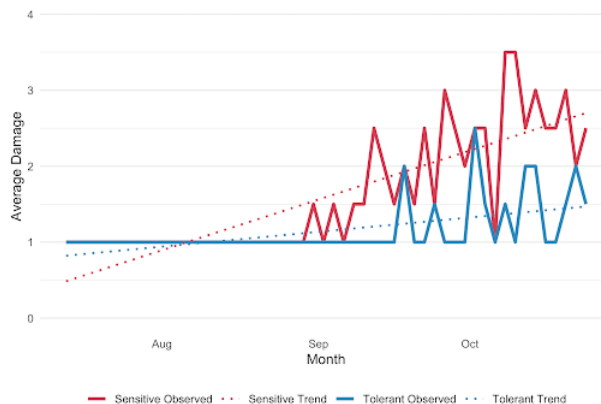


Figure 5. Average leaf damage over time in Denver (2023) for sensitive (red line) and tolerant (blue line) snap bean cultivars exposed to ozone. The dotted lines show the linear regression model for both treatments. The x-axis shows months starting in August due to no recorded damage prior to this, even though the data collection began on July 13th 2023. The y-axis represents the average damage rating, ranging from 1 (lowest) to 3.5 (highest observed).

statistically significant difference in the two cultivars' response to tropospheric ozone [t.test, $p = 2.5e-6$]. The tolerant group had an average damage rating of 1.173 while the sensitive groups had an average damage rating of 1.678, revealing that the sensitive group experienced higher levels of ozone damage, with a mean difference of about 0.5 units. On average, the sensitive group produced about 12.5 beans per plant, and the tolerant group produced about 13.6 beans per plant and there was not a significant difference in bean yield ($p = 0.69$). At the end of the season the sensitive group had an average bean weight of 10.8 g per plant, and the tolerant group had an average bean weight of 14.4 grams per plant, but there was not a significant difference ($p = 0.2606$).

4 DISCUSSION

Overall, this analysis confirmed that bioindicator snap beans (sensitive cultivar) experience significant physiological damage from ozone pollution in the Denver Metro Area. The highest ozone concentrations aligned with the hottest months of July and August. Interestingly, the most physiological damage was measured in the cooler months of September and October. Similar results were observed in Pringle's study of bioindicator coneflower in Philadelphia, Pennsylvania⁴. Despite year-round production, tropospheric ozone reaches the highest concentrations in the warmest months, resulting in cumulative damage seen most significantly in older leaves⁴. Research on bioindicator coneflowers has found a "latency period" characterized by a slow onset of foliar damage

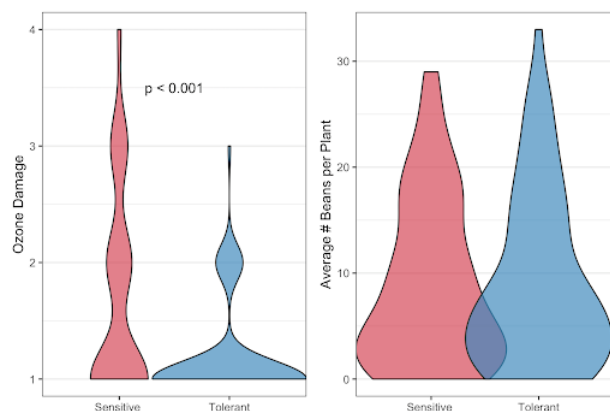


Figure 6. Distribution of average ozone damage ratings between cultivars and average number of beans per cultivar. Violin plots of the distribution of ozone damage ratings in the sensitive snap bean cultivar (red) and the tolerant cultivar (blue). Sensitive plants exhibited a wider range of damage, with more instances at higher damage levels, whereas the majority of damage in the tolerant group remained at the lowest level. A two-sided Welch's t-test indicated a significant difference in means ($t = 4.98$, $df = 129.8$, $p = 2.597 \times 10^{-6}$). There was not a significant difference in the average number of beans per plant between the two cultivars.

that rapidly intensifies later in the season, regardless of decreasing ozone concentrations⁴. Our study paralleled Pringle's observation that foliar damage begins slowly in the early summer months, and quickly accelerates around August⁴. While Pringle's study used a different bioindicator species in a different environment, our results support the idea of a latency period in the snap beans foliar injury response to ozone.

Although we obtained interesting results that add to the understanding of how ozone concentrations and plant responses vary with geographic region, there are two caveats to acknowledge. The first limitation on this study is that the temperature and ozone data used were obtained from monitoring stations located 5-7 miles from the University of Denver. These were the closest monitoring stations available that consistently uploaded verified data, but ideally, they would have been much closer to the garden to provide a more accurate representation of the plants' environments. Secondly, in September 2023, a second person took over monitoring. While we both took the same training, there is inevitably some subjectivity in defining the level of damage on the leaves.

This project supports nationwide research on tropospheric ozone, and has also become an outdoor classroom for DU students and community members. A core class sequence for environmental science majors "Environmental Systems" has begun using the garden in a lab to give students the experience of identifying damage and understanding the physical impacts

of ozone pollution. This connects DU students to real-world nationwide datasets, as the garden is a part of the Ozone Garden Network operated by the National Center for Atmospheric Research (NCAR). The university corporation for atmospheric research obtained grant funding from NASA to support the expansion of ozone gardens across the US to better understand how geography and climate is affecting plant damage. NCAR's dataset from nationwide ozone gardens is being used to understand precise levels of when damage appears, how severe the damage gets, and how this damage varies across regions and climates.

Although our research successfully demonstrated ozone concentration effects on snap bean bioindicators in Denver, refinements would yield more accurate results. We would specifically recommend randomizing cultivar placement for a double-blind design, expanding the sample size, and implementing weekly monitoring of all plants. Additionally, focusing more on the aesthetic of the garden may help to engage community members. Recognizing the physical impacts of ozone pollution is a critical step to empower local communities to engage in discussions about environmental health and protection.

In the 2024 growing season, we focused more on the aesthetic appeal and educational draw of the garden. We installed three signs from the Ozone Garden Bioindicator Garden Network to explain why it is important to care about ozone, how the bioindicator garden works, and steps individuals can take to reduce their contribution to ozone pollution. We also planted 15 milkweed plants with the goal of long-term perennial monitoring, as they return every growing season. This ensures that even without planting new seeds, the garden will remain useful for visualizing ozone pollution. In preparation of the 2025 growing season, we have acquired seed potatoes and snap bean, milkweed, and coneflower seeds. It is our hope that a vibrant garden accompanied by informative signs will encourage people to think about how their actions are affecting the natural world around them.

5 ACKNOWLEDGEMENTS

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6 EDITOR'S NOTES

This article was peer-reviewed.

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Orange Peel by Brynn Hassan
Acrylic on canvas

Assessing YouTube finance influencers: guidance or hype for Generation Z?

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Abstract

This study evaluates the content of YouTube finance influencers (finfluencers) to assess whether they provide overly promotional advice or can help improve the low financial literacy of Generation Z. A total of 407 videos sampled using the nine knowledge areas tested in the TIAA Institute Personal Finance Index (P-Fin Index) were analyzed using Structural Topic Modeling (STM). Eight topics were observed in the videos, ranging from general literacy to emergency planning. Comparing the observed topics to the P-Fin Index categories showed that finfluencers address six of the nine key areas of financial literacy, with gaps in the coverage of long-term focused content, such as retirement fluency. The findings suggest that finfluencers provide accessible content focused on many key areas of financial literacy, making them a viable tool for financial education. However, because many finfluencers operate in a largely unregulated space and may lack required disclosures or credentials, efforts to promote accountability and transparency are essential to ensure their reliability as educational resources.

Keywords: financial literacy, finance influencers, Generation Z

1 INTRODUCTION

Many Americans lack the levels of financial literacy required to effectively manage their personal financial responsibilities. This is a particular challenge for Generation Z. The TIAA Institute Personal Finance Index (P-Fin Index) Survey, which sampled Generation Z individuals born between 1997 and 2003, found that only 37% have a high level of financial literacy, defined as scoring at least 78% on 28 questions spanning nine categories from borrowing to saving for retirement. By comparison, Millennials (born 1981–1996) scored 10% higher, and Generation X (born 1965–1980) scored 23% higher. While the gaps in financial literacy could partially be due to differences in financial experience among age groups, financial literacy among US adults has remained around 50% since the inception of the survey in 2017. This suggests that low financial literacy is a structural issue rather than one that resolves with age¹.

The implications of these low levels of financial literacy for Generation Z are especially concerning given the broader shift in financial responsibility from employers to individuals. In the 1980s, 60% of employers offered pension plans to their employees; today, that number has dropped to 14%².

These low levels of financial literacy are not due to

a lack of concern. A CFA Institute and FINRA survey of Generation Z individuals demonstrated that 55% wanted to save for unexpected expenses and 51% wanted to be able to retire comfortably. However, 34% of non-investors cited a lack of financial knowledge as the top challenge preventing them from meeting these goals.

To address these knowledge gaps, 48% of Generation Z is turning to social media, citing that it is easily accessible, free, and understandable. YouTube is an especially popular source, used by 60% of those in Generation Z who use social media for financial literacy³. On social media, individuals can find content from finfluencers, defined by Hamamci and Aren⁴ as “content producers who share information about financial products and markets on social media platforms”⁴.

This study seeks to better understand Generation Z’s reliance on social media for financial literacy information by analyzing influencer content on YouTube to assess its potential to improve financial literacy for this demographic.

2 LITERATURE REVIEW

2.1 Traditional and Recent Sources of Financial Literacy

Traditionally, personal financial literacy has been taught through programs in high schools, colleges, workplaces, and community organizations. However, the effectiveness of these programs has been questioned. Yates and Ward⁵ found that while high school and college financial literacy courses can improve short-term knowledge, individuals often struggle to retain this information for the long-term. Their study also noted the importance of age, finding that college students were better able to retain the information, possibly because they could directly apply concepts, such as budgeting, to their daily lives. Gale and Levine⁶ corroborated these findings and extended the analysis to include employer- and community-based programs. These programs were also found to have limited effectiveness in improving financial literacy, as participants often already possessed higher levels of financial literacy and only experienced marginal knowledge improvements.

In response to these gaps in traditional financial literacy education, many individuals have turned to blogs and text-based social media platforms for information. These platforms are often favored for their personalized content and simple explanations. Kupec⁷ found that individuals sought out blogs that presented information in understandable terms and featured writers they could relate to. The study noted that women ages 22 to 29 were particularly drawn to female bloggers, whom they perceived as more understanding of their unique challenges than traditional finance professionals. However, while the informal approach of blogs may be popular, Hoffmann and Otteby⁸ argue they are not effective for improving financial literacy among those with initially low levels of knowledge because those who use these blogs often already have high levels of financial literacy, enabling them to find, access, and evaluate the content. Therefore, the overall impact of blogs on financial literacy may be limited. These findings have been corroborated when evaluating content on other text-based social media, such as the platform Seeking Alpha, a social media website for exchanging information about stock performance. Participation on the website was found to improve returns for investors, but this effect was largely limited to those who already felt comfortable with investing and were able to evaluate the information⁹.

2.2 Impact of Finfluencers on Financial Behavior

Finance-focused bloggers from the 2010s have paved the way for today's social media finfluencers as content creators focused specifically on financial content. Individuals seeking to improve their financial literacy

are drawn to finfluencers for similar reasons identified by Kupec⁷ for bloggers. Finfluencers present complex finance topics in simplified terms and provide relatable personas. Chhabra and Gupta¹⁰ and Cao et al.¹¹ also observed that individuals frequently seek out social media sources because of their comprehensive coverage of a diverse range of subjects and use of simplistic language, which fosters positive user experiences and encourages continued engagement.

A key factor in the appeal of these finfluencers is the perception of credibility, expertise, and attractiveness they convey through their online presence. Hamamci and Aren⁴ and Luan et al.¹² emphasize the importance of these traits in influencing viewer intentions. Specifically, Luan et al.¹² determined that Taiwanese investors are more likely to follow the advice of finfluencers they perceived as both attractive (defined as both good-looking and having likable personalities) and highly knowledgeable. Handranta et al.¹³ and Kaabachi et al.¹⁴ further established the impact of these perceptions on willingness to participate in financial markets. Handranta et al.¹³ found that the presence of trusted influencers significantly impacted a viewer's willingness to invest if they were already actively involved in investing; however, it did not motivate participation in the market for those not already engaged in trading. Furthermore, Kaabachi et al.¹⁴ found that finfluencers that were perceived by their audience as trustworthy and authentic were more likely to encourage their audience to purchase financial products, specifically banking services.

Beyond providing understandable and relatable content on social media, finfluencers resonate with Generation Z investors due to the flexibility they offer. Espeute and Preece¹⁵ found that Generation Z investors felt empowered by the capacity of social media to facilitate financial learning on their own time and in a manner that aligned with their individual needs; this is an advantage not offered by traditional financial advisors or financial literacy courses.

2.3 Finfluencer Content

In addition to research on the factors driving Generation Z's reliance on social media for financial information, some studies have begun to examine the content produced by finfluencers. The nature of this content varies considerably in scope and approach, depending on the specific social media platform and the influencer's regional focus. For example, Mota et al.¹⁶ conducted a content analysis of personal finance videos on YouTube published in Brazil from 2016 to 2020. The study revealed that the videos primarily offered information on investments, financial behavior, and consumption. By using view and like counts as indicators of content demand, Mota et al.¹⁶ found that Brazilian viewers pre-

dominantly sought short-term, practical information (e.g., budgeting advice) rather than long-term investment strategies (e.g., retirement planning). Specifically, 16.5% of the videos focused on financial behavior, defined as setting financial goals, compared to only 3.3% on retirement savings. Espeute and Preece¹⁵ observed similar trends in their limited evaluation of American finfluencer content across various social media platforms, including TikTok and YouTube. The study found that most content centered on general guidance and informational advice, rather than the promotion of specific investments. Furthermore, the analyzed content frequently employed jargon-free explanations and data visualization techniques to enhance viewer comprehension.

As Generation Z increasingly turns to social media for finance information, it is critical to develop a deeper understanding of what this information covers. While prior research has examined why individuals turn to social media for financial literacy information, comparatively little attention has been given to evaluating the substance of the information shared. A small number of studies have conducted analyses of finfluencer content, but they are often descriptive or limited in scope; therefore, it remains unclear whether the information most visible to individuals who use these platforms, like YouTube, adequately addresses the knowledge required to be financially literate. This study addresses this gap by conducting an analysis of YouTube finfluencer content, identifying both the financial topics discussed and assessing their relevance against established standards of financial literacy.

3 METHOD

To answer the research question “Are YouTube finfluencers a viable source of personal finance information for Generation Z?,” a content analysis using Structural Topic Modeling (STM) was conducted. This assessed both the content of YouTube finfluencer videos and the relevance of the information shared. The relevance of the information was assessed by comparing the content of the finfluencer videos against the categories tested by the P-Fin Index Survey, an established benchmark of the knowledge required for financial literacy.

3.1 Data Collection

Search terms were developed to directly align with the nine knowledge areas assessed by the P-Fin Index¹. Table 1 presents each P-Fin Index category, its definition, and the associated search term. The search terms were designed to reflect the language that a Generation Z individual with limited financial literacy might use by including phrases such as “beginners” or “basics.”

Videos and their transcripts were collected using

YouTube Data API and the youtube-transcript-api library in Python. For each search term, the first 50 videos returned by the search term were collected and filtered to only include videos between three and thirty minutes in length. Videos less than three minutes were excluded to avoid superficial content, and videos longer than thirty minutes were excluded to prevent longer videos from disproportionately impacting the results. Videos were collected without date restrictions to reflect how YouTube’s algorithm promotes content, based on the following: relevance, how well the video aligns with the search term; engagement, measured by total watch time, views, and likes; and quality, defined by the channel’s demonstrated “expertise, authoritativeness, and trustworthiness”¹⁸. This approach ensured that the sample reflected content typical users are likely to encounter.

Although the search terms were intentionally created to reflect what beginner investors may search, this study cannot directly verify that the sampled videos were viewed by Generation Z individuals. However, because video selection was conducted using fixed search parameters via the YouTube Data API and emphasizes content relevance over user demographics, the resulting sample captures financial content that is broadly accessible to novice users and plausibly encountered by Generation Z. This is particularly likely as 60% of Generation Z individuals who report using social media for financial literacy cite using YouTube as their primary source, and the search terms were designed to mirror language these individuals would use¹.

For each video, the following metadata were collected: video title, URL, number of views, channel name, and number of subscribers. The final dataset consisted of 407 videos after removing duplicates and videos without transcripts.

3.2 Data Analysis

3.2.1 Understanding STM

STM was used to analyze the transcripts of the collected finfluencer videos. This method was chosen as it identifies underlying themes in large textual datasets while incorporating document-level metadata¹⁹. This approach built on the research of Mota et al.¹⁶ which used the STM model in R developed by Roberts et al.¹⁹ to analyze Brazilian finfluencer content.

STM is an unsupervised probabilistic topic model, meaning it uses machine learning to identify themes based on patterns in word occurrences across texts. Words that appear frequently together are grouped into topics and then interpreted by researchers to understand the underlying themes. For example, if a model finds that “stock,” “investment,” and “index fund” occur frequently together, it would group them together as a topic. The researcher could then interpret these keywords to show that the topic was about investing.

Table 1 P-Fin Index Categories and Search Terms

Category	Definition	Search Term
Borrowing	“Relationship between loan features and repayments” ¹⁷	Borrowing for beginners
Comprehending risk	“Understanding uncertain financial outcomes” ¹⁷	What is financial risk?
Consuming	“Budgets and managing spending” ¹⁷	How to budget
Earning	“Determinants of wages and take-home pay” ¹⁷	What is take home pay?
Go-to information sources	“Recognizing appropriate sources and advice” ¹⁷	Financial literacy sources
Insuring	“Types of coverage and how insurance works” ¹⁷	How does insurance work?
Investing	“Investment types, risk and return” ¹⁷	Investing for beginners
Retirement fluency	“Social Security benefits, Medicare coverage of healthcare expenses, employment-based retirement savings, ensuring lifetime income and life expectancy in retirement” ¹	Retirement planning basics
Saving	“Factors that maximize accumulations” ¹⁷	How to build savings

Additionally, STM can incorporate covariates, like subscriber and view count, allowing for analysis of how these factors influence topics.

Two primary outputs are produced by STM: topic prevalence and topic content. Topic prevalence refers to the proportion of each document dedicated to a given topic, showing how much attention is given to or how important a topic is for both the individual document and complete sample. Topic content is the distinctive words that define each topic. These are referred to as keywords. This study utilizes FREX keywords, which select keywords based on their frequency and how exclusive they are to the topic. As a result, this measure of topic content produces topics that are more likely to be unique and identifiable¹⁹.

STM can automatically identify topics without training but requires the identification of the number of topics (K) in advance. Selecting an appropriate K is critical to avoid having too few topics that obscure important details or too many that are overly granular. To address this, the searchK function in R was used. The function evaluates multiple models to identify an optimal number of topics that maximize semantic coherence (how often words occur together) and exclusivity (how unique a word is to a topic). Higher coherence increases interpretability but reduces exclusivity; therefore, a balance is required^{16,19}.

3.2.2 Application of STM

Figure 1 summarizes the data collection and application of STM in this study.

After data collection, the first step of analysis was understanding what information is being shared. Once

the transcripts were processed with the STM model, the FREX keywords, the measure of topic content, and topic prevalence, the proportion of each topic, were outputted. To interpret and label the topics, two additional functions in R were used: findThoughts and theta matrix. FindThoughts extracts text excerpts from documents where a given topic is most prevalent, providing context for the FREX keywords. The theta matrix shows the topic prevalence per document, or what portion of a specific video transcript discusses each of the topics identified, providing further context.

These labeled topics were then analyzed with the metadata of view count and subscriber count. View count was included to measure user demand, indicating how often users sought out specific content¹⁶. Subscriber count was included to be a proxy for a channel’s credibility and perceived expertise, as channels with more subscribers are generally viewed as more trustworthy and influential²⁰. The inclusion of these proxies allows for the evaluation of the impact of user demand and perceived credibility on influencer content.

Finally, to assess the relevance of the information being shared by influencers, the labeled topics were compared against the P-Fin Index categories. Since the search terms used to collect the videos were based on these categories, alignment between the modeled topics and the P-Fin Index categories was expected. Closer alignment between the two types of topics would suggest that influencers produce content relevant to established standards of financial literacy. Gaps or mismatches would suggest influencers are not fully addressing areas of content critical to improving financial literacy.

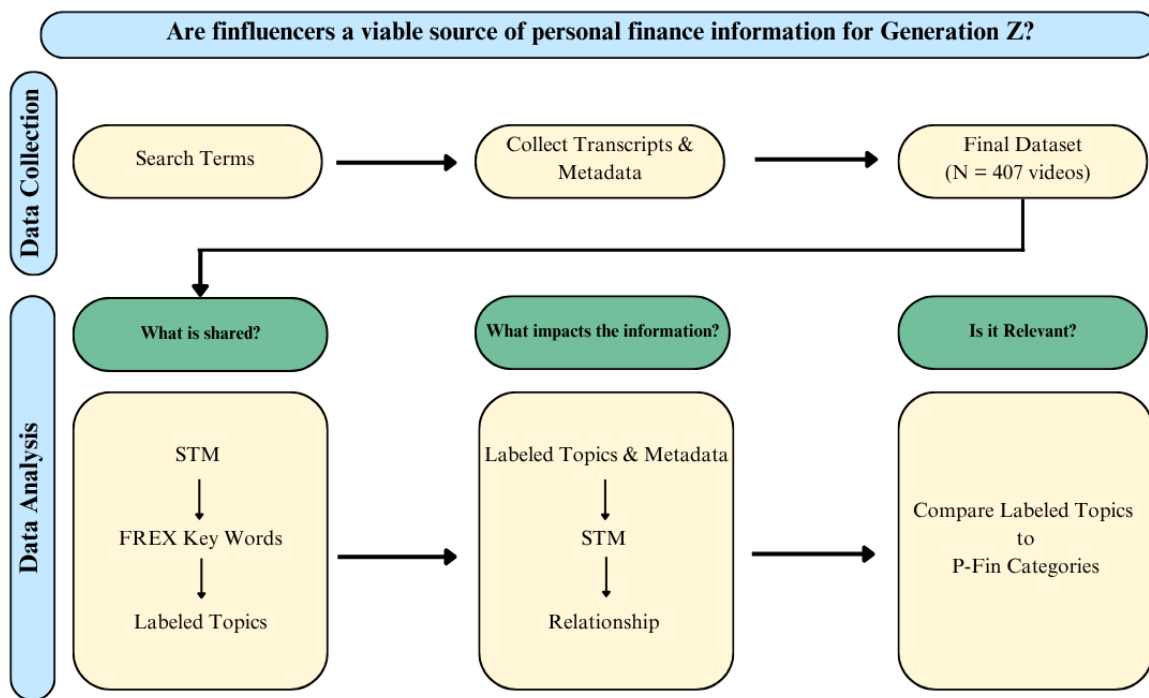


Figure 1. Overview of Method of Analysis

4 RESULTS

A total of 407 influencer videos were collected and analyzed. The results are presented in three parts: topic content and prevalence, effects of user demand and influencer credibility on topic prevalence, and a comparison of the observed topics to the nine P-Fin Index categories.

4.1 Topic Content and Prevalence

After analyzing the semantic coherence and the exclusivity of the model, an eight-topic model was selected. Table 2 summarizes the topics, their FREX keywords, and overall prevalence in the sample.

Topic 1, Emergency Planning, was the most prevalent. It included the keywords "volatility," "fund," and "emergency" and sample documents that focused on building emergency funds and finding appropriate insurance coverage for emergency situations.

Topic 2, labeled General Literacy, had the second highest prevalence. It includes a broad set of financial terms: "risks," "stocks," "budget," and "loan." The topic was widely present throughout the corpus, as was displayed in the theta matrix, suggesting it represents foundational knowledge.

Topic 3, Budgeting, focused on planning and tracking expenses. The keywords "quantitative," "chart," and "budgeting" were reflected in the sample documents that discussed how to create budget trackers us-

ing Google Sheets and how to integrate different goals such as investing.

Topic 4, Investing, included the keywords "management," "stock," and "tax." These aligned with the sample documents, which consisted of investment advice and definitions for beginning investors such as: "buying an index fund is buying one fund that mirrors market index performance."

Topic 5, Borrowing, included the terms "planning," "probability," "interest," and "salary." These were associated with documents explaining types of borrowing (such as different types of home loans), the impact of salary on loan size, and the calculation of interest.

Topic 6, Literacy Resources, reflects the discussion of various sources of personal financial literacy information. The sample documents included phrases such as "the first resource I wanted to share was developed by the FDIC," aligning with the keywords "education," "spending," "risk," and "invest."

Topic 7, Managing Risk, focuses on methods to handle financial uncertainty. The FREX keywords "distribution," "index," and "select" aligned with the sample documents that consisted of risk management investment advice, such as balancing portfolios with a distribution of bonds and stocks and investing in index funds over individual stocks.

Topic 8, Spending, had the keywords "liquidity," "funds," and "calculate" and was mostly focused on how to calculate net income and plan for discretionary

Table 2 Finfluencer Video Topic Keywords and Prevalence

Topic	Label	FREX Keywords	Prevalence
1	Emergency Planning	thought, smart, volatility, fund, emergency, estate, reference, policy	17.32%
2	General Literacy	people, literacy, risks, stocks, budget, loan, minus, employer	16.45%
3	Budgeting	stuff, students, quantitative, investing, budgeting, lender, chart, insurance	14.96%
4	Investing	mean, description, management, stock, expenses, mortgage, function, tax	12.89%
5	Borrowing	things, planning, probability, ETF, category, interest, enter, salary	11.20%
6	Literacy Resources	didn, education, risk, invest, spending, property, column, pension	10.81%
7	Managing Risk	man, resources, distribution, index, link, loans, select, health	8.39%
8	Spending	whole, lesson, liquidity, funds, spend, bitcoin, calculate, Medicare	7.97%

spending. It also provided strategies for ways to control discretionary spending.

4.2 Covariate Analysis

Two covariates, view count and subscriber count, were included in the analysis to understand their relationship with topic prevalence, a measure of how important a topic is. STM estimates indicate the direction of the relationship between the covariate and topic prevalence. A p-value less than 0.05 indicates statistical significance.

Table 3 Relationship between View Count and Topic Prevalence

Topic	Label	Estimate	p-value
1	Emergency Planning	0	0.792
2	General Literacy	0	0.55
3	Budgeting	0.01	0.011*
4	Investing	0.01	0.017*
5	Borrowing	0.01	0.266
6	Literacy Resources	-0.02	0.000*
7	Managing Risk	-0.01	0.055
8	Spending	0	0.884

* $p < 0.05$

View count, the measure of user demand, had a statistically significant relationship with topics 3, 4, and 6. Topics 3 and 4 had positive relationships with view count, indicating that individuals are seeking out or demanding information on investing and budgeting from influencers. There was a negative relationship between view count and topic 6, indicating that users are

not seeking out information related to financial literacy resources.

Table 4 Relationship Between Subscriber Count and Topic Prevalence

Topic	Label	Estimate	p-value
1	Emergency Planning	-0.02	0.004*
2	General Literacy	0	0.641
3	Budgeting	0	0.854
4	Investing	0.01	0.178
5	Borrowing	0	0.973
6	Literacy Resources	0	0.636
7	Managing Risk	0.01	0.011*
8	Spending	0	0.49

* $p < 0.05$

Subscriber count, the measure of influencer credibility, had a statistically significant relationship with topics 1 and 7. Topic 1 had a negative relationship with subscriber count, indicating that users are not receiving emergency planning information from more popular or credible influencers. There is a positive relationship between subscriber count and topic 7, indicating that individuals are referring to more popular or credible influencers for advice on risk management.

4.3 Comparison to P-Fin Index Categories

To understand the relevance of influencer content, the topics found using STM were compared against the P-Fin Index categories, as seen below in Figure 2.

The influencer videos contained six of the nine P-

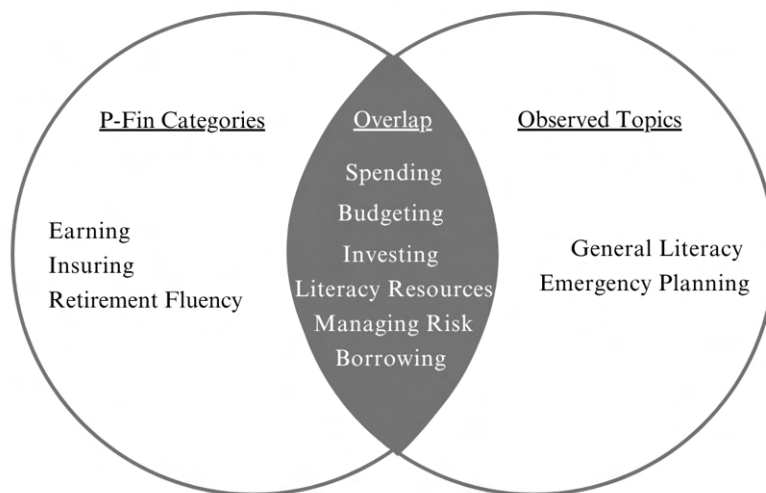


Figure 2. Comparison to P-Fin Index Categories

Fin Index categories. There were no corresponding observed topics for the P-Fin Index categories of earning, insuring, and retirement fluency. This suggests that influencers are not addressing these topics. There were two topics found in the influencer videos that did not correspond to a P-Fin Index category, which were general literacy and emergency planning.

5 DISCUSSION

This study sought to understand both the content and relevance of influencer videos to determine if they can help improve the financial literacy of Generation Z. From the STM analysis of the influencer transcripts, eight topics were identified: emergency planning, general literacy, budgeting, investing, borrowing, literacy resources, managing risk, and spending. The covariate analysis revealed that users are seeking out content on investing and budgeting, while credible influencers tend to produce content on managing risk. Comparing the observed topics with the P-Fin Index categories showed that influencers are addressing six of the nine key financial literacy areas assessed by the TIAA Institute. These findings support the conclusion that influencers are a viable source of financial literacy information and have the potential to help improve Generation Z's financial knowledge.

5.1 Understanding Influencer Content

The three most prevalent topics were emergency planning, general literacy, and budgeting. This indicated that the influencer content was mostly focused on short-term financial needs. The findThoughts and theta matrix outputs revealed that these videos often focused on monthly budgeting strategies, opening and man-

aging savings accounts, and preparing for one-off expenses, such as car repairs. This aligns with Mota et al.¹⁶, who found that Brazilian influencer content focused on savings, investment basics, and setting short-term financial goals and Espeute et al.¹⁵, who reported similar findings for American influencer content.

User demand, measured by view count, was positively correlated with the topics of investing and budgeting, which corroborates previous findings¹⁶. This suggests that users are demanding this content by actively searching for it. However, it is also possible they are being shown this content by YouTube's recommendation algorithm after watching similarly related financial content. The analysis of the findThoughts output revealed that information was presented in simple, beginner friendly terms, often explaining concepts like mutual funds or how to create a budget. Conversely, view count had a negative relationship with the literacy resources topic, indicating low interest in content on finding financial resources. The remaining five topics—general literacy, borrowing, spending, emergency planning, and managing risk—did not have a statistically significant relationship with view count. This suggests that users are more likely to engage with this content passively or encounter it through their YouTube algorithm, rather than actively searching for this information. It is also possible that, because how foundational these topics are to financial knowledge, they are frequently covered or embedded in other financial content, making users feel more familiar with them and less likely to directly search for them.

Influencer credibility, measured by subscriber count, was positively associated with the topic of managing risk. This suggests that users are more likely to encounter risk management content from influencers with larger followings. In contrast, subscriber count

was negatively correlated with emergency planning, the most prevalent topic. This suggests that users are getting this information from smaller finfluencers, potentially due to a large number of finfluencers creating such content. The seven other topics did not have a statistically significant relationship, indicating that their consumption is independent of finfluencer following size.

5.2 Understanding the Relevance of Finfluencer Content

The comparison of the observed topics to the P-Fin Index categories allowed for an evaluation of the relevance of finfluencer videos. The analysis showed that finfluencers covered six out of the nine P-Fin Index categories: spending, budgeting, investing, literacy resources (go-to information sources), managing risk (comprehending risk), and borrowing, as seen in Figure 2. However, the categories of earning, insuring, and retirement fluency were absent from the observed topics, suggesting gaps in coverage of certain long-term financial skills.

Two additional topics, emergency planning and general literacy, were present in the observed topics but not in the P-Fin Index categories. The analysis of the Find-Thoughts outputs for these topics suggests that they might provide exposure to the concepts of the missing categories by providing a general understanding of concepts such as retirement planning. However, they most likely lack the in-depth explanation required to meet the specificity of P-Fin Index categories.

5.3 Implications

These findings indicate that finfluencer content is more than excessively promoted advice; it provides relevant information that addresses many of the key areas of financial literacy. Generation Z's preference for social media sources and the prevalence of finfluencer content suggest that it is a key tool for financial education. However, the absence of topics such as retirement fluency and earnings suggests the need for more variation in content. To address these gaps, finfluencer videos could be paired with traditional methods of teaching financial literacy such as curriculum-based classes or the FDIC's Money Smart curriculum. Additionally, efforts could be made by finfluencers or financial institutions, such as TIAA, to create more content on meeting long-term financial goals such as saving for retirement, understanding Medicare, and Social Security.

While finfluencers can serve as valuable sources of personal finance information, it is important to recognize the current lack of regulation regarding the content they promote. According to a 2024 report from the U.S. Securities and Exchange Commission's (SEC) Dis-

closure Subcommittee of the Investor Advisory Committee, many finfluencers effectively act as unlicensed investment advisors. Some receive compensation in exchange for promoting financial products without adhering to the disclosure requirements that apply to traditional brokers and advisors. The SEC has already taken enforcement in several cases, including a 2022 "pump and dump" scheme in which eight social media influencers were charged with manipulating stock prices and generating approximately \$100 million in profit through coordinated posts on Twitter²¹.

To make finfluencer content a viable and trustworthy source of information going forward, regulatory frameworks must evolve to ensure greater transparency. This could include required disclosure of conflicts of interest, compensation received for the content, and the finfluencer's qualifications or credentials to provide financial advice. These disclosures would help young investors be able to evaluate the information shared and better protect themselves from potential fraud or misinformation²².

5.4 Limitations

This study has limited generalizability due to a small sample size of 407 videos. While this sample provides a meaningful foundation, it represents a small fraction of the personal finance content on YouTube. The use of nine search terms also limits the generalizability as they could have excluded relevant videos that used different phrasing. Lastly, view count does not provide insight into the demographics of individuals watching these videos. There is the potential that those watching these videos are not within the Generation Z age group, influencing the interpretation of the findings. Additionally, the use of view count as a measure of user demand does not account for the potential influence of bot activity on YouTube, which may artificially inflate the view count metrics and affect the interpretation of the covariate analysis.

5.5 Future Research

While this study has improved the understanding of finfluencer content, much remains unknown about its effectiveness at improving knowledge. Future research should explore experimental methods of comparing traditional methods of teaching financial literacy to watching finfluencer videos to assess if finfluencer content can lead to sustained knowledge gains or behavioral changes. Additionally, more content-focused studies with larger sample sizes would improve generalizability and provide a more comprehensive understanding of finfluencer content.

6 CONCLUSION

This study evaluated whether influencer content can serve as a viable source of financial literacy information for Generation Z. The analysis showed that influencers cover a wide range of personal finance content that is closely aligned with the established financial literacy categories of the TIAA's P-Fin Index. While gaps remain in the coverage of long-term financial literacy topics, influencers have the potential to be a key tool in improving financial literacy for Generation Z. However, this potential depends on users remaining aware of their limitations and on greater accountability and transparency within the content itself, ensuring that influencers function as credible guides rather than as part of an overhyped social media trend.

7 EDITOR'S NOTES

This article was peer-reviewed.

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Becoming by Kayla Stutz
Charcoal on paper, 22 x 30 in.

Generation Z and the AI misinformation paradox: understanding a new digital vulnerability

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Abstract

This study examines how and why Generation Z is particularly vulnerable to AI-generated content, and the implications of this vulnerability for democratic participation and information resilience. Drawing on empirical studies, survey data, and meta-analyses published between 2019 and 2025, this analysis synthesizes research on Gen Z's exposure to and interaction with AI-produced content across social media platforms. While this cohort has grown up in an increasingly digital age, multiple studies show that technological exposure and fluency do not reliably translate into digital literacy or resistance to misinformation. This vulnerability stems from three intersecting factors: high content volume, developmental traits favoring surface-level engagement, and algorithmic amplification of emotionally salient material, which collectively heighten susceptibility. Despite these risks, interventions such as prebunking and targeted media literacy training demonstrate measurable success in improving discernment and reducing belief in AI-generated falsehoods. These findings suggest that Gen Z's challenge is not a lack of access or awareness, but overexposure to AI-mediated information ecosystems that exploit attention and trust. Mitigating this vulnerability is essential for democratic resilience and the development of evidence-based policies.

Keywords: Artificial Intelligence (AI), misinformation, disinformation, Generation Z, prebunking, media literacy, cognitive bias, policy, education, digital resilience

1 INTRODUCTION

AI increasingly shapes the information youth consume, often in ways that undermine accuracy and critical evaluation. From deepfakes to algorithmically generated social media posts (content automatically produced or personalized by AI algorithms), these technologies circulate widely^{1,2}. This proliferation poses novel challenges for Gen Z and the political systems in which they participate^{2,3}. In democracies, citizens and their representatives rely on accurate information to self-govern effectively.

Born between 1997 and 2012, members of Gen Z grew up in a digitally saturated world. They engaged with AI tools and content earlier, more frequently, and more intuitively than any previous generation¹. Although technological fluency is high, multiple studies show that early exposure to AI-mediated information environments does not guarantee resistance to mis/disinformation^{2,4,5}. While some longitudinal evidence hints at potential life-course effects, this analysis primarily synthesizes current adolescent findings.

To situate Gen Z's experience, older cohorts (Millennials, born 1981–1996; Generation X, born 1965–1980) typically accessed digital media later in life and may rely on traditional news sources more heavily. This contrast underscores why early, immersive exposure to AI content can uniquely shape adolescent vulnerability⁶.

Given these vulnerabilities, recent scholarship emphasizes educational and policy strategies that reduce the negative impacts of AI-generated mis/disinformation, particularly for younger audiences. Prebunking strategies, especially when delivered through interactive or game-based formats, have been shown to reduce susceptibility more effectively than disclosure labels, which demonstrate limited or inconsistent effects on belief and persuasion^{7,8,9,10,11}.

1.1 Key Terminology

Misinformation and disinformation encompass a broad range of content, from conspiracy theories and political deception to well-intentioned but inaccurate claims². Misinformation refers to incorrect or misleading infor-

mation shared without intent to deceive, whereas disinformation is deliberately false content created to mislead, often spread covertly to influence public opinion or obscure the truth¹². Freelon and Wells further refine this distinction by identifying three critical criteria for disinformation: deception, potential for harm, and intent to harm³. Recognizing these differences is essential for evaluating AI-generated content, which can simultaneously produce content that is misinformation and disinformation at a large scale, making it challenging for users to discern.

Artificial Intelligence (AI) is defined as computer systems capable of performing complex tasks typically requiring human reasoning, decision-making, or creativity¹³. AI includes technologies relevant to the spread of mis/disinformation, such as large language models (LLMs) that can recognize and generate text¹⁴, voice cloning that reproduces a person's voice using recorded datasets⁷, and AI-generated images and videos. While these tools are not inherently deceptive, their ability to produce content at scale and low cost makes them powerful vehicles for both misinformation and disinformation, particularly among youth^{15,16}. Rapid generation and amplification of AI-produced content increases exposure to misleading information while also enabling the creation of content deliberately designed to deceive^{2,17}.

As noted above, Gen Z, the focus of this analysis, consists of individuals born between 1997 and 2012. Within this cohort, teens (ages 13–17) are particularly relevant for understanding the effects of AI generated content, as they are highly active online and still developing critical cognitive skills.

2 METHODS

This study employed a targeted literature review of peer-reviewed scholarship, policy reports, and reputable news sources examining youth, AI-generated content, and digital misinformation. The review specifically sought studies that explored patterns of social media use among Generation Z, cognitive vulnerabilities affecting susceptibility to misinformation, and interventions designed to mitigate AI-driven mis/disinformation, including key studies such as Roozenbeek and Van der Linden⁷, Kyrychenko et al.⁴, and Spearing et al.⁸. Keywords used in searches included: “*Generation Z*”, “*youth digital media*”, “*AI-generated content*”, “*misinformation*”, “*disinformation*”, “*prebunking*”, “*media literacy*”, and “*social media algorithms*”.

The initial search focused on peer-reviewed articles from databases such as Pew Research Center, JSTOR, Google Scholar, and Scopus, emphasizing research published between 2020 and 2025 to reflect recent developments in AI technologies. Key studies informing this

review include investigations into social media habits and political information exposure^{18,19}, cognitive susceptibility to AI-generated misinformation^{4,5}, and experimental studies on prebunking and media literacy interventions^{7,15}, however, rather than examining these domains in isolation as prior research often does, this review synthesizes them to demonstrate how patterns of digital exposure, cognitive vulnerability, and intervention effectiveness interact to shape Generation Z's susceptibility to AI-driven misinformation.

Since U.S.-based programs are limited, European Union initiatives, including the Digital Services Act and AI Act, were also examined to provide a comparative perspective. Given the evolving nature of this field, conclusions remain tentative, particularly for culturally distinct subpopulations of Gen Z interacting with rapidly changing AI technologies.

2.1 Landscape and Exposure

Gen Z's pervasive use of social media and constant online connectivity amplifies their exposure to digital misinformation, creating unique vulnerabilities despite their digital nativity. According to a 202 Pew Research survey of 1,391 U.S. teens, nearly half reported being online “almost constantly,” a 24% increase from a decade ago, while 96% reported daily internet use. TikTok, Instagram, and Snapchat remain the most popular platforms among U.S. teens, whereas Facebook and X use have declined sharply¹⁸. Similarly, a Pew Research Center survey of 1,453 U.S. teens ages 13–17 found that 95% have access to a smartphone, desktop, or laptop (Pew Research Center). Notably, 77% of U.S. young adults aged 18–34 reported using social media platforms such as X/Twitter, Instagram, TikTok, Reddit, YouTube, and Twitch as their primary sources of political information during the 2024 election cycle¹⁹. Together, these findings demonstrate that today's youth are both highly connected (frequent access) and heavily reliant (primary source for information and social interaction) on digital media.

Algorithmic curation further shapes Gen Z's online environment. Platforms tend to prioritize sensational, emotionally charged, or highly engaging content, increasing the visibility of misleading or polarizing material^{1,2}. Influencers—individuals with substantial online followings—also significantly shape information consumption. When political or social commentary is embedded within entertainment or lifestyle content, teens may struggle to distinguish factual reporting from opinion or sponsored messaging². These patterns create conditions in which misinformation can spread rapidly and broadly, particularly among youth with underdeveloped critical evaluation skills.

Table 1 Seven Types of Mis/Disinformation, Reproduced information from Claire Wardle, *"Fake news. It's complicated"*, First Draft, 2017.

Type	Definition	Harm Level	Category
Satire or Parody	No intention to cause harm but has potential to fool	Least Harmful	Misinformation
False Connection	When headlines, visuals, or captions don't support the content	Low	Misinformation
Misleading Content	Misleading use of information to frame an issue or individual	Moderate	Misinformation
Fake Context	When genuine content is shared with false contextual information.	Moderate	Disinformation
Imposter Content	When genuine sources are impersonated	High	Disinformation
Manipulated Content	When genuine information or imagery is manipulated to deceive	High	Disinformation
Fabricated Content	New content that is 100% false, made to deceive and do harm	Most Harmful	Disinformation

A 2025 Misinformation Susceptibility Test (MIST) asked participants to classify twenty headlines (ten real, ten false) as “fake” or “real.” Gen Z participants demonstrated the lowest accuracy across age groups, misclassifying a significant proportion of false headlines⁴. Despite growing up immersed in technology, many teens lack formal training in evaluating sources, including structured media literacy, critical news analysis, or instruction in recognizing manipulated or synthetic content⁵. While some individuals may have encountered such training in higher education or professional settings, it is not consistently embedded in K–12 curricula, leaving teens particularly vulnerable. The MIST also revealed that Gen Z expressed low confidence in identifying misinformation, aligning self-perception with actual performance⁴. This combination of high exposure and low confidence creates a cycle in which teens remain easily influenced by misleading content.

Experimental evidence highlights the real-world consequences of these vulnerabilities. In one study, 52% of youth participants interpreted a grainy video filmed in Russia as evidence of ballot tampering in the 2016 U.S. primaries, even though it lacked verification or context². The video depicted indistinct footage of individuals handling ballots and moving around a polling location, which participants misinterpreted as fraudulent activity. Across participants, 97% failed to fact-check sources or consider potential biases, and 66% could not differentiate news stories from sponsored content². Globally, similar patterns persist: a UNICEF survey of ten countries found that up to three-quarters of youth reported feeling unable to judge the veracity of online information².

AI-generated misinformation adds an additional layer of concern. Teens (defined here as individuals aged 13–17) encounter AI-written captions, synthetic images, and automated videos at scale, often crafted to

mimic the style and tone of credible sources, making discernment especially difficult^{1,2}. AI can also promote cognitive offloading, a measurable process in which users rely on surface-level cues such as headlines, visuals, or perceived source credibility rather than engaging in deeper analytical reasoning¹. These adolescents rarely verify sources when encountering AI content, reflecting both limited critical evaluation skills and the overwhelming volume of AI-generated material¹.

These findings underscore the need for targeted educational and policy interventions, including age-appropriate media literacy curricula, explicit instruction on identifying AI-generated content, platform transparency requirements, and safeguards limiting algorithmic amplification of misleading information. Without such measures, Gen Z's high exposure to AI-driven content may continue to outpace their ability to critically evaluate it.

2.2 Cognitive Vulnerability Mechanisms

While artificial intelligence offers notable benefits across sectors like health care, education, and finance, its rapid integration into youth information ecosystems amplifies cognitive vulnerabilities and susceptibility to misinformation¹⁶. Moreover, the sheer volume of AI-produced content can overwhelm cognitive capacity, making it increasingly difficult for teens to distinguish credible material from misinformation.

AI systems rely on machine learning algorithms to detect patterns in large datasets rather than being explicitly programmed. This autonomy has made content production faster, cheaper, and less dependent on human input¹⁶. Major news organizations, such as The Washington Post, Reuters, and Bloomberg, and tech platforms including TikTok and YouTube, have integrated generative AI tools for headline generation, automated

summaries, or image and video enhancement^{1,16}. However, because these systems learn from human-created data, they often replicate existing perceptual, emotional, and social biases. For example, if AI content is trained on politically polarized posts, it may disproportionately present emotionally charged political content, normalizing extreme perspectives¹⁶.

Adolescents' cognitive development amplifies these vulnerabilities. Executive function, impulse control, and metacognitive monitoring, which are essential for evaluating credibility, detecting bias, and reflecting on information, are still developing in teens^{16,20}. Consequently, repeated exposure to biased AI content can shape implicit attitudes, reinforce confirmation bias, and normalize distorted perspectives. If an AI system repeatedly presents hyper partisan headlines as credible news, this may lead adolescents to perceive such framing as typical or authoritative, even when it is misleading.

While users bring preexisting biases to online environments, AI can encode and amplify these biases through engagement-optimized ranking, probabilistic content generation, and training on biased datasets^{1,16}. Biased or unverified content combined with passive scrolling, where users minimally engage or reflect, creates ideal conditions for misinformation to flourish¹. Social media algorithms, optimized to capture attention and promote shareable material, routinely amplify sensational or emotionally charged content, including clickbait, conspiratorial rhetoric, and deceptive narratives².

AI intensifies these vulnerabilities by enabling the rapid production of hyper-realistic images and videos that mimic journalistic aesthetics, dramatically increasing both the scale and perceived credibility of misleading visual content¹. AI-generated news-style videos may replicate visual markers of credibility, such as professional formatting, authoritative narration, and branded graphics, making synthetic content difficult to distinguish from legitimate reporting. Visual information is processed far more rapidly than written communication, and youth are less likely to employ critical reasoning when encountering videos or images². This effect is particularly pronounced for AI-generated visual content, which can include deepfakes or hyper-realistic media that mimic credible sources, bypassing critical scrutiny. Consequently, even well-intentioned adolescents may unknowingly internalize misleading narratives, reinforcing stereotypes or misconceptions over time^{16,20}.

The convergence of low production costs, high accessibility, and limited factchecking creates a high-risk online environment for young users. For adolescents with developing brains, repeated exposure to manipulative or false narratives can reshape worldview, influence political attitudes, and erode trust in institutions, threatening democratic participation itself²⁰. For instance, a

teen overwhelmed by AI-generated stories vilifying a social group or swayed by a deepfake political video may withdraw from civic engagement altogether. This dynamic illustrates the duality of AI, highlighting how it can both educate and inspire, for example by providing accessible explanations of complex topics, generating personalized learning content, and supporting interactive engagement with news and civic information, while also subtly distorting beliefs, particularly among impressionable youth. Such examples are not merely hypothetical but are already observable in today's media landscape²⁰. Understanding mechanisms such as algorithmic amplification, AI-generated content that mimics credible sources, and users' reliance on surface-level cues rather than critical evaluation is essential for designing interventions that both leverage AI's educational potential and mitigate its risks.

2.3 Intervention Mechanisms

Addressing youth vulnerability to AI-generated misinformation requires targeted interventions. As existing research highlights both the potential and limitations of strategies such as disclosure labels, prebunking, and media literacy programs, one consistent conclusion across modern scholarship on AI generated mis/disinformation is the urgent need for reform. Policymakers face a difficult balance: They must protect youth from harmful content while respecting the right to freedom of expression and access to information. The latter "can be infringed by over-zealous attempts, including regulations, to restrict access to online content and communities"². To date, three main intervention strategies have been studied: disclosure labels, prebunking, and media literacy programs. While these approaches are often discussed separately, they should be understood as complementary rather than mutually exclusive. As summarized in Table 2, research suggests that each approach has both strengths and limitations. Collectively, these approaches aim to improve digital discernment, strengthen critical reasoning, and reduce the likelihood that adolescents will unknowingly share or internalize false information.

Disclosure labels are defined as "explicit messages, icons, or text that accompany media and alert viewers that the content was created or modified by an artificial intelligence system"²¹. Although designed to increase transparency, these labels are often ignored or distrusted by teens. Gallegos and coauthors found that while 94.6% of youth participants in a study recognized authorship labels, the labels had no significant effect on message accuracy judgments, attitude change, or sharing intentions⁹. Similarly, Schmalzle and coauthors found through a second study that labeling messages as AI-generated influenced evaluation but not ranking, with a slight bias against AI-created messages²¹. Li and

Table 2 Overview of Major Intervention Types.

Intervention	Definition	Effectiveness	Strengths	Limitations
Disclosure Labels	Labels or icons indicating content was AI-generated	Low–moderate	Increase transparency and awareness	Often ignored; minimal behavioral impact; may reduce credibility of true content
Prebunking (Inoculation Theory)	Exposure to weakened misinformation techniques to build resistance	High (short-term)	Builds cognitive resilience; effective across ages; works well when interactive or game-based	Effects fade without reinforcement; requires facilitation
Media Literacy Programs	Education on analyzing, evaluating, and creating digital content responsibly	Moderate–high (long-term)	Promotes critical thinking; scalable in schools; adaptable for youth	Resource-intensive; uneven implementation; requires curriculum updates

Yang likewise concluded that labeling had no meaningful effect on perceived accuracy, message credibility, or sharing intention, though labels did not negatively impact overall platform trust¹⁰. These studies suggest that while labeling may increase awareness, it is insufficient to alter cognitive or behavioral responses on its own, particularly among adolescents who tend to be highly visually oriented and exposed to continuous content streams².

These weak effects should not be interpreted as a reason to abandon disclosure labels entirely, but rather as a signal that the labels may require refinement, through either clearer design, integration with interactive cues, or reinforcement through education to increase effectiveness.

A related study of U.S. and U.K. youth revealed that labeling headlines as AI-generated reduced perceived accuracy and willingness to share them, even when the headlines were true or human-written¹¹. However, this “AI aversion” effect was three times weaker than labeling content as false, suggesting that audiences assume AI-generated headlines are unsupervised by humans¹¹. These results underscore that labeling should be implemented carefully to avoid stigmatizing legitimate AI content. Collectively, current research calls for further study on how disclosure effects vary by content type, region, and demographic factors before they can be considered a reliable mitigation tool.

Prebunking, or inoculation theory, involves warning individuals about potential misinformation and exposing them to a weakened form of misleading techniques to build cognitive resistance⁷. Evidence on prebunking’s effectiveness among youth is encouraging, though its effects tend to fade without reinforcement. Spearing and coauthors found through a study that source-focused inoculation reduced overall trust in AI-generated information but did not significantly diminish the influence of specific misleading articles⁸. In

another study, however, combining inoculation with debunking eliminated misinformation effects entirely⁷. Fulsher and coauthors found that using generative AI itself for prebunking through model fine-tuning, prompt design, and classroom integration, showed strong potential but required human facilitation to ensure accuracy and ethical oversight¹⁵. This highlights the dual role of AI as both a source of misinformation and a potential tool for cultivating critical reasoning. As Jia and coauthors argue, all education stakeholders “must be prepared to thoughtfully navigate GenAI’s dual potential as both a source of and solution to misinformation”¹⁷.

Youth-oriented prebunking studies further highlight interactive learning. Dangol and coauthors developed *AI Puzzlers*, a system that helps children identify reasoning errors in generative AI. Even younger children (ages six and under) who were not fluent readers could detect inconsistencies in AI generated solutions, leading to reflective discussions about “how AI thinks”²². Likewise, Roozenbeek and Van der Linden’s “fake news game” trained players to use six misinformation tactics, polarization, emotion, conspiracy, trolling, deflection, and impersonation, and found improved resistance to misinformation across age, ideology, and education level⁷. Gamification and interactive methods engage multiple cognitive pathways, encouraging adolescents to recognize manipulation strategies actively rather than passively consuming content. Collectively, this evidence suggests that prebunking, especially when gamified and reinforced over time, is one of the most effective tools to strengthen youth misinformation resilience.

Media literacy programs represent a third major intervention. These structured educational frameworks teach students how to access, analyze, evaluate, and create media responsibly²³. Results are mixed but promising. Yim and Su highlight the growth of AI literacy initiatives using age appropriate tools such as Google’s

Teachable Machine, *Learning ML*, and *Machine Learning for Kids*, which enhance both engagement and soft-skills acquisition²⁴. Jia and coauthors proposed a holistic AI literacy framework consisting of three dimensions: AI awareness, AI mechanics, and AI impacts, each encompassing skills from understanding AI applications to responsible practice¹⁷. Li and coauthors found that while teachers generally understand AI's core functions, they face challenges accommodating students' varying AI skill levels; encouragingly, opportunities for AI literacy learning did not significantly vary by socioeconomic status¹⁰. These programs aim to build durable skills for critical evaluation, fostering long-term resilience against emerging AI-generated misinformation.

All three approaches – disclosure labels, prebunking, and media literacy programs – show partial effectiveness. Disclosure labels enhance transparency but yield minimal behavioral change and risk being misunderstood or ignored. Prebunking is the most empirically supported, showing strong short-term effects, especially through gamified learning, though it depends on reinforcement and human facilitation. Media literacy programs provide comprehensive frameworks and long-term potential but face scalability and resource barriers. Taken together, embedding prebunking games within school curricula and sustaining media literacy education may create the most robust defense against AI-driven mis/disinformation among adolescents.

3 POLICY CONTEXT

Current policy frameworks addressing AI-generated misinformation vary across regions. The European Union has implemented strategies such as the Digital Services Act and the AI Act, aiming to increase platform accountability, enhance transparency of algorithmic content, and protect vulnerable populations, including youth¹. Together, these policies provide a model for balancing innovation with consumer protection². However, transferring EU approaches to the U.S. context is complicated by institutional differences. The U.S. places a stronger emphasis on First Amendment protections, which operates under decentralized regulatory structures, and often relies on industry self regulation, which may limit direct applicability of EU frameworks^{1,2}. Adapting EU inspired frameworks to the U.S. would therefore require careful consideration of legal and political constraints to ensure both effectiveness and respect for freedom of expression.

4 CONCLUSIONS

As AI technologies evolve at an unprecedented pace, effective policy and educational interventions must simultaneously advance to protect Gen Z from escalating risks of AI-driven misinformation. As demonstrated

throughout this analysis, scholars widely agree on two central points: (1) Gen Z is highly vulnerable to AI-generated misinformation and disinformation due to factors such as content volume, sophistication, developmental stage, accessibility, and media habits; and (2) concrete policy and intervention efforts to mitigate these effects and close generational literacy gaps remain insufficient. Promising interventions, particularly prebunking strategies delivered through interactive, gamified, or educational formats, show measurable short-term benefits, but scalability and long-term durability remain limited, highlighting the need for coordinated institutional support. Early policy efforts, particularly those establishing accountability for AI developers and protections for children, mark important progress but require sustained expansion and enforcement. Given that Gen Z represents the future electorate and workforce, policymakers and local institutions must act urgently to strengthen these initiatives.

In the near term, schools represent the most direct and scalable setting for equipping youth with the critical tools to navigate digital environments. As AI becomes an embedded feature of daily life, educators must treat media and AI literacy as core competencies on par with traditional subjects. Embedding interactive prebunking exercises, critical evaluation tasks, and scenario-based learning into curricula can reinforce resilience, allowing students to apply analytical reasoning in real-world contexts. Integrating prebunking and media literacy through interactive, experiential learning can help students cultivate discernment, skepticism, and resilience from an early age. Over time, embedding such practices into formal education may lay the foundation for a more critically literate society.

Meanwhile, it is critical for policymakers to accelerate legislation addressing AI-enabled misinformation, which has a disproportionate impact on youth. Since regulatory processes often lag technological development, action must be proactive rather than reactive. Comprehensive AI governance anchored in transparency, safety, and accountability should remain a top priority to protect Gen Z and global democratic integrity from the destabilizing effects of AI-generated misinformation. In practice, this requires policies that are adaptive, regularly reviewed, and informed by empirical evidence on youth engagement with AI content. Continuous collaboration between lawmakers, educators, researchers, and platform developers is essential to translate policy into effective, real-world safeguards.

4.1 Future Directions

Despite growing evidence of Gen Z's susceptibility to AI-generated misinformation, significant gaps remain, highlighting the urgent need for longitudinal, cross-cultural, and intervention-focused research. Specifically,

future research should prioritize prolonged studies to assess how Gen Z's misinformation exposure and resilience evolve over the life course and as AI systems become more sophisticated. Tracking these trajectories can help identify critical periods for intervention and inform the design of sustainable educational strategies. More extensive cross-cultural analyses are also needed to develop a deeper understanding of how differences in education systems, media environments, and policy frameworks affect susceptibility across nations.

Another critical avenue involves evaluating the sustainability of prebunking and media literacy programs. To what extent, if at all, do game-based and interactive interventions maintain their benefits over longer periods of time, and for whom? Research should also examine how hybrid approaches combining digital and in-person interaction, can reinforce learning outcomes and support adaptive coping strategies against evolving AI misinformation techniques. Additionally, scholars will likely continue to explore how AI can be leveraged as a defensive tool to combat the negative effects of AI-generated mis/disinformation.

Finally, policymakers and developers must collaborate to design transparent, youth-centered AI governance frameworks that protect against manipulation while empowering young users as informed digital citizens. Such frameworks should incorporate principles of accountability, inclusivity, and evidence-based oversight, ensuring that youth are not only protected but also equipped to engage critically with digital media. Advancing these efforts will be key to closing the generational vulnerability gap and ensuring that future information ecosystems promote resilience, critical awareness, and democratic integrity.

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6 EDITOR'S NOTES

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Sun Bleached by Aliyah Goldberg

Greenspace access in the Denver metro region: historical housing policy impact on modern greenspace distribution

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Abstract

Access to urban greenspaces is often unequal, with disparities being linked to race, socio-economic status, age, and geography. In recent years, there has been an increase in interest in greenspace access in the environmental field, but much of that work has been done internationally. This paper examines greenspace access in the Denver Metro Region (DMR) with a particular focus on how historical housing policies are connected to modern inequities. With the City and County of Denver and surrounding areas serving as a case study, this paper uses mapping tools such as the Trust for Public Lands' ParkServe tool, U.S. Census Data, and redlining maps to examine where inequalities in park access exist and how those inequalities correlate with historically targeted minority communities. Although on its face the DMR has high levels of greenspace access, the areas without access are highly concentrated in minority, low-income, and elderly communities. These areas also align with historically redlined communities and areas that have had discriminatory housing policies and zoning. To improve access to greenspace for affected communities, municipalities can implement needbased greenspace planning and emphasize community-driven planning processes.

Keywords: environment, equity, justice, greenspace, access

1 INTRODUCTION

Scholars across the field have consistently shown that access to urban greenspace is unequal and often shaped by race, class, and geography. Studies in U.S., European, and South American cities have shown that people of color, specifically Black, Hispanic, and Indigenous communities, often face the greatest disparities in access to urban greenspaces^{1,2,3,4,5}. At the same time, older adults have consistently less access to urban greenspaces. Evidence suggests that exposure to green spaces is particularly important for this group as the social, physical, and mental benefits can greatly improve their quality of life. More specifically, access to green spaces can reduce social isolation for older adults.

These inequalities are not only social, but also spatial. In studies of cities in Brazil and China, researchers found distributional inequalities between residents living in the center of cities and those on the peripheries. Residents in the center of the cities tended to have greater access to greenspace, and those on the peripheries, who were more likely to be racial minorities in the case of the Brazilian studies, tended to have less access.^{1,6} Recent findings about social and spatial in-

equalities in greenspace access have challenged historical approaches to greenspace provision. The most common approach to greenspace distribution is a standards-based approach: this applies universal standards to entire areas without regard to geographic and demographic differences within cities.^{7,8} Instead, scholars advocate for a transition to needs-based and community-input driven models. These models more intentionally bring in community perspectives and the individual needs of areas.⁷

In all, the field of study surrounding greenspace accessibility calls for a social justice approach to greenspace provision. Through the study of social and spatial disparities, government officials, community leaders, and researchers can better understand the realities of greenspace access in their communities. Governments and municipalities should engage meaningfully with community input and approach greenspace allocation with an environmental justice lens to more equitably distribute greenspace and increase its community utility. This study aims to bring this social justice approach to the Denver Metro Region and highlight the connection between historical housing policy and present greenspace realities.

1.1 Historical Context

In the City of Denver, parks have historically been funded by property taxes. In the early years of the CCD’s investment in parks, the city was divided into four districts, with more money being given to the areas that paid more in property taxes. These areas were most often made up of white and wealthy residents. Because of this, parks established in these areas tended to be bigger and better maintained. Furthermore, the housing practices around those parks tended to exclude non-white citizens. In the period from around 1902 to 1945, CCD’s parks were tax-funded. Zoning policies around parks, such as “Residential A” zoning classifications, required large, single-family homes to be built on large lots. Often, these zoning classifications were highly centered around parks. And created areas with high density of expensive and large homes.⁵ Because of zoning practices such as “Residential A” zoning, people of color were often priced out of the areas surrounding the biggest and highest quality parks.

In the Post-War-Era, from around 1945 to 1982, white residents started to leave Denver proper in favor of newly emerging suburbs. This, in turn, lowered property tax revenues, and encouraged disinvestment in public parks.⁵ As “white flight” continued, more people of color gained access to parks, but the parks became increasingly underfunded. In this era, the lowest income communities and many communities of color remained in areas of the city that were heavily industrialized and lacking in greenspaces. Additionally, the suburbs that were largely zoned using covenants often prevented white homeowners from selling to people of color. Some of these covenants even date back to the 1920s.

For example, Cherry Hills Village proposed one such covenant (Figure 1) in 1922 aimed to prevent people of color from moving into the area.⁹ These practices had lasting effects, with people of color still often being underrepresented in areas such as Cherry Hills Village, with the area being made up of around 87% white residents according to the 2020 census.¹⁰

In the modern era, 1983 to present, some demographic change occurred, however the largest and best quality parks tended to be inaccessible for people of color, older populations, and low-income communities. Additionally, the CCD has created modern investments in parks, which are often meant to be “urban marketing tools” that aim to drive up property taxes and attract new, often wealthy, residents. Modern development and greening projects, aimed at driving up property tax revenue, have further pushed vulnerable groups out of their communities.⁵ These projects mirror those in other cities studied by other scholars. In Shanghai, practices like “green gentrification” and bad faith greening have been found to increase the cost of living in previ-

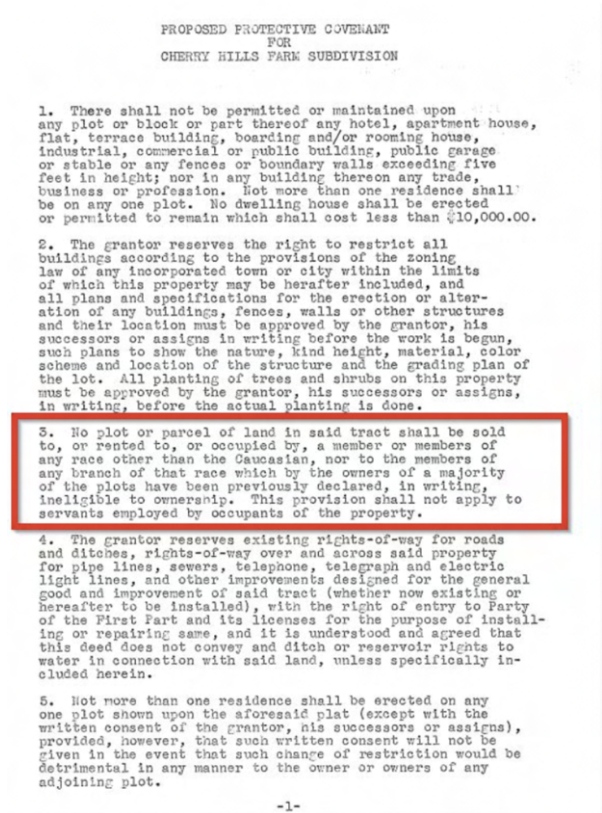


Figure 1. Covenant proposed in Cherry Hills Village in 1922 featuring racial restrictions on property ownership.

ously inexpensive areas, pushing people out in favor of more wealthy residents.⁶ Additionally, shifts in funding sources for parks from property taxes to bonds and grants have introduced new issues of access and equity. Because of the organizing and consistent engagement it takes to get a community bond issue passed and to apply for and receive grants, under-resourced communities may have less access to these funding sources. This has the potential to greatly impact the greenspace development of these communities.

The City of Denver’s historical policies continue to affect taxation and park funding, and therefore the racial and socio-economic makeup of the city. When compared to the “Mapping Inequality” map of the CCD’s historic redlining practices (Figure 3) with ParkServe’s greenspace map (Figure 2), similarities show through. Denver’s redlining practices designated many sections of the city as “Definitely Declining” and “Hazardous.” These designations were deeply harmful and largely based on the racial and ethnic makeup of the city. More specifically, these harmful practices targeted people from the Black, Jewish, and Latino communities. Areas in the central, eastern, northern, and southeastern parts of the city were the most extremely redlined, preventing the residents of these communities from accessing things like home loans and insurance, perpetuating

racial and economic inequality. On the ParkServe map, these are also the areas that most consistently have poor access to public green spaces.

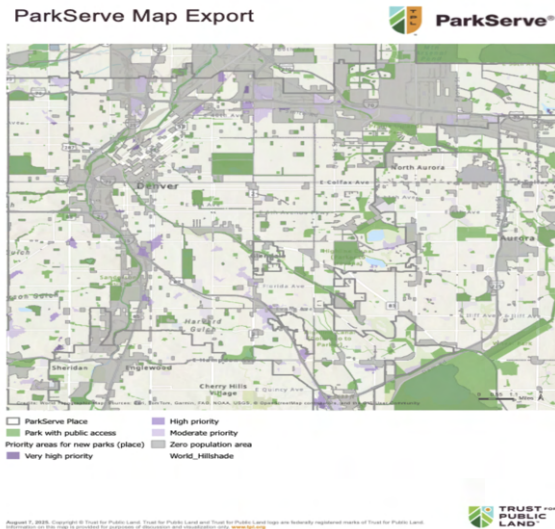


Figure 2. Map showing both the existing parks in Denver and the areas without access to greenspace.

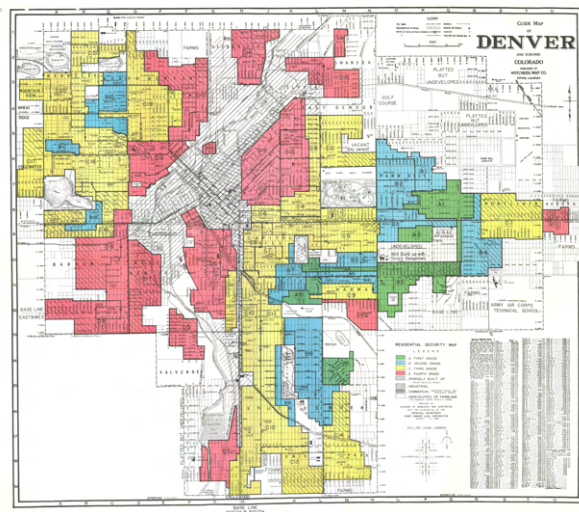


Figure 3. A Mapping Inequality map showing the areas that were historically racially redlined.

2 DENVER CASE STUDY

Urban green spaces are much more than neighborhood beautification projects, often serving as vital 3rd spaces for youths and older populations, offering areas for exercise and recreation, and increasing environmental resilience.¹¹ Yet, across U.S. cities, access to these urban amenities is often unequal, shaped by complex histories of racially discriminatory policies, economic disparities, and uneven development. The Denver Metro Region

(DMR), a rapidly growing and diversifying metroplex, primarily made up of the City and County of Denver (CCD), and Arapahoe, Jefferson, Adams, Douglas, and Broomfield counties, presents a compelling case to study these dynamics.

How are green spaces distributed in the DMR? How do factors such as race, socioeconomic status, age, historical context, and geographical location impact this distribution and access? This paper explores the social, historical, and geographic realities of DMR greenspace provision. Using academic sources and publicly available maps, including historical and contemporary maps related to greenspace provision and discriminatory housing policies, the paper identifies patterns of inequality, areas of policy success, and opportunities for improvement. Through this, it offers a nuanced review of how past and present policies across policy areas continue to affect greenspace access in the region.

3 METHODOLOGY

How are green spaces distributed in the DMR? How do factors such as race, socioeconomic status, age, historical context, and geographical location impact this distribution and access? This paper explores the social, historical, and geographic realities of DMR greenspace provision. Using academic sources and publicly available maps, including historical and contemporary maps related to greenspace provision and discriminatory housing policies, the paper identifies patterns of inequality, areas of policy success, and opportunities for improvement. Through this, it offers a nuanced review of how past and present policies across policy areas continue to affect greenspace access in the region.

Spatial data were sourced from the Trust for Public Lands' (TPL) ParkServe tool. Redlining information and maps were pulled from the University of Richmond's "Mapping Inequality" tool. Textual sources were collected from various peer-reviewed academic journals, informing the approach to spatial data and mapping resource collection. Finally, demographic data was gathered from the U.S. Census Bureau's 2020 census.

While the data used in this paper are pulled from various sources, the recency and reliability of each of the sources support the credibility of the findings. Data from the ParkServe database, created from the Environmental Systems Research Institute's (ESRI) software, highlight areas of need in the DMR, and demographic data of the people who live in those areas. Park amenity data and climate data were pulled from the Open Street Map and the EPA, respectively.¹² Further information on the origins of ParkServe data can be found on the TPL website. U.S. Census data used in this paper was from the 2020 census. Finally, the historical maps from "Mapping Inequality" were compiled in the summer of 2023 but span from different years. The CCD maps were

created in the 1930s by the Home Owners' Loan Corporation.¹³ Because of limited availability of zoning maps and early policy realities of other DMR municipalities, "Mapping Inequality" only featured a map of the cities of Boulder and Denver. This limits the ability to connect historical housing and zoning policies to greenspace access in suburban areas. Additionally, some areas with low population density were marked as high-priority areas on ParkServe. To ensure that areas with little to no population were not used as data for this paper, the "Population Density" and "Zero Population Zone" filters were used on all areas of high priority.



Figure 4. ParkServe map of Cherry Hills Village, Colorado. All non-highlighted areas have limited access to public green spaces, yet satellite imagery shows they are largely green and include a golf course and the High Line Canal Trail.

4 RESULTS

Based on maps from ParkServe and "Mapping Inequality," this section delves into the demographic, geographic, and accessibility trends for green spaces in the DMR. Through analysis of the CCD's ParkServe map, several of these trends became clear. The ParkServe tool has three base filters meant to highlight the overall quality of a given city's parks. These filters are "Park with Public Access," "10-Minute Walk Service Area," and "Priority Areas for New Parks." Together, these three filters provide a surface-level understanding of where parks are, how easily community members can access them, and where areas of growth are. On this surface level, the CCD appears to have been relatively successful at providing parks for the majority of its residents. According to the ParkServe tool, 96% of Denverites have a park within a 10-minute walk of their homes. Areas in southern and northern CCD tend to have the highest number of "priority areas," while areas in central, eastern, and western CCD tend to have the lowest need and highest access to parks. Importantly, these areas of high need are not always void of greenspace. As the TPL requires an area to "be located outdoors, be a named destination (e.g. not an unnamed median or drainage way), encourage informal public use (e.g., the

public is encouraged to walk through and stay awhile), and encourage at least one 'park-like' activity such as socializing, enjoying nature, or play/exercise," some green areas are not included in their analysis of DMR greenspace access. Some areas identified on the TPL map as having a need for greenspaces are private areas with plentiful greenspace. This includes areas near golf courses, private developments with large lots, etc. This trend of private greenspace is particularly present in suburban areas around the CCD. One example of these areas is Cherry Hills Village (Figure 4). On the ParkServe map, the suburb is marked as having a high need for greenspace. However, this is misleading because Cherry Hills Village, the area outlined in red, has ample greenspace, large lots, and generally has its greenspace needs met through private areas. The areas not highlighted in light green are areas marked as in need of green spaces. Through satellite mapping those areas are clearly green, and the town has a lot of large open greenspaces.¹²

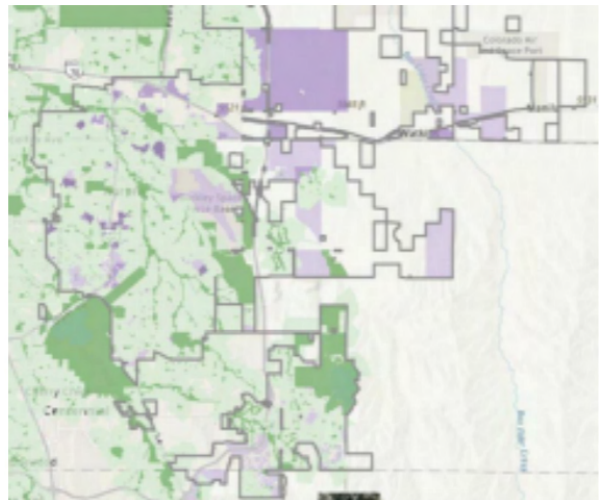


Figure 5. ParkServe map of greenspace access in Aurora, Colorado.

5 DISCUSSION

Through detailed analysis of the ParkServe map, it is clear greenspace in the Denver Metro Region is unequal. Members of minority and marginalized groups often live in the areas with the least access to public greenspaces. These findings suggest that, while the DMR has relatively good access to public green space, areas with high populations of racial and economic minorities tended to have the least access. This means these groups are likely to have less access to the physical, emotional, and social benefits associated with park access.

These trends largely align with those found in other studies of other cities. Rigolon et al. Found in their 2018 study that many U.S. cities face similar challenges when

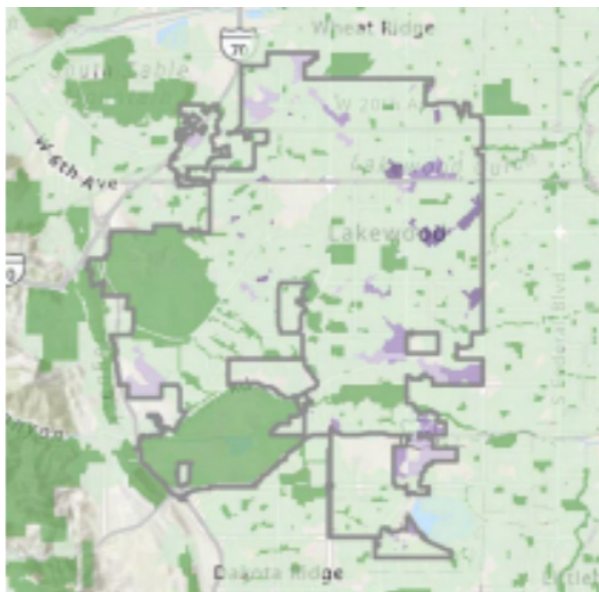


Figure 6. ParkServe map of greenspace access in Lakewood, Colorado.

it comes to greenspace provision. They cited changes in funding mechanisms as a main factor contributing to these trends.⁴ A case study of Miami found non-Hispanic White to be the group with the most access to greenspace. Moreover, they found that Hispanics, non-Hispanic Blacks, and Indigenous populations had the least access.² These trends are also not just contained to a U.S. context. In studies conducted in China and Brazil, researchers found patterns similar to those present in the ParkServe map. They found the peripheries of cities to have the most scarcity of public greenspaces. Within these areas, they also found that racial and ethnic minorities, low-income communities, and older populations commonly had the least access.^{1,6} Chen also found that urban greening practices and green gentrification were leading to vulnerable populations being pushed from their communities in favor of wealthier populations.

There are various possible roots for these issues. In the context of the City of Denver, one possible root is the city's history of discriminatory housing policy. As previously noted, redlining policies significantly affected minority communities in Denver. These policies often prevented marginalized groups living in redlined communities from accessing things like home loans and insurance, greatly reducing economic mobility for years to come. Studies have found connections between redlining policies and household income, poverty levels, incarceration rates, and even family structure.¹⁴ These effects reproduce harmful cycles in historically redlined communities. Because of these economic realities, many communities in these redlined areas are unable to move to greener, more environmentally resilient neighborhoods, which have already been established as whiter and wealthier. Another possible reason for these

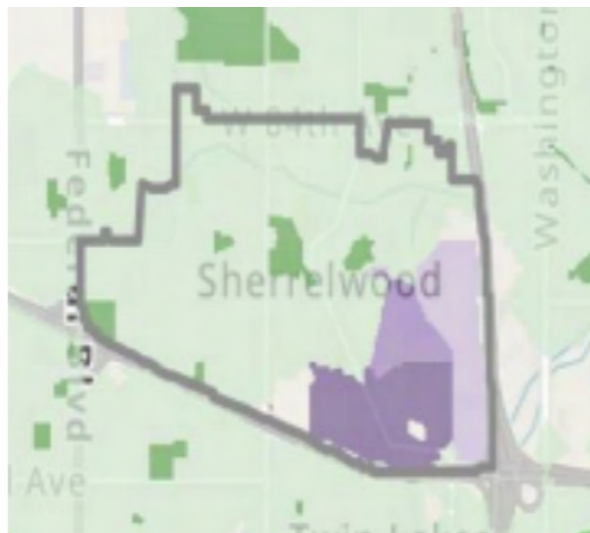


Figure 7. ParkServe map of greenspace access in Sherrelwood, Colorado.

trends are historical zoning laws, such as “Residence A” zoning. In Denver, this zoning term and others like it were intended to prevent smaller, cheaper housing from being built on the peripherals of parks. Exclusionary zones were established around many of Denver's largest parks in the 1940s. For example, much of the land around Washington Park and City Park, two large parks in CCD, was zoned with exclusionary subdivision policies, greatly limiting the type of housing that could be built in those areas.⁵

Outside of historical policies, various authors point to modern policy and incentive causes for unequal greenspace distribution. One modern cause is the approach officials take when determining where parks should be located. Many cities use standards-based approaches, which enact rigid benchmarks for greenspace provision and distribution. Often the rigidity of these standards prevents community-level nuances from being taken into account during the planning and construction of parks. Other approaches to greenspace provision take a needs-based approach. This helps to mitigate the negative effects of the standards-based approach by highlighting the different needs of each community. While this addresses the needs of individual communities, it can fail to recognize the competing and intersectional interests of community members.⁷ To minimize these effects, a community input approach may be implemented after the initial needs assessment. In the City of Englewood, Colorado, a parks bond was recently approved by voters. This bond not only featured community input for its initial passage, but also community meetings, city surveys, and other public participation measures. These measures are aimed at ensuring both equitable distribution of public funds, and that community needs are met.¹⁵ This project is

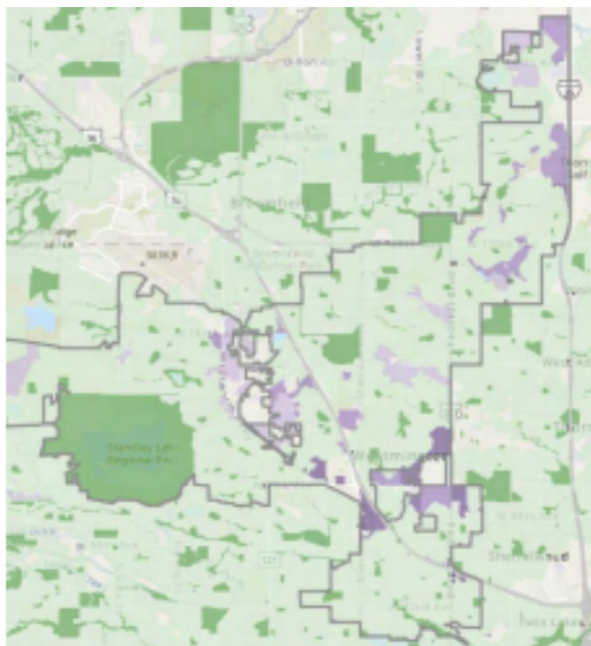


Figure 8. Parkserve map of greenspace access in Westminister, Colorado.

an example of a synthesis of a needs assessment and community-engaged approach to park planning and distribution. While this approach is largely more equitable, for communities with high numbers of low-income residents, community participation may not be as viable a solution.

6 CONCLUSION

Historical housing policies, as well as the approaches taken by cities when planning and funding greenspaces, have lasting impacts on the accessibility of said greenspaces for underrepresented communities. As found by a variety of other researchers in cities around the world, funding mechanisms and approaches to planning further gaps between various marginalized groups. In the DMR, racial and socio-economic factors played a significant role in one's access to greenspace. Additionally, geographic and age-based patterns of greenspace access held true in the CCD. Through analysis of maps highlighting areas that are lacking in greenspace and historically redlined areas, a connection became apparent. These divisions were furthered by the mechanisms governments used to determine where greenspaces were needed and the ways they funded them. In a broader sense, these findings show a clear trend of people of color and those of a low socio-economic status having less access to greenspaces, and therefore less access to the benefits they provide. These communities are less able to have essential third spaces and experience the social, mental, and physical benefits of greenspaces.

Through the implementation of social justice-based and community input-driven approaches, communities in the DMR and elsewhere may be able to better accommodate communities of color and low-income residents. In the future, more work can be done to determine the realities of these approaches and the overall access and utility of spaces planned using these methods.

7 LIMITATIONS

Given the large area of the DMR, a deeper analysis of the area's park distribution and equity may be needed. ParkServe, a helpful tool for understanding urban green spaces, is not perfect. As already acknowledged, ParkServe tends to highlight little or no population areas as in need of greenspace. It also does not take into account private green spaces and the accessibility of those areas. Both issues can be addressed using other park serve tools. On the map, there is a "Zero Population" filter that can be applied to account for those areas. The satellite view may be useful in determining when private green spaces may be located in high-priority areas, however more research is needed to determine the accessibility of these areas. Additionally, the mere presence of green space does not guarantee accessibility. Factors such as physical and mental disability accommodations and public access points can determine the actual accessibility of these areas. Additionally, park amenities are important to encourage use of public greenspaces. Often, these areas act as third spaces for community groups. Because of this, community-specific amenities should be installed in parks. An area of further study could be the actual use of parks, the presence of amenities in said parks, and the community's impressions of those amenities. Finally, "Mapping Inequality" as a limited selection of zoning maps. Many of the suburban areas around the CCD relied on covenants to establish building practices. While some covenants were located and discussed, further research into these documents is needed to understand their effects on marginalized communities as they relate to greenspace access.

8 ACKNOWLEDGEMENTS

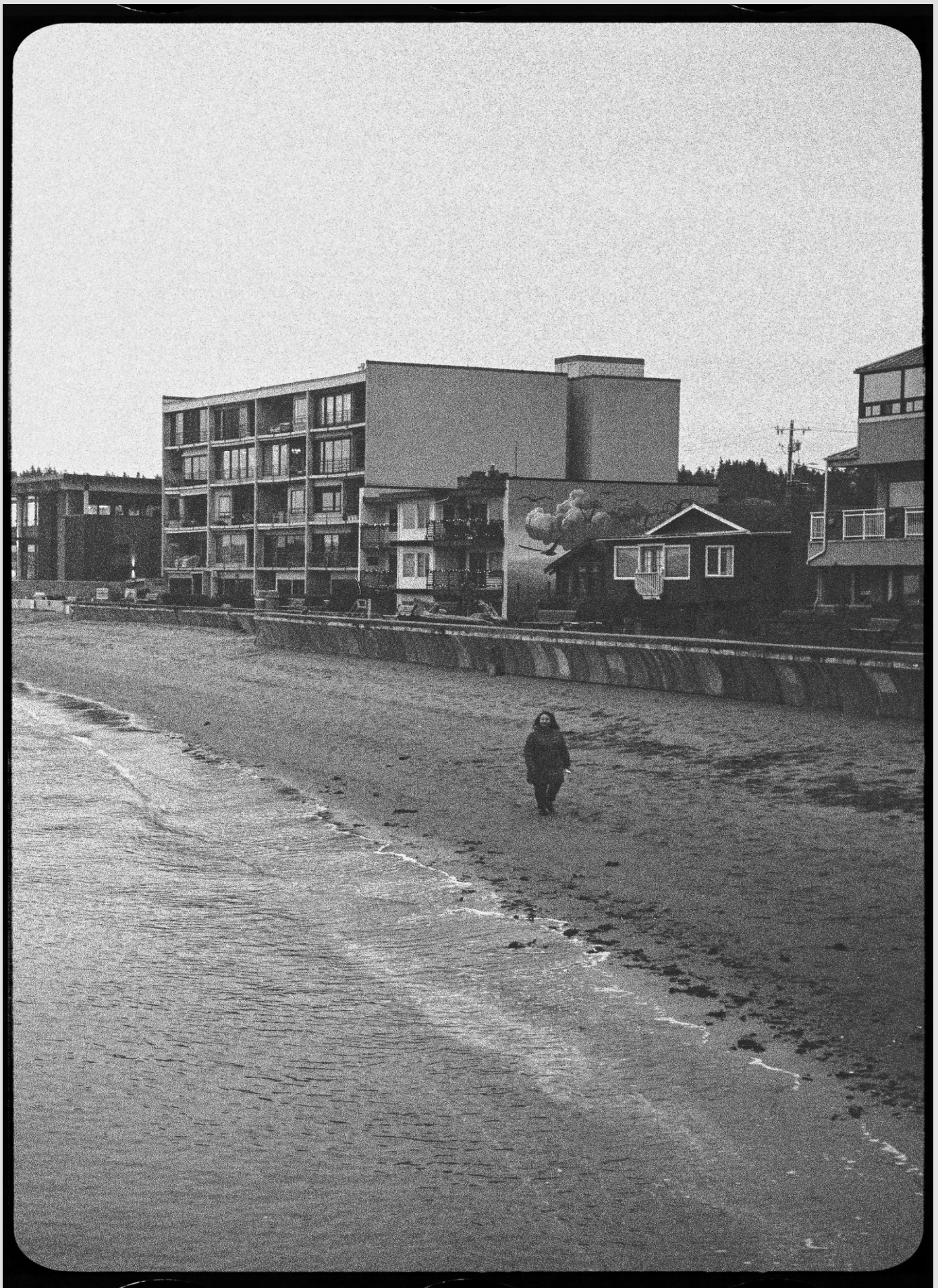
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9 EDITOR'S NOTES

This article was peer-reviewed.

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Alone by Aliyah Goldberg

Impact of eating disorder type on general population perceptions of stigma and likelihood of comorbidity

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Abstract

Eating disorders carry a significant risk of mortality, necessitating further research. Previous work has examined how stigma influences treatment seeking in other mental health conditions, creating a potential area for improving disordered eating outcomes. Additionally, prior meta-analyses have discovered high comorbidity of other mental health diagnoses with disordered eating. Some work has attempted to examine the perception of comorbid mental health problems alongside eating disorders, but this construct has not been studied in depth within general populations. To date, no work has simultaneously examined stigmatization and knowledge of common mental health problems with disordered eating in this population. This study sought to examine how stigmatizing attitudes and lay beliefs about comorbidity differ by eating disorder type in a general population. We displayed two vignettes, each depicting a college student with anorexia nervosa (AN) and bulimia nervosa (BN). We hypothesized that BN would be significantly more stigmatized than AN. However, AN was rated as significantly more stigmatized than BN. Participants then completed a self-report measure of stigma and rated the likelihood that each student had four mental health diagnoses. We hypothesized that perceived comorbidities would align with actual prevalence. This was true for anxiety and obsessive-compulsive disorder (OCD). Participants considered the AN student to be significantly more likely to have OCD, while they considered the BN student to be significantly more likely to have depression. No significant differences were found for anxiety or attention-deficit hyperactivity disorder (ADHD). This work demonstrated that significant between-disorder differences exist both in stigmatization and lay beliefs about comorbid diagnoses, providing an important initial insight into general population attitudes. Future studies examining how lay beliefs about disordered eating develop and interact with stigma are warranted.

Keywords: Disordered eating, anorexia nervosa, bulimia nervosa, stigma, perception, comorbidity, lay beliefs

1 INTRODUCTION

Eating disorders have consistently been associated with a significantly high rate of mortality, risk of long-term health issues, and impaired quality of life¹. Despite a wealth of research, chronic treatment resistance has remained high². Research of potential underlying mechanisms of resistance to seeking and completing treatment may be critical to future applied work addressing the treatment of eating disorders with greater long-term efficacy. One potential proposed factor influencing attitudes toward help-seeking across mental health diagnoses is the broader population's perception of people with a mental health diagnosis³. Thus, we aim to investigate a general population's perception of specific types of eating disorders and how accurately they perceive the prevalence of commonly co-existing (comorbid) mental health disorders in order to gain deeper

insight into these mechanisms of resistance.

Eating disorders encompass a spectrum of mental health disorders that broadly impact eating behaviors, exercise patterns, and body image. Two common eating disorders are anorexia nervosa (AN), defined by restriction of food intake, and bulimia nervosa (BN), defined by periods of consuming high amounts of food followed by behaviors intended to compensate for the high food intake (throwing up, laxative or other medication use, exercise). These disorders have high prevalence and are known commonly across the general adult population, making them a key target for research⁴.

In addition to high prevalence, eating disorders have also been found to have significantly high comorbidity with other mental health diagnoses⁴. Comorbidity may be associated with worse outcomes for people diagnosed with an eating disorder, making it a critical con-

sideration in future eating disorder research⁵. Several studies have examined the actual prevalence of anxiety, depression, obsessive compulsive disorder (OCD), and attention deficit hyperactivity disorder (ADHD), which are common comorbid diagnoses with AN and BN^{4,6,7}. While attitudes towards mental illness have been examined, how comorbidity, or multiple diagnoses, interact or predict changes in perception is less understood.

Stigma, defined as a negative social belief towards a person or group, has been widely discussed in relation to negative downstream effects on mental health through general population perception³. Stigma has also been theorized to impact treatment seeking and mental health outcomes⁸. Stigma has been explored specifically within the disordered eating domain, with findings showing negative attitudes towards individuals with eating disorders unique to each diagnosis⁹. Further work exploring stigmatization in disordered eating could be approached through understanding other contributing factors, including lay beliefs.

Researchers have previously examined the perception of eating disorders, but this work has primarily been about stigma only⁹. Additional work examining eating disorders has explored perception of what people with disordered eating and the general population consider the underlying problem of someone with an eating disorder to be, but this work did not examine comorbid diagnoses¹⁰. To date, no studies have examined both perceived stigma and comorbid diagnoses of eating disorder patients from the perspective of the general population. We thus sought to study both perceived stigma and public knowledge of eating disorder comorbidity across different types of eating disorders to better understand the general public's perception of disordered eating, extending prior work.

Understanding the general public's knowledge and perception of eating disorders has long-term potential for future scientific work and applied action within communities. If stigma and social perception do contribute to the desire to seek treatment or extension of support to people with eating disorders, as we theorize, understanding if there are between-disorder-type differences (AN versus BN) could help identify what the public does (and does not) know about eating disorders. This could have implications for broader education about eating disorders to the public, particularly if there is no congruence between what the research reflects on eating disorder comorbidity and what the general population believes. Education and outreach about eating disorders and mental health could then be developed and disseminated to improve knowledge and decrease stigma, which may also have a beneficial downstream impact on treatment-seeking and long-term health outcomes.

The present study is an online survey examining general public perceptions of stigma and likelihood of spe-

cific comorbid diagnoses (anxiety, depression, OCD, and ADHD) in reaction to two vignettes depicting fictional college students with anorexia nervosa and bulimia nervosa. We have five hypotheses about stigma and these four comorbid diagnoses. In line with prior results of studies examining differences between anorexia and bulimia, we hypothesize that I) there will be significantly more self-reported stigma in reaction to the vignette depicting someone with bulimia than the vignette depicting anorexia¹¹.

Based on prior work examining the actual prevalence of comorbidity across the four potential diagnoses that participants will be presented with, we hypothesize that public perception will align with actual comorbid prevalence in the following; II) people will perceive a diagnosis of anxiety as equally likely in AN and BN, III) people will perceive a diagnosis of depression as equally likely in AN and BN, IV) people will perceive a diagnosis of OCD as significantly more likely for the anorexia vignette condition, and V) people will perceive a diagnosis of ADHD as significantly more likely for the bulimia vignette condition.

2 METHODS AND MATERIALS

2.1 Overview

In the present study, we sought to examine how eating disorder type in a hypothetical vignette impacts stigmatizing attitudes and perception of the likelihood of another mental health diagnosis. We conducted a within-subjects experiment using randomized vignettes and self-report measures to assess our hypotheses.

2.2 IRB and Preregistration

This study was deemed exempt from Institutional Review Board oversight by the University of Denver Institutional Review Board prior to all study procedures. Planned procedures, original hypotheses, and analyses were preregistered in advance with AsPredicted¹².

2.3 Participants

An a priori power analysis indicated that a sample size of $n = 90$ would be necessary to achieve 80% power in each paired sample t-test¹³. As such, we aimed to collect data until a viable sample size of $n = 90$ was reached or until funding was depleted. We initially recruited a sample size of $n = 129$ participants via CloudResearch, an online crowdsourcing survey platform¹⁴. Participants were excluded if they did not consent to participate or use their data in our study, failed to pass the reCAPTCHA test, failed an attention or data validity test, or scored three standard deviations above the mean or higher on our disordered eating measure (see Mate-

rials). After applying our exclusion criteria, we had a final sample size of $n = 110$. Participants' ages ranged from 19-73 years old ($M = 41.5$, $SD = 12.3$). Participants predominantly identified as White ($n = 83$, 75.5%). However, a portion of participants also identified as Black ($n = 13$, 11.8%), Latino/a/x ($n = 8$, 7.3%), and Asian ($n = 8$, 7.3%). Participants also selected other/prefer not to say ($n = 2$, 2.2%). Participants identified as women ($n = 62$, 56.4%) and men ($n = 48$, 43.6%). Participants' annual household income was distributed across six categories: \$0-\$29,999 ($n = 17$, 15.5%), \$30,000-\$59,999 ($n = 31$, 28.2%), \$60,000-\$89,999 ($n = 19$, 17.3%), \$90,000-\$119,999 ($n = 11$, 10.0%), \$120,000+ ($n = 29$, 26.4%), and "Prefer not to say" ($n = 3$, 2.7%).

3 MATERIALS

3.1 Vignettes

In this study, we used an adapted version of the two vignettes used by Mond¹⁵. These vignettes describe one hypothetical female college student with symptoms of AN and one hypothetical female college student with symptoms of BN. We adapted the spelling of some words to reflect the American spelling used by our target population. We removed the final sentences which describe mental health symptoms not directly related to disordered eating (i.e., doing poorly in school, withdrawing from friends and family), and minimized usage of the word "bingeing" in the BN vignette to avoid revealing the eating disorder type. See Appendix A for the full text of each vignette condition.

3.2 Stigma

In order to measure stigma, we employed the 9-item Attribution Questionnaire (AQ-9);¹⁶ which measures stigma using nine domains (responsibility, pity, anger, dangerousness, fear, help, coercion, segregation, and avoidance), corresponding to one item per domain. This scale is a shortened version of the 27-item Attribution Questionnaire (AQ-27);¹⁷ which measures stigma using the same nine domains but with three items corresponding to each domain instead of one. Items are rated on a 9-point Likert scale. Responses to each item range from "Not at all" to "Very Much". We opted for the short form to reduce survey completion time and alleviate participant fatigue. Scores from each item are summed to create a composite score, with higher scores representing more stigma. Overall reliability for the AQ-9 is acceptable but not excellent ($\alpha = .65$).

3.3 Perceived Comorbid Diagnoses and Baseline Diagnoses

To achieve a baseline measurement of perceived mental health diagnoses uninfluenced by disordered eating pathology, participants were asked to rate the likelihood that an average 19 year old, female college student would be diagnosed with depression, anxiety, ADHD, and OCD on a 7-point Likert scale where 1 corresponded to "Extremely Unlikely" and 7 corresponded to "Extremely Likely". Participants completed the same four items for both the AN and BN conditions. Single-item mean scores were utilized for each diagnosis. Each item was novel and created for this study, and they have not been studied in other work to date.

3.4 Disordered Eating

As part of our exclusion criteria, we had participants complete a self-report scale to measure disordered eating. The Eating-Disorder Examination Questionnaire (EDE-Q-6);¹⁸ is a 28-item survey that utilizes a 7-point Likert scale to measure disordered eating behaviors of the past 28 days. The possible responses to each item range from 1 "No Days" to 7 "Everyday". This scale includes items about body image, eating behaviors, exercise behaviors, and purging behaviors. Due to incomplete responses on the final seven items, we had to exclude these from the composite score calculation. Mean scores from each item are averaged to create a composite score. The modified version we used indicated excellent reliability ($\alpha = 0.93$).

3.5 Procedure

Participants gave consent and passed a reCAPTCHA screening test. Failure to consent or successfully complete the reCAPTCHA screener would send the participant to the end of the survey, and they would not be permitted to participate. Participants rated how likely they believed a female, 19-year-old college student would be to have anxiety, depression, OCD, or ADHD (see Materials). Participants then read one vignette describing a fictional female college student displaying symptoms of either AN or BN. After reading the vignette, participants filled out the AQ-9 and the perceived comorbid diagnosis items, then repeated the process for the other vignette condition. The order in which participants read each vignette was randomized to protect against order effects. After completing both vignette conditions, participants filled out the EDE-Q-6, as well as demographic questions on their race, gender, age, and income. Pilot testing indicated that the average completion time was ten minutes or less.

3.6 Power

A sensitivity analysis was conducted ($\alpha = 0.05$, $1 - \beta = 0.80$). Results indicated the ability to detect a small effect size of $d = 0.24$. Therefore, we were adequately powered to detect our intended effect of $d = 0.30$.

4 RESULTS

4.1 Hypotheses

The following hypotheses were tested: I) that participants would stigmatize BN more than AN, II) that participants would not rate anxiety or III) depression as significantly more likely for BN or AN, IV) that participants would rate OCD as significantly more likely for AN, and (V[8.1][GN8.2][9.1]) that participants would rate ADHD as significantly more likely for BN.

4.2 Stigma

We conducted a paired samples t-test to evaluate whether there was a significant difference between stigma in each ED condition. AN ($M = 3.10$, $SD = 1.14$) was significantly more stigmatized than BN ($M = 2.95$, $SD = 1.09$), $t(109) = -2.75$, $p = .007$, $d = -.26$, 95% CI $[-.45, -.07]$ (Figure 1). Thus, our first hypothesis that there would be more stigma towards someone with bulimia nervosa was not supported.

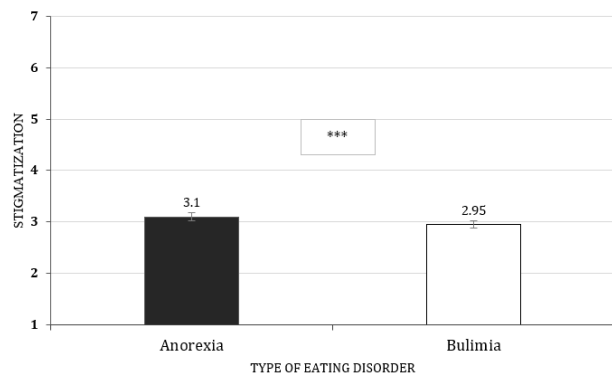


Figure 1. Note: This figure demonstrates the difference between ratings of stigma for AN and BN. This difference, on a seven-point Likert scale, indicates that they are significant at the level, $p < .001$.

4.3 Perceived Likelihood of Diagnoses

4.3.1 Anxiety

We conducted a repeated-measures analysis of variance (ANOVA) to evaluate the effect of condition (AN, BN, or baseline) on perceived likelihood of an anxiety diagnosis (Figure 2). Mauchly’s test indicated that the assumption of sphericity had been violated, $\chi^2(2) = 34.76$, $p < .001$; therefore, statistics will be reported

using the Huynh-Feldt correction. The effect of condition type on perceived likelihood of anxiety diagnosis was significant, $F(1.59, 173.00) = 25.55$, $p < .001$. Post-hoc pairwise comparisons (Least Significant Difference) were conducted to test where significant differences were present. There was no significant difference in perceived likelihood of an anxiety diagnosis between the AN and BN conditions ($p = .903$). However, perceived likelihood of an anxiety diagnosis was significantly higher in the AN condition ($M = 5.99$, $SE = 0.11$) than the baseline condition ($M = 5.35$, $SE = 0.10$), $p < .001$. Additionally, perceived likelihood of anxiety diagnosis was also significantly higher in the BN condition ($M = 5.98$, $SE = 0.10$) than the baseline condition ($M = 5.35$, $SE = 0.10$), $p < .001$.

4.3.2 Depression

We conducted a repeated-measures analysis of variance (ANOVA) to evaluate the effect of condition (AN, BN, or baseline) on perceived likelihood of a depression diagnosis (Figure 2). Mauchly’s test indicated that the assumption of sphericity had been violated, $\chi^2(2) = 32.38$, $p < .001$; therefore, statistics will be reported using the Huynh-Feldt correction. The effect of condition type on perceived likelihood of depression diagnosis was significant, $F(1.61, 175.30) = 42.66$, $p < .001$. Post-hoc pairwise comparisons (Least Significant Difference) were conducted to test where significant differences were present. Perceived likelihood of a depression diagnosis was significantly higher in the BN condition ($M = 5.69$, $SE = 0.12$) than the AN condition ($M = 5.51$, $SE = 0.13$), $p = .047$. Perceived likelihood of a depression diagnosis was significantly higher in the AN condition ($M = 5.51$, $SE = 0.13$) than the baseline condition ($M = 4.65$, $SE = 0.11$), $p < .001$. Additionally, perceived likelihood of a depression diagnosis was also significantly higher in the BN condition ($M = 5.69$, $SE = 0.12$) than the baseline condition ($M = 4.65$, $SE = 0.11$), $p < .001$.

4.3.3 ADHD

We conducted a repeated-measures analysis of variance (ANOVA) to evaluate the effect of condition (AN, BN, or baseline) on perceived likelihood of an ADHD diagnosis (Figure 2). Mauchly’s test indicated that the assumption of sphericity had been violated, $\chi^2(2) = 9.03$, $p = .011$; therefore, statistics will be reported using the Huynh-Feldt correction. The effect of condition type on perceived likelihood of ADHD diagnosis was not significant, $F(1.88, 205.15) = 2.41$, $p = .095$.

4.3.4 OCD

We conducted a repeated-measures analysis of variance (ANOVA) to evaluate the effect of condition (AN, BN, or baseline) on perceived likelihood of an OCD diagnosis (Figure 2). Mauchly’s test indicated that the assumption of sphericity had been violated, $\chi^2(2) = 12.51$, p

= .002; therefore, statistics will be reported using the Huynh-Feldt correction. The effect of condition type on perceived likelihood of an OCD diagnosis was significant, $F(1.83, 199.61) = 75.73, p < .001$. Post-hoc pairwise comparisons (Least Significant Difference) were conducted to test where significant differences were present. Perceived likelihood of an OCD diagnosis was also significantly higher in the AN condition ($M = 5.07, SE = 0.14$) than the BN condition ($M = 4.75, SE = 0.15$), $p = .007$. Perceived likelihood of an OCD diagnosis was also significantly higher in the AN condition ($M = 5.07, SE = 0.14$) than the baseline condition ($M = 3.39, SE = 0.13$), $p < .001$. Additionally, perceived likelihood of an OCD diagnosis was also significantly higher in the BN condition ($M = 4.75, SE = 0.15$) than the baseline condition ($M = 3.39, SE = 0.13$), $p < .001$.

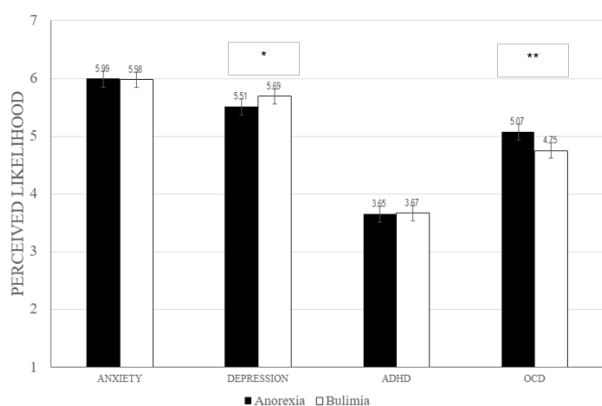


Figure 2. Note: This figure summarizes the perceived likelihood of the four commonly comorbid health disorders between AN and BN. These scores were calculated by subtracting BN by baseline and AN by baseline for each of the disorders. Significance levels are denoted as follows: * $p < .05$, ** $p < .01$, *** $p < .001$.

5 DISCUSSION

This study sought to explore the general population's stigmatizing beliefs and understanding of comorbidity with eating disorders, as well as examine whether these constructs were differentiated by type of eating disorder. We found significant disorder-type differences in stigma, with participants rating the AN condition higher on stigma compared to the BN condition. This contradicted our original hypothesis (I) that BN would be significantly more stigmatized than AN. Additionally, we found significant disorder-type differences in perceived likelihood of comorbidity for depression, with the BN condition perceived as more likely to have comorbid depression than the AN condition. This also contradicted our original hypothesis (III) that depression would not be rated significantly differently. We also found perceived likelihood of comorbidity was significantly different for OCD, with participants rating

the AN condition as more likely to have comorbid OCD than the BN condition. This did validate our original hypothesis (IV) that OCD would be rated as significantly more likely for the AN condition. However, the perceived likelihood of a comorbid anxiety or ADHD diagnosis was not significantly different in either eating disorder condition. This validated our hypothesis (II) that we would not find a significant difference for anxiety but did not validate our hypothesis (V) that ADHD would be significantly more likely for the BN condition.

While several of our analyses were significant, there are key limitations to the findings of this research. This study only examined anorexia nervosa and bulimia nervosa in its vignette conditions, and it is possible that the effect size or significance would change with different eating disorders or testing of all DSM-5-TR diagnoses. Additionally, we chose not to define each diagnosis for study participants to examine uninfluenced ratings, but providing these definitions may have changed or clarified comorbidity ratings for participants who are less familiar with psychiatric diagnostic criteria. It is possible that explaining the criteria or exactly what disorders we were referring to would have resulted in higher accuracy of diagnosis ratings. This study also solely examined knowledge of eating disorders through comorbidity with specific diagnoses, and it is possible that the general population has or does not have knowledge in other domains relating to eating disorders, such as symptoms or treatment, not reflected within this research. Additionally, we were unable to obtain complete data on the EDE-Q-6, which may have resulted in a higher number of excluded participants or failed to capture participants with relevant disordered eating. Critically, we also did not ask about personal or familial history of eating disorders, and it is possible that participants who themselves have had or know someone who has had an eating disorder would have less stigma or more accurate knowledge about comorbidity.

These results fill a critical gap in the literature surrounding general population attitudes and beliefs about eating disorders, helping to extend the broader literature on mental health stigma and lay beliefs about psychopathology from a general population previously not heavily used in the context of eating disorders. These results help to characterize the general population's stigmatizing attitudes and understanding of two specific eating disorders, which can provide a baseline metric for public knowledge and attitudes while simultaneously benchmarking where progress still remains in providing accurate mental health knowledge to the public. These findings demonstrated stigmatizing attitudes towards hypothetical people with eating disorders, as well as discrepancies between what the general public understands about eating disorder comorbidity and what is reflected within actual prevalence. This work also contradicted prior work that found higher stigma

associated with bulimia compared to anorexia, necessitating future work clarifying how eating-disorder type can differentiate stigmatizing attitudes^{10,11}. This could also mean that lay beliefs about comorbidity are not consistent and may be more heterogeneous across the population than previously expected.

Further qualitative work examining how the general population forms impressions and attitudes towards people with eating disorders, as well as how their lay beliefs surrounding comorbidity are developed, could be used to directly extend this work and further clarify our mixed findings on disorder-type differences. Further research examining stigmatizing attitudes across the full spectrum of eating disorders, as well as research examining knowledge of eating disorders beyond specific comorbidity, is warranted. Future research could also specifically explore if additional comorbid diagnoses impact the stigmatization of people with eating disorders. Additional research into the development and testing of specific eating disorder educational programs to examine if accurate education about eating disorders reduces stigma and raises the accuracy of eating disorder knowledge within the general population could yield beneficial results. Improving empirical understanding of general population mental health knowledge can yield critical findings for changing the long-term trajectory and treatment seeking of those suffering from eating disorders.

6 EDITOR'S NOTES

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Bumblebee Banquet by Ryuka Nagamine
Photo taken at the DU Bridge Community Garden

King of the jungle: comparative analysis of the geopolitical narratives surrounding Fordlandia and a proposed resort park in El Mirador

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Abstract

Environmental geopolitics is a field of study in which narratives about the environment are analyzed to reveal the underlying motivations and objectives they support. Using Shannon O’Lear’s¹ framework of environmental geopolitics, I conduct a comparative analysis of the narratives surrounding two distinct development projects: Henry Ford’s historical company town in the Brazilian Amazon, Fordlandia, and a proposed ecotourism resort park in El Mirador, Guatemala. Analysis of Fordlandia reveals a narrative of American frontierism and a man-versus-nature perspective that served to paint the environment as belligerent and thereby justify corporate control and Indigenous assimilation. In contrast, narratives surrounding El Mirador represent the environment as fragile and in need of protection. However, this representation fuels a similar conclusion to Henry Ford’s: that external control is necessary and that local communities are not capable of being stewards of their land. Ultimately, this comparison demonstrates how enduring geopolitical narratives—whether they frame the environment as antagonistic (Fordlandia) or fragile (El Mirador)—serve to undermine Indigenous sovereignty and land stewardship in favor of foreign capitalist development goals. These case studies reveal development as an inherently geopolitical process that tends to disregard the autonomy of marginalized populations.

Keywords: environment, El Mirador, Fordlandia, Indigenous sovereignty, geopolitics, conservation

1 INTRODUCTION

In the field of environmental geopolitics, scholars explore how certain actors advance desirable place-based^a outcomes through the geopolitical narratives they present to the public¹. Analyzing these narratives and how they support particular agendas helps develop a holistic view of the cultural, political, and environmental factors involved in geopolitical issues. O’Lear identifies three common themes in environmental geopolitics: claims tend to 1) present unclear arguments about what “the environment” refers to, 2) obscure human agency and power dynamics, and 3) employ selective spatial focuses that hide larger systemic problems¹. Critical analysis of environmental geopolitical narratives involves questioning the assumptions underlying claims or arguments made by different actors and determining how they relate to their potential motivations or objectives.

^a“Place-based” describes an approach where activities, policies, or projects are fundamentally centered on a specific geographic location and influenced by its community.

Using O’Lear’s¹ themes as entry points to examine geopolitical narratives of the past helps uncover a clearer picture of the intentions and consequences behind past political decisions. Historical geopolitical narratives can then be compared to current-day controversies in the geopolitical arena, helping to clarify important questions about the agendas of different parties and their methods for achieving them. O’Lear’s¹ theme of blurred or simplistic representations of “the environment” is the most useful lens for applying the environmental geopolitics framework to these case studies and will be the central focus of this paper. Comparing the past and present reveals how enduring geopolitical narratives about the environment influence capitalist development plans and affect marginalized groups such as Indigenous peoples and small local communities. This comparative geopolitical analysis of Fordlandia and the proposed development of a privately funded park in El Mirador highlights how development, as a geopolitical process in a globalizing world, tends to disregard Indigenous peoples’ autonomy and stewardship of their land based on differing perceptions of value or power

inherent in the environment.

2 METHODOLOGY

I conducted a literature review in which I first examined the geopolitical narratives surrounding each case study, focusing on O’Lear’s¹ first theme of environmental geopolitics: unclear, blurred, or biased representations of “the environment”. I then compared the case studies to explore how long-lasting narratives about “the environment” influence development plans and marginalized communities. I first gathered basic historical and contextual information about Henry Ford’s company town, Fordlandia. I searched for the prevailing geopolitical narratives surrounding the project by reviewing archived newspaper articles, historical media, and contemporary scholarly works to determine how the endeavor was framed by primarily U.S. American audiences. This analysis involved critically examining the messaging surrounding Fordlandia to understand how narratives about the project represented and defined “the environment”, specifically the Amazon rainforest. Because the literature from the time lacks Indigenous perspectives, in this step I sought to address questions such as: what or who did these narratives neglect to acknowledge, particularly regarding Indigenous populations, culture, and their stewardship of the land? How did the framing of Fordlandia as a battle against an “unconquerable” wilderness help further a corporate and colonial agenda?

I applied the same critical analysis to the modern controversy in El Mirador, Guatemala. This process involved gathering news, interviews, and articles from the perspectives of American archaeologist Dr. Richard Hansen and the Native communities living in the El Mirador basin to identify the current geopolitical narratives at play. I focused my investigation on how Hansen and his allies blur representations of the environment to their advantage, often overlooking the successful, existing local conservation efforts and the impact that their development plan could have on local communities. I concluded my analysis by comparing the historical narratives of Fordlandia with the contemporary narratives of El Mirador. This comparative analysis serves to investigate how portrayals of the environment have changed or remained consistent over time, and how these narratives have helped to advance desirable outcomes for powerful players in the geopolitical arena.

3 FORDLANDIA: GEOPOLITICAL NARRATIVES OF HENRY FORD’S COMPANY TOWN

In 1927, Henry Ford acquired a large plot of land in the Amazon rainforest on which he intended to grow a rubber plantation that would produce latex for vehi-

cle manufacturing—the only natural resource involved in Model T production that he did not yet control². The project involved building a town reminiscent of American cities in which Ford’s plantation employees would live and work². Ford attempted to transplant the American midwest, spending millions on two towns that boasted central squares, indoor plumbing, Cape Cod-style bungalows, manicured lawns, movie theaters, golf courses, and roads hosting Model T’s². These features were ill-placed in the Amazon rainforest, presenting long-term maintenance issues for Ford and causing both physical and cultural discomfort for Indigenous laborers. Indigenous people were not forced to work for Ford, but the alternative was leaving the land they had called home for generations. While living and working in Fordlandia, workers were required to assimilate into American culture, including participating in square dancing classes, complying with alcohol prohibition and a strict bell schedule, and eating unfamiliar foods like oatmeal and canned peaches³. The Fordlandia plantation eventually failed due to leaf blight, a disease caused by monocropping rubber trees, which drove the formation of a second plantation down the river known as Belterra⁴. Efforts to recover Fordlandia were hindered by worker rebellion as Indigenous employees grew frustrated with Ford’s attempts to control their lifestyles. Belterra was eventually overcome with blight as well, and in 1945, Ford sold both plots of land back to the Brazilian government for a mere \$250,000 compared to the \$20 million he had invested over the decades⁴. Ford’s attempt to control the Amazon and its people without regard for existing systems and practices eventually resulted in Fordlandia’s downfall.

Representations of the Amazon rainforest created not only by Ford but by popular media and Western^b culture at the time reveal the colonial implications of Fordlandia’s development and suggest that Fordlandia was more than just a business venture. As Grandin² writes, the creation of Fordlandia was “billed as a proxy fight” in which Ford represented the “vigor... that defined American capitalism” while the Amazon “embodied... an ancient world that had so far proved unconquerable”². News circulated about Ford’s ambitious mission, exciting the masses. A German newspaper wrote that this was the beginning of “a new and titanic fight between nature and modern man”². An author in the Washington Post hailed Ford for bringing “‘white man’s magic’ to the wilderness”^{2,c}. Geopolitical narra-

^bAnthropologist Kwame Anthony Appiah discusses the history of the term “Western” and why it is not an accurate descriptor in his opinion piece “There is no such thing as western civilisation”⁵. Despite the inaccuracy of the term, which can be understood as a euphemism for the white, Christian, developed world of European heritage, it is used in this paper as a familiar reference to the hegemony of the aforementioned culture on a global scale.

^cFor other mentions of Fordlandia in the news, see “Ford Efficiency Scores Triumph on Rubber Farm” (1935)⁶ and Dyer (1949)⁷.

tives represented the Amazon as being a sort of “final frontier” in need of conquering and settlement, and Ford was the white American hero who would finally manage to triumph over nature.

These themes were further enforced by a Walt Disney production titled *The Amazon Awakens*, made for the U.S. Coordinator of Inter-American Affairs and released in 1944. The Office of the U.S. Coordinator of Inter-American Affairs was an agency that sought to promote economic cooperation and “strengthen the bonds” between the Americas⁸. The film provides a synopsis of the settlement of the Amazon basin, including an introduction to Fordlandia. The geopolitical narratives of the Amazon as an environmental frontier and Ford as a brave pioneer are consistent messages throughout the film. At the beginning of the documentary, the narrator claims, “The river has rich reward for all who will come...and to all mankind, a new frontier”(2:20)⁹. While discussing the deforestation along the Tapajós River to make space for Fordlandia, the narrator comments that, “Sometimes the jungle giant will stubbornly resist the encroachment of man, but it’s a losing battle”, further contributing to the branding of Fordlandia’s creation as being a fight against nature (19:04)⁹. The film goes on to say that, “The jungle falls back to make way for a model community” and that it “does its share to fulfill human needs, (24:04)⁹. These messages imply that the Amazon is somehow antagonistic or corrupting due to its wildness and that it should be tamed and made to provide for its conquerors. Furthermore, the concept of a “model community” replacing the jungle and existing Indigenous settlements suggests that the native community does not fulfill the criteria of being good or civilized. In this way, the Indigenous inhabitants of the Amazon are wrapped up in the definition of “the environment” by the geopolitical narratives surrounding Fordlandia, which ignore their autonomy and promote the idea of a “civilized” alternative.

The narrative of American frontierism in *The Amazon Awakens* fails to acknowledge Indigenous communities that had settled and were living in the Amazon centuries before Fordlandia’s development. In this narrative, man must tame the wilderness and exert dominion over the new frontier—an example of man-versus-nature thinking that has persisted in Western culture for centuries as a result of early religious and philosophical thinking^{10,d}. Indigenous settlements, cultures, and lives either remain unacknowledged or are considered part of the Amazon environment and therefore intolerable. The legacy of Indigenous displacement as a result of colonization in the Americas exemplifies the

^dThe nature-culture divide has both classical and theological origins: Socrates’ writings discuss evolutionary theory and the idea that man is unique for his higher perceptive ability, and in Judeo-Christian theology, Genesis 1 commands humankind to exercise dominion over other living things¹⁰.

environmental geopolitical narratives that accompany the Western man-versus-nature cultural tension. Clear parallels can be drawn between Ford’s company town and the historical erasure of Indigenous peoples and Indigenous biocentric^e worldviews in places like the Amazon. From the perspective of Western hegemonic culture, Indigenous people were not entitled to land that they had not tried to conquer or control in some way. Indigenous peoples value land differently, often considering nature and the environment equal in power to human society. Considering the implementation of man-versus-nature thinking in colonial histories, the discourse surrounding Fordlandia’s creation in the untamable jungle was inherently geopolitical. It further suggests that Ford intended not only to industrialize the Amazon but to colonize it as well.

Other scholars have also studied the colonial implications of the Fordlandia project. Rochat discusses Fordlandia as an example of primitive accumulation⁶ and colonial capitalism, which he claims took form through “indigenous land dispossession and exploitation of the earth”³. Bousfield interprets Fordlandia as a case study of how automation and a lack of human-nature integration are connected to the limitations of the settler colonial project^{11,f}. Both evaluations support the conclusion that Ford’s “settler fantasies of progress” drove his attempt to impose reason and control on the Amazonian jungle¹¹. Ford viewed his methods as superior simply because they were modern, American, “civilized” methods. He did not acknowledge the role that the nonhuman, vegetal world would play in his goals for Fordlandia. His monoculture plantation ignored the ecology of the rubber trees he intended to grow, leaving them susceptible to blight. He also did not acknowledge the Indigenous community’s existing way of life, choosing to forcefully assimilate them into his culture rather than respecting or learning from them. His efforts to save Fordlandia were hindered by employee rebellion as a result.

Ford prioritized an idealistic vision of transforming the untamable rainforest through his controlled system of rubber production. He relied on public support for scientific progress and the misplaced belief in the superiority of his methods to fuel his endeavor, rather than on an understanding of the Amazonian land or its people. Western assumptions of value, power, and sovereignty underlay Ford’s failure to consider the role of the natural world in determining how the human-

^eBiocentric worldviews acknowledge the intrinsic value of all life forms, in contrast to anthropocentric worldviews, which posit that human beings possess greater inherent value and that only human interests matter.

^f“Settler colonialism” refers to a form of colonialism in which settlers claim territory, displacing its original inhabitants, and establish a society to replace that which existed prior. See Schuessler (2024)¹² for a discussion of the use of this term in high-visibility modern geopolitical issues.

built environment would interface with the Amazonian environment. Told from another perspective, the story of Fordlandia's downfall is one of environmental and Indigenous resistance to settler and corporate colonialism, displacement, and erasure.

4 EL MIRADOR: A PROPOSED RESORT PARK IN THE MAYA JUNGLE

The Maya Biosphere Reserve, located in El Petén, Guatemala, is a UNESCO-recognized biosphere reserve representing one of the largest tropical forest sites north of the Amazon (UNESCO, 2024). The reserve is part of a larger forest system known as the Selva Maya and hosts an ancient Maya settlement called El Mirador. Dr. Richard Hansen, an American archaeologist who has dedicated decades of his career to studying El Mirador, has suggested that this site—rather than more well-known destinations such as Tikal—was the cradle of Maya civilization, giving it great cultural and historical significance¹³. Hundreds of Maya structures have been discovered in and around El Mirador, including pyramids and even ancient highways¹³. Hansen's plan to preserve the area has generated massive controversy in recent years: he aims to use U.S. government funding to acquire the land and develop a privately managed ecotourism resort park in El Mirador, complete with hotels, restaurants, guided tours, and even a light rail through the jungle¹⁴. Native communities are disillusioned by Hansen's proposal, claiming it is an imperialist vision that would strip them of control of their land and undo the benefits of local conservation programs. Jeff Abbott, an author for the North American Congress on Latin America, suggests that the controversy surrounding El Mirador is "the latest front in a battle between top-down and bottom-up models of development" for the region¹⁴. As with any land development program proposed for on Indigenous territories, discussions surrounding the park are characterized by charged geopolitical narratives directed related that relate directly to the environment.

4.1 Dr. Richard Hansen's Perspective

Hansen has repeatedly insisted that his only goal is to protect and preserve the Mirador Basin, framing the environment as precious and fragile in his claims. He believes the area is at risk of destruction by organized crime groups that have entered the reserve to participate in illegal economies such as logging, poaching, and drug trafficking; he feels that the proposed park will offer better regulation and protection from these intruders¹³.

When asked about his intentions, Hansen said: "I am not leading any imperialist invasion... We are simply trying to suggest that there is a viable, superior eco-

nomic alternative for the impoverished communities [in El Mirador] through controlled, restricted ecotourism, as opposed to... poaching, looting, logging, oil drilling, and money laundering by corrupt forces that do not want the conservation and protection of this area"¹³.

Hansen has also said that he does not support big capital investment in El Mirador because it would interfere with archaeological studies and harm the jungle through the construction of highways, airports, and recreation areas¹⁵. Instead, he proposes that a light rail would limit environmental impact while providing tourists with access to the basin in order to fund research and conservation¹⁵. Despite this claim, Hansen's vision for hotel and museum construction constitutes a large infrastructure investment in El Mirador which implies negative environmental consequences for the Selva Maya. Hansen further supported his argument that he aims to conserve the jungle by sharing his research findings about the collapse of El Mirador, which he believes was caused by an abuse of natural resources. His research suggests that extensive burning of wood to create quicklime, a status symbol in Maya society, led to soil erosion and contamination, creating the conditions for drought and famine¹³. Hansen claims "they stopped thinking about the future and the fatal consequences of environmental abuse" and "[he] finds it curious that... the same mentality and attitudes continue to the present day"¹³. This research finding provides Hansen with both professional and emotional credibility when he claims that his sole objective is the environmental conservation of the Mirador Basin. However, Hansen has also called El Mirador a "real live Disneyland", expressing, "We don't have to invent anything. It's all here. Animals, crocodiles, tapirs, jaguars, ruins, jungle, macaws, parrots, toucans, it's all here!"¹⁶. Referring to El Mirador as "Disneyland" indicates a desire to capitalize on the tourism value of the Selva Maya. Hansen presents opposing representations of the environment with inconsistent claims about his desire to protect its fragility versus claims of its potential economic value as a tourism destination.

To obtain the funds for his proposed park, Hansen authored a bill that was introduced to the United States Senate titled the "Mirador-Calakmul Basin Maya Security and Conservation Partnership Act of 2019". Sponsored by Sen. James Inhofe [R-OK], the bill would have "[authorized] the Secretary of the Interior to establish a Maya Security and Conservation Partnership Program" and "[authorized] appropriations for that program" had it passed¹⁷. Appropriations would have consisted of USD 12,000,000 for each of the fiscal years 2021 through 2026¹⁷. In the bill, the Congressional findings acknowledge that the Mirador Basin is a "reservoir of genetic diversity that can spark... advances in medical, agricultural, and industrial technology", representing the environment primarily as an economic and scien-

tific resource rather than inherently valuable¹⁷. The bill was proposed right before land concessions contracts in Guatemala, which are renewed every twenty-five years, were to be reviewed by the Guatemalan government¹⁴. Concession renewal offered Hansen the best opportunity to make his plan a reality as his proposed park overlapped with several areas that would be up for renewal in 2023¹⁴. The bill did not pass, meaning Hansen has not yet secured government funding for public or private entities to finance infrastructure projects in El Mirador.

Despite many opposing voices, such as a protest at the L.A. Book Festival in 2023, Hansen plans to continue trying to create a sustainable sanctuary in El Mirador through his development proposals. Some who support his cause, such as Neshá Xuncax, secretary of Maya Visión, suggest that there is a disinformation campaign against Hansen that has attempted to discredit him as an imperial intruder with hidden financial motivations¹⁵. He has even received death threats¹⁵. Hansen and Xuncax both consider that such a campaign may be in the interest of corrupt organizations that aim to prevent further protection in the area so they may continue illegally poaching or logging¹³. The complex range of interests in the area creates ripe opportunity for conflicting representations of the environment. Hansen employs varying narratives about his development plan, framing the Selva Maya as both fragile and resilient, as well as both useful and dangerous to exploit. The representation he uses often depends on his audience.

Finally, Hansen's opinion of the Guatemalans who oppose his plan is useful contextual information when considering geopolitical narratives involved in the situation. He has repeatedly suggested that resistance to the proposed park is "largely because Guatemalans are not familiar with the type of development he plans"¹⁶. In an interview with VICE News, Hansen expressed his frustration with the sentiment that he is an "imperialist gringo" and "wants to get rich"¹⁴. He went on to imitate a gesture of smoking marijuana while saying "These people are so... They don't see the way. That's one of my criticisms of the Guatemalans, there's no vision"¹⁴. Through statements like these, Hansen characterizes residents of El Mirador as careless and opposed to taking any action, which perpetuates a harmful colonial stereotype that Indigenous people are "primitive" or oppose development⁸.

⁸Hansen's comment about Guatemalans' "lack of vision" for their land is reflective of deeply rooted, harmful stereotypes about Indigenous peoples that can be traced back to colonial ideology about "lazy Indians". The "lazy Indian" myth and other stereotypes that suggest native peoples are maladjusted to modern times likely inform Hansen's biased perspective about native communities' inability to be stewards of their own land. By portraying Indigenous peoples as inherently lazy, myths like these justify colonial intervention as being necessary for progress.

4.2 Through Local's Eyes

Most of the opposition to Hansen's planned resort park is from local residents of the area. They feel that Hansen's project will replace successful community conservation efforts with an industrial tourism model that will harm their livelihoods and the environment¹⁸. Local land management programs, including the community forestry model run by the Association of Forest Communities of Petén (ACOFOP), already meet environmental goals and generate economic benefits¹⁹. Under this model, local Maya and mestizo communities live in the reserve and sustainably produce and harvest timber, latex, allspice, nuts, and an ornamental palm called xate¹⁹. Communities also successfully protect their land from fire and outsiders through patrols trained in drone use²⁰. Several studies demonstrate that Indigenous-managed land shows lower rates of deforestation and that there have even been net gains^h in forest cover within the eastern Maya Biosphere Reserve^{19, 16}. Even without government or financial incentives, Native peoples have historically protected their environments because they rely on them. Communities in the Mirador Basin are no different, and science confirms the efficacy of their management. Furthermore, large-scale tourism, even if it is intended to be controlled and managed sustainably, will increase the demand for natural resources in the area and inevitably cause harm to the environment through disturbance. Local communities worry that Hansen's plan will harm the Selva Maya rather than protect it.

Beyond environmental concerns, locals also argue that Hansen's plan will develop El Mirador, but will leave them behind in the process. If protected areas become privatized instead, Indigenous communities will lose access to the forest, which they rely on for the sustainable harvesting of wood, latex, xate, and other products for their livelihoods^{19, 18}. Iyaxel Cojtí Ren, a Maya K'iche' archeologist, expresses the concern of local communities: "...they will be excluded and become employees of the planned tourism enterprise; they would no longer be protagonists in the [Mirador Basin]"¹⁹. Hansen's project would dominate the economy and locals would be left with only two choices—work as employees at Hansen's resort park or search out new opportunities away from their home. Local communities feel as though they have no say in the process as Hansen did not fulfill his Free, Prior, and Informed Consentⁱ obligation of consulting with Indigenous peoples about any projects that would impact their land¹⁹. From an Indigenous perspective, the environment of El Mirador

^hSee CONAP & WCS, 2018²¹.

ⁱFree, Prior, and Informed Consent (FPIC) refers to the legal framework which requires the consent on Indigenous communities before any project which will affect their territory is approved. The right to consultation is protected in the UN Declaration on the Rights of Indigenous Peoples, which Guatemala has signed²².

represents their livelihood and ancestral heritage, both of which they fear losing if Hansen's proposal comes to pass.

5 CONCLUSION: PARALLELS BETWEEN FORDLANDIA AND HANSEN'S EL MIRADOR

Examining the geopolitical narratives surrounding Fordlandia's development compared to Hansen's proposed resort park in El Mirador produces what seems like opposite results at first. Fordlandia was an attempt to tame the wilderness and control nature via development in the Amazon rainforest, while Hansen seemingly wants to develop El Mirador in order to protect nature. Narratives surrounding Fordlandia represented the environment as belligerent and a powerful enemy, while most narratives surrounding El Mirador represent the environment as fragile and unprotected. However, the underlying assumption of these conflicting conclusions is quite similar: in both situations, geopolitical narratives do not afford the environment or the people living there the right or the autonomy to protect their way of living.

Given the theme of "civilizing" the forest and its inhabitants, Fordlandia can be safely described as a colonial project. On the other hand, Hansen refutes any accusations of imperialism or colonial intentions, despite a number of comments that allude to his disrespectful views of Guatemalan people and excitement about a tourism industry. While he insists that his intentions are misrepresented, seeking U.S. government funding to control the land and introduce foreign influence is suggestive of a possible colonial threat, owing to the potential for displacement of local communities. From the perspective of local communities themselves, Hansen is providing them with the same two choices the Indigenous people in Fordlandia were offered: work for him, or leave. Indigenous communities are disconnected from their territory and forced to comply with a foreigner's vision for development on their land, losing power in the process as their already successful land management strategies are threatened.

The comparative analysis of geopolitical narratives surrounding Fordlandia and Hansen's proposed project in El Mirador highlights the idea that development is an inherently geopolitical process, especially in a globalizing world where foreign actors may benefit economically from subtly controlling territories that do not belong to them. Too often, Indigenous people's sovereignty and rights to their land are not recognized; instead, they are considered part of the environment that needs to be developed or changed to align with foreign, often Western, concepts of efficiency and value. Indigenous and local communities must have the right to manage their lands and homes on their own terms,

free from the imposition of Western ideals that do not align with their ways of life.

Future research could expand upon the parallels between Fordlandia and the proposed El Mirador park by applying other elements of O'Lear's¹ environmental geopolitics framework. Specifically, the influence of human agency, power dynamics, and selective spatial focus in the discourse surrounding these developments warrants further analysis. Alternatively, comparisons with other historical and contemporary South and Central American examples could reveal additional evidence of how narratives about the environment play into geopolitical issues in the region. A broader-scope analysis is also possible, examining global narratives about nature and the environment to investigate how they contribute to the marginalization of specific populations. This sweeping comparison could involve case studies from North America, South America, South Asia, and other worldwide locations.

6 EDITOR'S NOTES

This article was peer-reviewed.

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Me as a Baby by Brynn Hassan
Acrylic on Canvas



Mothers on the ballot: gender and partisan dynamics in the evaluation of maternal political candidates

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Abstract

While scholarly research on the interaction between gender and political candidacy has grown in recent years, there is limited research on the way mothers are perceived in politics when they choose to run for office. The goal of this paper is to answer the following research question: How do partisanship and gender influence the public perception of mothers running for political office? The following question attempts to provide more insight into the underlying drivers of these perceptions: To what extent does social desirability shape these attitudes? Using a list experiment, this paper surveyed individuals in the United States to capture their beliefs toward mothers running for political office. It also examined survey participants' attitudes toward mothers running for public office, focusing on the candidate's party affiliation (Republican or Democratic) and level of office (federal or local). Furthermore, this study analyzed how the survey respondents' party affiliation and gender affected their perspective on mothers running for office. The findings revealed that, without the social desirability bias, almost one-third of participants reported feeling angry or upset toward mothers running for office. However, a much smaller number of participants revealed such feelings when asked directly. This finding suggested potential bias against mothers pursuing political careers and highlights the limitations of surveys in capturing accurate attitudes.

Keywords: mothers in politics, social desirability bias, list experiment, gender stereotypes, partisan perceptions, voter bias

1 INTRODUCTION

In early 2025, an image quickly gained public attention: Elon Musk, appointed co-leader of the U.S. Department of Government Efficiency (DOGE), carrying his son on his shoulders while in a meeting with President Donald Trump in the Oval Office, blending paternal imagery with political authority. CNN described this moment as "humanizing" because it allowed the public to learn more about his private life¹. As a man holding a high-level political office in the U.S., he received very little pushback for showcasing his fatherhood. Instead, he was praised for being a father as well as a leader. In addition, the public responded positively to former President Barack Obama's journey as a father and as president. Obama would consistently discuss the important role of fathers, and people would engage with and respond to his remarks². The public celebration of men as political figures and fathers stands in contrast to the challenges faced by mothers in politics.

When women in politics showcase their motherhood, they are oftentimes criticized for attempting to balance

leadership and caregiving. For example, Anna Paulina Luna, U.S. representative for Florida's 13th Congressional District, received backlash when she advocated for proxy voting accommodations for new parents in Congress. Marjorie Taylor Greene, former U.S. Representative, said, "Being in Congress is a privilege. You don't have to be here, and there are plenty of people in her district that could serve in Congress if she chose time to be home and be a mother"³. This expresses the sentiment that mothers should give up their congressional jobs to stay home and take care of their children. Beyond this example, mothers in political spaces are frequently questioned about their qualifications, priorities, and overall ability to do the work that holding public office requires. There is a double standard that exists for who is able to hold public office. This double standard comes from the long history of biases that people have exerted on women and mothers. Fatherhood enhances the image of male politicians, establishing caring public persona. In contrast, motherhood can complicate the perception of female politicians because voters may question whether family responsibilities will interfere

with their ability to fulfill the demands of public office.

This paper examined the beliefs of the public toward mothers running for political office to develop a clearer understanding of what the public perceptions look like. In the literature review, the paper discussed the gender effect in terms of gender stereotypes, voter perceptions, gender socialization, and political ambition. The analysis of gender and partisanship treated both variables as equally important, focusing on both their individual and combined effects on public perceptions. The term gender effect refers to the influence that gender stereotypes have on how voters perceive political candidates. Furthermore, the premise of the gender effect is the extent to which female candidates are judged more harshly than their male counterparts. The paper also explored the partisanship effect along with identity politics, party values, conservative traditions, gender roles, the Democratic Party, and inclusivity. In this case, the partisanship effect refers to the influence that being a Democrat or a Republican has on an individual and how this may change their views toward mothers holding political office. Moreover, this study also considers the concept of gendered offices and gender norms through local offices and election dynamics.

The findings revealed that, without the social desirability bias, almost one-third of participants demonstrated feeling angry or upset toward mothers running for office. However, a much smaller number of participants revealed such feelings when asked directly. Not only does this provide insight into the gender biases, but it also shows the willingness of people to hide their true opinions in public discourse.

2 LITERATURE REVIEW

2.1 The Gender Effect

2.1.1 Gender Stereotypes and Voter Perceptions

Masculinity is the hegemonic gender role. Okimoto⁴ asserted that, "Power and power seeking, in particular, are central to the constructs of agency and masculinity. Thus, these gender stereotypes make women appear less suited to powerful roles, as they are assumed to lack agency required for leadership"⁴. The idea of power is the focal point of politics, so when a candidate does not fit within the power-seeking description, it is less likely that the public will support them. Since this trait is at the center of masculinity, it is difficult for women to acquire these characteristics.

Huddy and Terkildsen⁵ discussed the impact of the public's perceptions of candidates' gender on candidate electability. The paper highlighted that voters interpreted female candidates to have traits such as warmth and expressivity and male candidates to have traits of competency and rationality. The traits that voters assign to candidates based on their ideas about gender are very

likely to impact the issues that they believe the candidates can solve. In addition, these beliefs are connected to partisanship, as traits stereotypically associated with women, such as compassion, are often perceived as aligning more closely with liberal and democratic identities. However, this phenomena extends beyond the traits voters think candidates have based on their gender. For example, a study conducted in 1993 showed how the Democratic Party has been more adept at dealing with domestic and social welfare issues, while the GOP has been more willing to handle inflation and economic issues. This illustrates how the Democratic Party is more accepting of female candidates as they embrace the traits that are typically associated with females. These ideas ultimately impact the type of offices and platforms that female politicians are perceived as qualified to pursue across parties.

2.1.2 Gender Socialization and Political Ambition

While the public perception of candidates is highly important, especially in a democratic electoral system, the perceptions that men and women have about themselves when running for office also impact their political outcomes. Gender socialization is a lifelong process that teaches individuals to behave in ways that align with their gender. Coffé⁶ explained that "This socialization may contribute to women's lower levels of political engagement with differences in political attitudes and participation beginning early in life and continuing over the life course"⁶. Political outcomes are not only influenced by how the public views candidates, but also how the candidates view themselves. Lawless and Fox⁷ wrote that women are underrepresented in politics because they are less likely to consider running for office, less likely to run for office, less likely to believe they are qualified for office, less likely to be encouraged by others to run for office, and more likely to view the political world as competitive and biased. Socially constructed gender norms, such as expectations that women should be nurturing and risk-averse, have shaped how women are evaluated and how they evaluate themselves. These norms persist in modern-day politics, where they not only discourage women from viewing themselves as qualified candidates but also shape how voters assess female candidates.

Political ambition is a personal trait that is affected by the process of gender socialization and is often reflected in an individual's willingness to seek elected office. Bledsoe⁸ discussed the paradox that exists between ambitious men and women. Among men, those who are ambitious are high-achieving and more likely to run for office, pursue more competitive races, and seek advancement to higher-level positions than men who are not as ambitious. On the other hand, ambitious women are not more likely to seek higher office, and in some cases are even less likely to do so than women

with lower levels of ambition. This counterintuitive pattern reflects a gendered paradox in political ambition. One explanation for this occurrence is that “Women may be socialized to disavow ambition because ambitious women are seen as ‘pushy’ even though this trait may be admired in males. Hence, women deny that pursuit of elected office is to further their careers and claim they desire only to serve the community”⁸. Consistent with this, Lawless and Fox⁷ found that men were almost twice as likely as women to have thought about running for office multiple times. Together, this suggests that women’s political ambition is inhibited by structural, cultural, and sociological barriers that not only discourage them but also shape how their ambition is expressed and acted upon.

2.2 The Partisanship Effect

2.2.1 Identity Politics and Party Values

The perceptions of women’s participation in politics are also impacted by the partisanship factor. In this paper, the partisanship factor refers to the way that a candidate’s alignment with a certain political party impacts public perception of the candidate. The two major political parties in the U.S., the Republicans and Democrats, have their own values and beliefs that influence perceptions of women within their own party lines. Shutt⁹ explained how a party’s willingness to engage in identity politics is an important factor that provides insight into how the party operates on an internal level. In this case, identity politics refers to the party’s adoption of specific gender ideologies. By analyzing the ways that the political parties choose to interact with gender-related identity politics, their values can be better perceived. To begin with, the Republican Party is one of conserving its customs. Republicans’ traditionalism extends into the issues they vote on and into the way they structure their party. The GOP uses identity politics to unite around its conservative ideals. For example, as of November 2024, data showed that almost half of Republican men and almost 40% of Republican women believe that women should return to their traditional roles in society¹⁰. Despite the GOP’s recent diversification of its constituent base, its identity politics have, for the most part, connected mainly to white identity politics and religion. During the 2018, 2020, and 2022 elections, there was a clear group of voters for the Republican Party: white evangelical protestants. Hartig¹¹ illustrated the following numbers for white evangelical Protestants who voted for Republican candidates in the 2018, 2020, and 2022 elections: 81%, 83%, and 86%, respectively.

2.2.2 Conservative Tradition and Gender Roles

Bjork-James¹² argued that “the main theological emphasis in post-civil rights era white evangelicalism is on the supremacy of the heterosexual, male-headed nuclear family”¹². This framework was reinforced by famous singer and entertainer Anita Bryant’s anti-LGBTQ activism in the 1970s, and has contributed to a robust historical connection between evangelical values and the modern Republican Party¹³. These values promote traditional gender roles that position men as leaders and women as primary caregivers at home. As a result, women who pursue political office may face both cultural and ideological barriers within these communities because their candidacy can be seen as conflicting with expectations of family-centered and subordinate roles. Religiously-rooted norms continue to shape voter perceptions and women’s political ambition in modern-day Republican politics.

Although these norms may discourage women from pursuing political office, they do not prevent women from running or holding positions within the Republican Party. For example, prominent figures such as Nikki Haley and Sarah Palin exhibit that women can and do succeed in conservative politics. However, their experiences do not negate the broader cultural expectations that shape women’s roles within these communities.

2.2.3 The Democratic Party, Inclusivity, and Intersectionality

On the other hand, the Democratic Party is generally associated with support for structural policy reforms. For example, a study conducted in 2023 showed that over 80% of Democrats supported the idea of changing the American electoral system, compared to only 47% of Republicans (Pew Research Center 2023). An example of these changes includes how eight in ten Democrats think the U.S. should replace the Electoral College with a popular vote system, compared to only 46% of Republicans¹⁴.

Unlike the conservative values that are present in the GOP, the liberal values in the Democratic Party tend to emphasize inclusivity. In this context, intersectionality refers to how overlapping identities, such as race and gender, shape individuals’ political experiences and preferences. The effect of intersectionality within the Democratic Party is much more pronounced than within the GOP. For example, Kim and Junn¹⁵ mentioned, “Thus, overwhelming support for candidates of the Democratic Party among women of color should be understood as their collective expressions to fight against racial and gender inequality in the US”¹⁵. Along the same lines, Barnes¹⁶ noted that, “The Democratic Party is known as a coalition party with many diverse internal constituencies, whereas Republicans are governed by a culture that values singular identi-

fication with the party and conformity with the party platform and eschews special-interest claims”¹⁶. The internal constituencies are groups that allow individuals to express their concerns while attempting to find policy-driven solutions.

Meanwhile, the GOP is more unified in its ideological approaches, making it less about special interests and more about strong loyalty to the party. Barnes¹⁶ also emphasized that “Women in the Democratic Party have played a more active role in shaping policy and the party platform given its greater acceptance of special-interest claims, and male Democrats at the national level have largely embraced this women’s rights policy agenda”¹⁶. For example, Representative Alexandria Ocasio-Cortez (AOC) has played a visible role in shaping the contemporary Democratic Party. AOC’s advocacy for progressive initiatives, such as the Green New Deal and the expansion of social welfare policies, illustrates how women in the Democratic Party can emphasize specific policy priorities. Women’s political participation being higher in the Democratic Party than the GOP is not a matter of respect for women, but about the institutional space for women to advance their policy agendas.

2.3 Gendered Offices

2.3.1 Gender Norms and Local Office Stereotypes

Brechenmacher¹⁷ revealed that in 2018, women only held 19.8% of the seats in U.S. Congress and that this was also a pattern at the state and local levels. However, Bernick and Heidbreder¹⁸ discussed how women are overrepresented in county clerk positions. The responsibilities in these roles, such as recordkeeping, filing, and completing paperwork before elections, closely align with broader gender norms that associate women with organization and detail-oriented work. These expectations are rooted in the same socialization processes that frame women as caretakers, extending beyond the home into the workplace with roles that emphasize assistance rather than leadership. As a result, positions like county clerk may be viewed as more acceptable for women because they mirror longstanding stereotypes which portray women as suited for administrative tasks. The U.S. Census¹⁹ reported that in 2019, 97% of secretary and administrative assistant jobs were held by women. The presence of women in local offices fits the rigid stereotypes that society has developed over time and these roles are positively reinforced through promotions within the same local offices.

Offices on the federal and local levels both have agendas that they are trying to achieve. However, higher-level offices tend to enact their agendas and make their decisions much more deliberately. The legislative process tends to include a lot more internal deliberations,

analysis, and legal considerations²⁰. However, on a more local level, the agendas that need to be accomplished are a lot more task-driven. Fox and Schuhmann²¹ mentioned that “women committee chairs in state legislatures were much more task oriented than their male counterparts”²¹. Even in higher-level offices, women are still undertaking the minute tasks that form the bigger picture. This reflects the existing gender norms that continue to push more women to be assigned roles that require skills tied to administrative tasks. Even in federal offices, where the decision-making processes are more analytical, women continue to take on tasks that reflect secretarial roles.

2.3.2 Election Dynamics

Patterns in electoral outcomes vary across levels of office and election contexts. Anzia²² mentions the advantages that women and men have in local elections, specifically in mayoral, city council, and school board elections. In mayoral elections, women are slightly disadvantaged when the elections happen during the off-cycle, midterm, and presidential elections. However, for city council and school board elections, women are advantaged in the previously mentioned three types of election timing sessions²². However, an important limitation is that women do not run for office at the same rate as men, meaning that electoral outcomes may partly reflect candidate emergence rather than solely voter preference. Deckman²³ explained, “Locally elected women place greater emphasis on cooperation and communication, and, as a result, spend more time with their constituents”²³. This reinforces the perception of women as compassionate and people-centered leaders.

Women on school boards is an especially interesting phenomenon. Deckman²³ mentioned that female and male candidates did not differ much when it came to the rates at which they won their elections. However, she also explained that these elections set women up for success. The main goal of running for a school board is to help implement policies that address the needs and concerns of children²³. Therefore, having children, as most school board candidates do, is an asset that can help an individual’s election prospects due to their knowledge about children’s needs. An interesting point made by Sparks²⁴ is that women’s positions on school boards are oftentimes quiet, non-aggressive, and focused on building a consensus rather than being a stern leader.

3 THEORY

3.1 The Intersection of Partisanship, Gender and Gendered Offices

Women candidates still face significant barriers to success, especially among Republicans, male voters, and when seeking leadership roles in high-level political offices. Throughout the literature review, three main parts were discussed: the gender effect, the partisanship effect, and gendered offices. These concepts combine to explain how the political participation of mothers is affected by their own gender and political party affiliation, as well as the gender and political party affiliation of voters. The theory section contextualizes three hypotheses in the next section.

The first hypothesis that is derived from the literature review and analyzed in the experiment is the following: Republicans are more likely to be angry or upset at mothers running for office because of the traditional values that the political party embodies. Conservatism includes traditional gender roles where women are solely caretakers and men are the main breadwinners in their families. These restricting gender expectations can create resistance to the idea of women working and especially seeking positions in public office, because when this happens, the woman is challenging their “primary responsibility” of being at home taking care of the children. Therefore, when mothers announce that they are going to run for office, many conservative voters see this as a challenge to their traditional values.

The second hypothesis is: male voters are more likely to be angry or upset at mothers running for office. These reactions could be associated with broader attitudes about gender and leadership. The identities of being a woman and a mother are concepts that have always been intertwined due to biological and sociological influences; therefore, women are automatically assumed to have feminine traits and an ethic of care. These perceptions of women lead to the conclusion that they should solely focus on being caregivers.

The third hypothesis is: political offices on a higher level are viewed as spaces that should be filled by male leadership; meanwhile, offices on a more local level are viewed by the public as ones that can potentially be led by women. Positions in office, such as governor or president, are perceived as ones that need stereotypically masculine traits, such as authority and strength. Meanwhile, school board and municipal-level offices are perceived to need leaders with qualities of compassion and attentiveness; therefore, women are seen as more fit candidates for these roles.

4 RESEARCH DESIGN

4.1 Social Desirability Bias

Social expectations inadvertently lead individuals to adapt their beliefs about certain topics to fit in with the “socially acceptable” answer; this phenomenon is called the social desirability bias. This concept does not pertain to one area of life, but rather can be observed everywhere. People tend to present themselves in a way that makes them seem favorable to other people. This concept means that voters will underreport their levels of stereotypes against women candidates.

The paper used a list experiment to determine what people’s beliefs about mothers in politics are without the social desirability bias skewing the results. A list experiment measures participants’ true attitudes while attempting not to activate their social desirability biases. Through a list experiment, the control group receives a list of four non-sensitive statements, and they are asked to say how many make them angry. Then, a treatment group receives the same four non-sensitive statements with an additional sensitive statement and is asked the same question. By doing this, the social desirability bias is minimized since participants do not have to directly mention whether the sensitive statement makes them angry. The following section illustrates the research design of the experiment and presents five hypotheses based on previous understanding of the topic.

4.2 Hypotheses

Based on the previous literature, five hypotheses, as seen in Table 1, were created about the relationship between voter preconceived notions and candidates running for office.

4.3 Variables

The independent variables in this list experiment include whether the candidate is presented as a mother, the political party with which the mother is affiliated (Republican or Democratic), and the level of political office sought (local school board). These conditions were included to assess whether a participant’s emotional reactions vary based on motherhood status, partisan affiliation, and office context. The dependent variable is the number of statements that participants reported as making them angry or upset. Additionally, the analysis considers moderating variables, including participants’ partisanship and gender, to examine how these characteristics shape responses to the experimental conditions.

4.4 Procedure

First, the participants were recruited through Cint Theorem, a system that provides respondents who are quota-

Hypothesis	Title	Statement
H1	Overall Public Sentiment	Overall, the public is not highly angry about the concept of mothers running for political office.
H2	Social Desirability Bias	Participants will exhibit social desirability bias in their responses.
H3	Participant Gender	Female participants will report lower levels of anger toward mothers running for political office than male participants.
H4	Participant Partisanship	Republican participants will report higher levels of anger toward mothers running for political office than Democratic participants.
H5	Gendered Offices Hypothesis	Participants will report lower levels of anger toward a mother running for a school board position than toward a mother running for a higher-level political office.

Table 1 Research Hypotheses.

matched to census data on gender, age, ethnicity, and geographic region. This service provided a representative sample that could be extrapolated from. To better understand the sample that was obtained, the data was divided based on gender and party affiliation. When the data is divided by gender, 544 individuals identified as female. Meanwhile, 391 individuals identified as male. When the data was analyzed by party affiliation, 208 individuals identified as Republican, 201 identified as Democratic, 181 individuals said they were Independent, and 345 individuals said that they identified with another political party. Then, the individuals were randomly assigned to a control group or one of the four treatment groups. The individuals in the control group were asked to read the statements to see which ones made them angry or upset (Appendix 1, Question 1). Next, they were asked to read the treatment statements (Appendix 1, Question 2) and then rank their feelings of anger on a scale (Appendix 1, Question 3). It is important to note that, as Table 2 shows, if a participant said anything other than “Not angry/upset at all,” they would be considered angry/upset. The individuals in the first treatment group were assigned the set of statements containing “mothers running for political office” (Appendix 1, Question 4). Meanwhile, the second treatment group was assigned the set of statements including, “Mothers running for the Republican presidential nomination” (Appendix 1, Question 5). On the other hand, the third treatment group was assigned the set of statements, including the statement, “Mothers running to be the Democratic presidential nominee” (Appendix 1, Question 6). Conversely, the fourth treatment group was assigned the statement group containing “Mothers running for positions on the local school board” (Appendix 1, Question 7).

5 RESULTS

To successfully conduct the analysis described in the previous paragraph, the study asked those in the control group to say how many of the statements in Ap-

pendix 1, Question 2 made them angry/upset. Figure 1 shows the scale that the participants could use to express how angry or upset the statements made them feel.

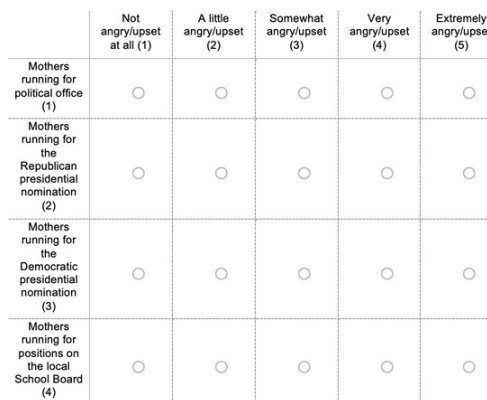


Figure 1. Scale for Emotions Regarding Statements

The study analyzes responses from 935 participants to see how many people reacted to statements about mothers running for political office with feelings of anger or being upset. By using unpaired t-tests, the analysis measured the differences between the control group and various treatment groups (with results considered significant if $p < 0.05$). In this context, the “mean” refers to the average number of statements that made participants feel upset within each group.

5.1 Overall Public Sentiment

The mean for the control group was 1.68, and the means of the treatment groups varied; however, there were mean differences among all four groups and the control group. For the statement found in Appendix 1, Question 4 (“Mothers running for political office”), the mean was 1.98, which indicates that, without the social desirability bias, 30% of the sample are angry or upset with mothers running for political office. For the statement in Appendix 1, Question 5 (“Mothers running for

the Republican presidential nomination”), the mean for this condition was 2.03, which means that 35% of the sample are angered or upset by this statement. For the statement in Appendix 1, Question 6 (“Mothers running to be the Democratic presidential nominee”), the mean was 1.88; therefore, 20% of the sample are angry or upset with the idea of a mother running for the Democratic presidential nomination. For the statement found in Appendix 1, Question 7 (“Mothers running for positions on the local school board”), the mean was 1.90, which means that 22% of the sample are angry or upset with the idea of mothers running for positions on the local school board. The social desirability bias was evident for all four statements (Table 2). For the statement in Appendix 1, Question 4 (“Mothers running for political office”), only 12.03% of the control sample reported feeling angry/upset, compared to 30% in the list experiment. Moreover, for Appendix 1, Question 5 (“Mothers running for the Republican presidential nomination”), 19.02% of the control sample expressed sentiments of anger or upset toward the statement, compared to the list experiment where 35% of the sample reported feeling angry/upset. In addition, for the statement in Appendix 1, Question 6 (“Mothers running for the Democratic presidential nomination”), only 14.76% of participants reported feeling angry/upset at the statement, compared to the list experiment where 20% of the sample were angry/upset with the statement. Furthermore, for Appendix 1, Question 7 (“Mothers running for positions on the local school board”), only 9.3% of the participants reported feeling upset or angry, compared to the 22% of the list experiment sample that were angry/upset with the statement.

5.2 Participant Gender

This section is a subgroup analysis that examines participant gender to determine if self-assigned females or males have lower or higher levels of anger toward the four different sensitive statements (Table 3).

5.2.1 Participant gender: Female

The mean value for female participants in the control group was 1.79. For female participants who were assigned to the statement in Appendix 1, Question 4, the mean was 1.82. Without the social desirability bias, 3% of female participants were angry/upset at this statement. In addition, the mean for female participants in the statement in Appendix 1, Question 5, was 2.20, which means that 41% of participants in this group were angry/upset at the statement. Furthermore, the mean for female participants in the statement in Appendix 1, Question 6 was 2.02, which means that 23% of the participants were angry/upset at the statement. Moreover, the mean for female participants assigned to the statement in Appendix 1, Question 7 was 2.10, showing

that 31% of the participants in this group were upset at the statement.

5.2.2 Participant gender: Male

The mean value for male participants in the control group was 1.65. For male participants who were assigned the statement in Appendix 1, Question 4, the mean was 2.30; therefore, 65% of participants in this group were angry/upset at the statement. Additionally, the male participant mean for the statement in Appendix 1, Question 5 was 1.96, which means that 31% of participants in this group were angry/upset at the statement. Moreover, the mean for male participants in the statement in Appendix 1, Question 6 was 1.90, which means that 25% of participants in the group were angry/upset at the statement. Furthermore, the mean for male participants in the statement in Appendix 1, Question 7 was 1.76, and therefore, 11% of participants were angry/upset at the statement.

5.3 Participant Partisanship

This section is a subgroup analysis looking into the participant partisanship. This section analyzes whether self-assigned Democrats or Republicans have lower or higher levels of anger toward the four different sensitive statements (Table 4).

5.3.1 Participant partisanship: Republican

The mean value for Republicans in the control group is 1.61. Meanwhile, the mean of those who identified as Republicans and were assigned the statement in Appendix 1, Question 4 was 1.86, meaning that, without the social desirability bias, 25% of Republican participants were angry/upset at this statement. In addition, the mean value for Republicans in the statement in Appendix 1, Question 5 was 1.81, so 20% of the participants were angry/upset at the statement. Moreover, the mean value for Republicans in the statement in Appendix 1, Question 6 was 1.99, which means that 38% of Republican respondents were angry/upset at this statement. Additionally, the mean value for the Republicans’ statement in Appendix 1, Question 7 was 1.76, which means that about 15% of Republicans were angry/upset at this statement.

5.3.2 Participant partisanship: Democratic

The mean value for Democrats in the control group was 1.98. Meanwhile, the mean value for Democrats assigned to the statement in Appendix 1, Question 4 was 2.15, so 17% of participants were angry/upset at the statement. In addition, the mean value for Democrats in the statement in Appendix 1, Question 5 was 2.40; therefore, 42% of the participants were angry/upset at the statement. Additionally, the mean value for Democrats in the statement in Appendix 1, Question 6 was 1.94,

Group	Implicit Anger	Explicit Anger	Little Angry	Somewhat Angry	Very Angry	Extremely Angry
Mothers	30%	12.03%	3.83%	4.92%	1.64%	1.64%
Republican Nominee	35%	19.02%	7.07%	6.52%	1.63%	3.80%
Democratic Nominee	21%	14.76%	3.83%	5.46%	1.09%	2.19%
School Board	22%	9.3%	3.83%	3.28%	2.19%	—

Table 2 Summary of Anger Levels by Group.

	Total Percentage	Percentage (Men)	Percentage (Women)
Mothers	30%*	65%*	3%
Republican Nominee	35%*	31%	41%*
Democratic Nominee	20% ⁺	25%	23%
School Board	22% ⁺	11%	31% ⁺

Table 3 Summary of the Results by Gender. * $p < 0.05$ ⁺ $p < 0.10$

which means that 4% less Democrats were angry/upset at the statement than reported in the control group. Moreover, the mean value for Democrats in the statement in Appendix 1, Question 7 was 2.11, which means that 13% of Democrats in this group were angry or upset at the statement.

6 DISCUSSION

The results yield interesting values in terms of the social desirability bias that was clearly present in the list experiment. In response to H1 (“Overall, the public is not very angry with the concept of mothers running for office”), 30% of participants were angry or upset with the concept of mothers running for office. Therefore, this hypothesis is accepted because this means that approximately 70% of the sample, the majority, is not angry or upset at mothers running for office. This finding reveals that there are still biases against mothers running for political office. These feelings of anger reflect the systemic barriers that prevent mothers from successfully running for office.

Regarding H2 (“There will be social desirability bias among most of the participants of the experiment”), the social desirability bias is present across the four sensitive statements (Appendix 1, Questions 4 – 7). Therefore, this hypothesis is accepted because when the social desirability bias was removed, it was revealed that 30%, 35%, 21%, and 22% of participants, respectively, were angry at the sensitive statement they were assigned. In contrast, when the control group was asked explicitly whether these statements made them angry or upset, the explicit levels of anger of the participants were 12.03%, 19.02%, 14.76%, and 9.3%. These results exhibit much lower levels of anger, which point toward the presence of the social desirability bias across all treatment groups.

H3 (“If a participant identifies as a female, then they will be less angry with a mother running for political

office than a male participant), provided results that were mixed and led this hypothesis to be rejected. Table 3 shows that in the Republican Nominee group, 41% of women were angry with the idea of mothers running for the Republican presidential nominee, compared to only 31% of men being angry. However, for the other conditions, such as the statement in Appendix 1, Group 4, women were less angry than men about the respective statements. These mixed results provide the insight that gender might not be a stable factor to look at when analyzing negative feelings toward these statements.

H4 (“If a participant identifies as a Republican, then they will be angrier with a mother running for political office than a Democratic participant”) provided a mixture of findings and led this hypothesis to be rejected. According to Table 4, when participants looked at the statement in Appendix 1, Question 5, 42% of Democrats said this statement made them angry/upset compared to 20% of the Republicans sharing this feeling. However, for the other groups in this analysis, Republicans had higher levels of anger when compared to the Democrats. This could be because Republicans feel the need to be loyal to members of their political party.

Finally, H5 (“Participants will be less angry about a mother running for a school board position compared to their anger levels with mothers running for a higher-level political office”) was rejected because this anger level was the third lowest among the four conditions. Only 22% of participants were angry or upset at mothers running for the local school board. Meanwhile, this value for the groups in Appendix 1, Questions 4 – 6 were 30%, 35%, and 21%, respectively. Clearly, there are fewer people feeling angry or upset when it comes to mothers running for a school board position when compared to other office levels.

	Total Percentage	Percentage (Republicans)	Percentage (Democrats)
Mothers	30%*	25%	17%
Republican Nominee	35%*	20%	42% ⁺
Democratic Nominee	21% ⁺	38% ⁺	-4%
School Board	22% ⁺	15%	13%

Table 4 Summary of the Results by Political Affiliation. * $p < 0.05$ ⁺ $p < 0.10$

7 LIMITATIONS

While the list experiment offers a creative way to test for the social desirability biases that may impact how the public feels about mothers running for office, the approach has limitations. The main limitations for this list experiment were design effects and survey respondent attentiveness.

Design effects are an important limitation of the list experiment. The statements in the list experiment are all politically charged, which makes it very likely that the responses of individuals to the question of how many statements make them angry or upset were inflated. This means that there could potentially be a misinterpretation of the results where respondents' feelings of anger are more influenced by the other statements and are therefore not a true reflection of how they feel about mothers in politics. Blair and Imai²⁵ discuss the problems that this misrepresentation of data has on statistical analysis, and they offer checks that can be implemented through statistical software. For future iterations, it would be interesting to enact these checks to see if the list experiment yields different results. Moreover, survey respondent attentiveness is another limitation. The nature of online surveys paired with possible respondent fatigue leads to overreporting or underreporting of the answers since the respondent might not be taking their time to answer carefully and accurately. Since there are no attention checks implemented throughout the survey, it becomes difficult to understand how accurate the responses are and if they are based on true preferences or if they are simply inattentive responses.

8 FUTURE DIRECTIONS

Future research should explore how other intricacies, such as ethnicity, impact voters' emotions toward mothers running for office. By examining how ethnicity shapes perceptions of mothers in politics across different levels of office, this research would aim to identify variation in public attitudes and bias. In addition, it may be important to further investigate how these responses compare to feelings of anger when the statements are about "fathers in politics." As suggested earlier in the paper, fathers are not as scrutinized as mothers when it comes to having a public life outside of their private one.

It would be interesting to run a similar experiment to this one but instead focus on whether fathers in politics produce negative emotions.

9 CONCLUSION

Politics is primarily viewed as a male-dominated arena because the skills that are associated with the field are masculine-coded, with traits such as authoritarianism, strength, and decisiveness. To further explore this idea, this study presented a list experiment to examine the beliefs of the public toward mothers running for political office. The goal of this paper was to answer the research question: How do partisanship and gender influence the public perception of mothers running for political office? To provide more insight into the underlying drivers of the perceptions, the extent of social desirability bias and how it shapes these attitudes was analyzed. Based on the findings of the analysis, when the social desirability bias was removed, 30% of the sample felt angry or upset toward mothers running for political office. Mothers also received negative feelings from the sample when they chose to run for presidential nominations across the two main party lines; negative feelings existed for the Republican Party (35%) and the Democratic Party (21%), signifying that this is not only a one-party issue. Other significant patterns arose when analyzing the participants' gender and the level of political office a mother chooses to run for. The findings in this paper revealed the gendered and partisan biases that mothers face in political life. Although this study explored important topics such as gender biases and social desirability bias, the research is impacted by design effects and respondent attentiveness to the survey. Future research should focus on addressing these limitations and consider how participant identities beyond gender and partisanship impact similar research about mothers and fathers in politics. By better understanding public perception of mothers running for political office, it will become easier to dismantle the barriers that are hindering mothers from being positively perceived by the public in relation to their political participation.

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APPENDIX 1

Survey Questions

Question 1

Please read the following statements and tell me how many of these make you angry or upset:

1. The high prices of groceries
2. Access to free public education
3. The lack of abortion clinics
4. States placing restrictions on gun ownership

Question 2

Women, and in particular, mothers, have increasingly been running for political offices in America. Some people think this is a good thing for American democracy and others aren't so sure. Please read the following statements and report how angry or upset they make you:

- Mothers running for political office
- Mothers running for the Republican presidential nomination
- Mothers running for the Democratic presidential nomination
- Mothers running for positions on the local school board

Question 3

Participants were asked to rank their feelings of anger or being upset through the following scale:

- Not angry/upset at all
- A little angry/upset
- Somewhat angry/upset
- Very angry/upset
- Extremely angry/upset

Question 4

The first treatment group (Mothers group) was asked the following:

Please read the following statements and tell me how many of these make you angry or upset:

1. The high prices of groceries
2. Access to free public education

3. The lack of abortion clinics
4. Mothers running for political office
5. States placing restrictions on gun ownership

Question 5

The second treatment group (Republican nominee group) was asked the following:

Please read the following wide-ranging statements and tell me how many of these make you angry:

1. The high prices of groceries
2. Access to free public education
3. The lack of abortion clinics
4. Mothers running for the Republican presidential nomination
5. States placing restrictions on gun ownership

Question 6

The third treatment group (Democratic nominee group) was asked the following:

Please read the following wide-ranging statements and tell me how many of these make you angry:

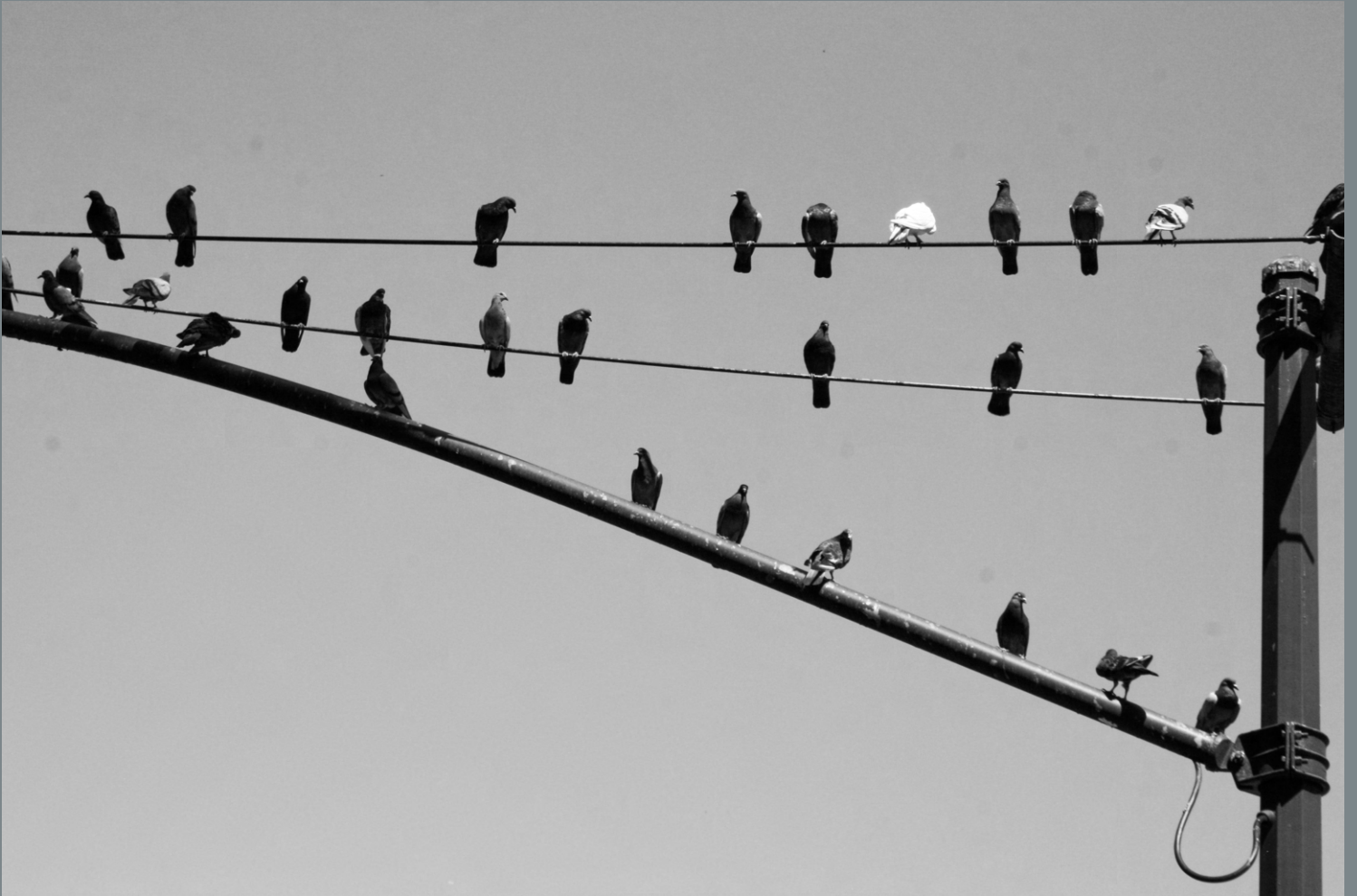
1. The high prices of groceries
2. Access to free public education
3. The lack of abortion clinics
4. Mothers running to be the Democratic presidential nominee
5. States placing restrictions on gun ownership

Question 7

The fourth treatment group (gendered offices group) was asked the following:

Please read the following wide-ranging statements and tell me how many of these make you angry:

1. The high prices of groceries
2. Access to free public education
3. The lack of abortion clinics
4. Mothers running for positions on the local school board
5. States placing restrictions on gun ownership



Birds by Riley McCarthy

Urban removal: The long-term impacts of the displacement of Denver's Auraria neighborhood

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Abstract

In the early 1970s, the Auraria Center for Higher Education was developed, displacing a well-established Denver Latino neighborhood, which encompassed a 38-block district at the time, including 155 families, 49 single individuals, and 237 businesses. The implementation of remedial measures for the displacement has fallen short of meeting the needs of displaced residents. The residents were promised affordable education through a program named the Displaced Aurarian Scholarship, which has similarly stated intentions of improving the educational attainment of the displaced individuals and their descendants. In 2022, the Colorado History Museum, as part of its Museum of Memory project, conducted 13 interviews with 21 different displaced individuals. This paper seeks to understand the long-term effects of gentrification upon the displaced Aurarians, centering on their social impact, economic impact, and the generational impact on the descendants. This study utilizes the Displaced Aurarian Memory Project and a theoretical framework, "linked fate," to contextualize past literature that examines the shortcomings of the remedial measures implemented by Denver authorities. The findings suggest that any remedial measures that provided long-term benefits to the residents occurred despite the actions of the City of Denver and the Auraria Center for Higher Education. These remedial measures required the tedious labor of West Denver activists to develop and implement, with and without cooperation from the institutions involved.

Keywords: Displacement, Urban Renewal, Discrimination, Activism, Higher Education, Denver, linked fate

1 INTRODUCTION

In the early 1970s, the residents of the Auraria neighborhood in Denver (then commonly referred to as West Denver) were displaced when the City of Denver established the Auraria Higher Education Center. Their homes were cleared to make way for the Metropolitan State University of Denver, the University of Colorado Denver, and the Denver Community College campus. The 38-block district at the time of displacement included 155 families, 49 single individuals, and 237 businesses¹. Although some residents received compensation for their homes, the implementation of remedial measures has been repeatedly described as falling short of the actual needs of displaced individuals. Information regarding compensation, preservation of cultural sites, scholarship, and any other remedial promises continues to be difficult for the public to access. Displaced residents were similarly promised affordable education through the Displaced Aurarian Scholarship. This measure was initially limited to children and the grandchildren of residents but has since expanded to include

direct descendants of someone who lived in the allotted area.

In 2022, the Colorado History Museum partnered with activists from the displaced community to conduct detailed oral histories with residents nearly 50 years after the displacement. This paper seeks to understand the long-term effects of displacement upon the displaced Aurarians, centering on the social, economic, and generational impact on the descendants of those displaced. To fully understand the shortcomings of the remedial measures, it is necessary to consider the context of the Auraria Memory Project, the activists involved, and their connections to the resource networks created during the gentrification in Denver from the early 1950s to the 1970s. Past research touches upon the shortcomings of the remedial measures on paper, understanding how they impacted the city of Denver. This paper extends that work, seeking to analyze the direct impacts of these remedial measures through first-person accounts of the individuals involved, and seeking to understand their changing political consciousness in the context of gentrification.

This paper applies the concept of linked fate, a term originally coined by Michael Dawson to understand the political behavior of Black Americans², to examine the experiences of displaced Aurarians. Linked fate is the phenomenon where one individual sees their fate as tied to the fate of others who belong to the same group. Any sense of linked fate that interviewees expressed is potentially tied to their shared experiences of displacement, economic hardship, and shared cultural, ethnic, or racial identity. These elements of linked fate could potentially explain why some residents felt strongly connected to the fate of other displaced Aurarians, while others did not feel a strong sense of community within the Auraria neighborhood. Similarly, connection to the networks that formed linked fate attachments meant connections to resources to help navigate the displacement. Residents who were not connected to these resources experienced the remedial measures of the city and the educational institutions differently. The findings suggest that any remedial measures that provided long-term benefits to the residents happened despite the actions of the City of Denver and the Auraria Center for Higher Education, and not because of them. Instead, these remedial measures required the tedious labor of West Denver activists to develop and implement, with and without cooperation from the City of Denver and the academic institutions involved.

2 LITERATURE REVIEW

2.1 The History of the Auraria Campus

The land underneath the Auraria campus has a complex history of development. The early Colorado neighborhoods, including Denver City and Auraria City, were located between the South Platte River and Cherry Creek, where Colorado was first settled³. They were established during the Gold Rush in Colorado, when Denver functioned as a hub for mining, cattle, and other related industries. Auraria City was known for frequent flooding because of its geography. The area is placed between several important features. To the South is Colfax Avenue, while the South Platte River and Cherry Creek form a triangle shape, surrounding the area and priming it to take on excess water^{4,5}. This pattern of flooding meant that space was described as undesirable for development^{4,5}. Despite these issues, the region offered an opportunity for lower-income, immigrant families to settle near the commercial district in Cherry Creek³. Several waves of migration from Mexico and New Mexico formed a cohesive Mexican and Mexican American community in Denver, surrounding local community spaces such as St. Cajetan's and St. Elizabeth's parishes, and a series of local businesses and other community spaces³.

In the context of a national movement towards urban

renewal, and decades after this West Denver community formed, the city and state governments established the Denver Urban Renewal Authority (DURA) and the Colorado Commission on Higher Education (CCHE). Despite an anti-growth sentiment from some residents during the Sixties and Seventies, the Denver metro area underwent an expansive process of suburbanization^{3,4,5}. Developer-friendly policies allowed publicly funded highway construction, water projects, and incentives for new development under a broader process of urban renewal, described as capturing misused lands for reuse through eminent domain⁵. DURA and CCHE identified the neighborhood as a prime location for the future Auraria campus due to its proximity to Cherry Creek and the West Denver location, which situated it close to important roads and waterways that had previously condemned the area as undesirable. The flooding in the region was used by CCHE and DURA as a reason to claim eminent domain and redevelop the land⁵. A shift towards urban renewal meant the expansion of infrastructure that placed the Auraria neighborhood in the center of a developing downtown Denver, and no longer on the outskirts of the city.

The campus would encompass the University of Colorado, Denver, Metropolitan State University, and the Community College of Denver, all in one shared space to foster interactions between the institutions^{4,5}. Page and Ross⁴ found that the project for the development of the Auraria neighborhood maintained heavy support from local government and the downtown business community, despite resistance from the residents of the community. In 1968, the CCHE, while working with DURA, overcame opposition to previous plans for a downtown campus by creating the shared campus project. From 1968 through 1984, DURA acquired property using the principle of eminent domain to condemn and clear buildings for the Auraria campus site. They estimated that two hundred to three hundred families left the neighborhood, drastically impacting the nearly two hundred businesses that were operating at that time⁶. Although it is unclear how many businesses were sustained through the period of gentrification, these changes drastically shifted the physical appearance of the neighborhood, changing the lives of community members.

2.2 Displacement as a Catalyst: Chicano Activism in Denver

While the residents of the Auraria neighborhood faced encroaching gentrification during the displacement, Denver was finding its place in the national Chicano activist movement. El Movimiento refers to the Chicano movement that formed in Denver, specifically, largely coordinated by Corky Gonzales and other Mexican American activists, some of whom had personal rela-

tionships with the interviewees featured in this study⁷. Mexican migrants had built communities in Auraria since the early 1920s, establishing extensive mutual aid networks⁷. The Sociedad Mutualista Mexico and El Sociedad Protectora Hispana Americana were two organizations that formed through these mutual aid networks. Later, individuals who participated in these organizations also participated in displaced Aurarian activism. This increase in activism can potentially be explained by an increase in linked fate attachment brought on by the experience of displacement. The level of integration into the community, religious networks, and shared language access impacted how the interviewees experienced the displacement, and any potential linked fate attachments that were formed or strengthened due to the displacement.

Churches also played a role in community support. St. Cajetan's Church, built in 1926, is said by residents to have "served as the center of Chicano life in the area," by providing residents a school, clinic, and credit union⁷. Since research has found that congregations play an important social role in cities (e.g., they build bridges between residents, provide community services and resources, and they inject a moral tone in the community through discourse and advocacy for the marginalized), it is expected that churches play an important role in buffering the side effects of gentrification⁸. Furthermore, during gentrification, congregations may have competed for a limited pool of members and exploit the niches introduced because of neighborhood change⁸. In West Denver, St. Cajetan's and St. Elizabeth's parishes became strong spaces in the community. During the period of displacement in Auraria, these churches were a valuable connection point between residents and a source for the dissemination of information. This is especially true of St. Cajetan's, which had a large Mexican American population and played a significant role in maintaining Mexican cultural events in the community.

Auraria residents had only a few months between when they heard of the plan for the downtown campus and the six-million-dollar special bond election that funded it⁷. Residents received leaflets describing the dislocation and dismemberment of the community. Centro Cultural, a Chicano and Jewish coalition, and the Auraria Residents Organization (ARO), headed by Father Pete Garcia from St. Cajetan's Church, provided outlets for residents to navigate the displacement when it became difficult to receive this information after residents began leaving⁷. Centro Cultural was a non-violent and inter-ethnic coalition created as an activist alternative to the more militant Crusade for Justice established by Corky Gonzalez⁷. Centro Cultural was created in part by the work of several interviewees, or their parents, who were involved in Auraria Activism. The Denver branch of the American Jewish Committee (AJC) helped

guide the formulation of the physical spaces that hosted Centro Cultural. Specifically, the AJC helped coordinate town hall meetings and physical spaces for the Auraria residents to receive information about the displacement process and subsequent remedial measures that were in development during the time Centro Cultural was active. The AJC participated in the coalition until 1971, which was when the displacement began. Members of St. Cajetan's Parish maintained important leadership roles in Centro Cultural, coordinating the distribution of information and resources to the residents during the displacement, particularly through the schools connected to St. Cajetan's and their neighbors at St. Elizabeth's (which included the Ave Maria clinic).

Past literature has examined outcomes of the mutual aid frameworks in place during the displacement. Perez⁶ looked at Father Garcia and the role of St. Cajetan's Church in forming ARO to advocate for Auraria residents specifically. One of the earliest examples of this included a household survey, which found more individuals eligible for relocation supported a bond issue which attempted to allocate funds for building and aiding the development of low-income housing. In 1970, ARO members advocated for new low-income housing, subsidized home purchases, and measures to rebuild dilapidated homes. In this process, they secured funds for a health clinic, contested zoning laws that would replace existing homes with high rises and commercial buildings, and fought transportation plans that would direct extreme traffic through the neighborhood⁶. This process ultimately changed the cultural makeup of the community living there by pushing out a well-established Latino community. As this community engaged in activism to save their homes, they received some remedial measures from the government and the educational institutions. Linked fate suggests that a sense of a shared future within this community encouraged the development of political consciousness among the displaced residents.

2.3 Remedial Promises

The displacement of West Denver occurred in tandem with policy favoring urban renewal and investment in large infrastructure projects such as highways and high-rise buildings. This policy change incited a wave of interest in the preservation of historical structures that were threatened. When the National Historic Preservation Act of 1966 was passed, it created a legal structure for activists to pursue the preservation of historical West Denver. A 1967 City of Denver Preservation Ordinance was added after the Skyline Urban Renewal Project tried to raise 26 blocks containing the oldest architecture in Denver^{1,4}. This ordinance was overseen by the Denver Landmark Preservation Commission (DLPC), which created historic districts and designated individ-

ual landmarks to be protected, including many sites on the Auraria campus⁴. This legal framework provided the avenue for Auraria residents to preserve some important cultural sites, although not all. The preserved sites include St Cajetan's Church, Emmanuel Chapel, St Elisabeth's Block on Ninth Street, and the famous Tivoli Brewery^{4,5}. This measure also preserved historical structures that were not originally located in the Auraria neighborhood but were moved to be displayed on campus as historical exhibitions. One example of this is the Golda Meir house, which was moved from another neighborhood to be displayed on campus near the block the interviewees lived on¹.

To receive federal funds for infrastructure changes, DURA was obligated to "rehouse in safe, decent, and adequate housing in a manner which [would] not be detrimental to any of the families involved," by Federal regulations and Colorado Urban Renewal law⁶. As part of the remedial measures taken by Auraria authorities, they developed the Displaced Aurarian Scholarship to address the concerns of local activists that the quality of education for the West Denver community was irreparably harmed by the displacement.

2.4 Complications of Promises Made: The Displaced Aurarian Scholarship

The Displaced Aurarian Scholarship initially applied only to the displaced residents but was eventually expanded to include their children and descendants. Although in theory, the scholarship would allow the original 227 displaced residents to pursue a low-cost education at the campus, the reality and efficacy of the scholarship have repeatedly been challenged by the displaced residents and literature on the topic^{4,5,6}. Residents were assured, despite not receiving physical documentation, that their children could receive an education on the new campus and that the scholarship would extend for residents between 1955 and 1973 to include individuals displaced by events interrelated to the establishment of the Auraria Center for Higher Education⁶. For example, some residents were forced to leave after severe floods damaged their homes, before they ever received notices from city officials that they would be required to relocate^{4,5,6}. In 1994, after rigorous community campaigns, the schools extended scholarships to include the displaced residents' children and grandchildren. If the project were implemented with its stated intentions, it would alleviate the impact of the displacement on the educational attainment of the descendants of displaced Aurarians. This generation grew up disconnected from the academic resources their parents had accessed through the private catholic schooling tied to St. Elisabeth and St. Cajetan's. This measure also sought to address the promise of an education on the new campus that several interviewees received but was never

clearly documented by the city.

Colorado legislature left the implementation of the scholarship to the three schools, meaning that scholarship eligibility and guidelines vary by institution. Many of these guidelines created limits on what the scholarship could be used for and who is eligible, preventing some Aurarians from accessing the scholarship altogether^{4,5,6}. The remedial attempts of Auraria authorities fell short of what was promised, leaving the displaced residents to navigate displacement in isolation.

An important facet of the gentrification of Auraria included the dismantling of the mutual aid networks that had existed previously. Although activists sought to maintain these structures, the physical displacement of individuals resulted in a loss of resources that could have been shared by the community. Community members were isolated from each other, and the governmental remedial measures could not account for the gaps left by displacement.

3 THEORETICAL FRAMEWORK - LINKED FATE

The concept of linked fate can be used as a tool to connect the political activity of the residents to their experiences during and long after the period of displacement². A strong perception of linked fate means that an individual sees their fate as tied to that of other individuals in their ethnic group and will make political decisions according to the group's interests. Sanchez and Masuoka⁹ build on these concepts, studying linked fate among Latinos in America. This framework understands the political behavior of Latino communities given the context of immigration experiences, race, and socioeconomic status. Linked fate moves beyond concepts like shared historical experience to understand what motivates political consciousness. During the period of displacement, from the early 1950s to the late 1970s (the period determined by the Displaced Aurarian Scholarship), several displaced individuals engaged in Denver politics to slow or stop the displacement and to fight for remedial measures to ease the effects of the displacement on the former residents.

As such, the linked fate framework helps to understand how race, economics, and migration experiences shape the political activity of the Auraria residents. Understanding their behavior through the formation of linked fate and the processes that lessen this link helps explain the long-term effects of gentrification upon the political activity of the Chicano community in West Denver.

4 METHODS

In 2022, the Colorado History Museum, as part of the Museum of Memory project, conducted 13 interviews

with 21 individuals who lived on Ninth Street in Auraria, who received notice in the early 1970s that their buildings would be demolished for the construction of the Auraria campus. Although 21 people participated in the interviews, 13 interviews were conducted. Several family members of interviewees with a connection to Auraria participated in the interviews. Most of the interviews were conducted in the family homes of interviewees, allowing several other family members with a connection to Auraria to participate. There were three interviewers, two of whom participated as interviewees in oral histories themselves. The Auraria Memory Project also included a library exhibition of archival materials, a community mural, and the construction of a robust map and database centered around 9th Street, detailing the history of the residents of Auraria before the campus was built. The map and database were coordinated through the University of Colorado Denver, spanning from 1955 to 1973.

The early interview questions in the oral histories focused on describing what it was like living in Auraria using sensory descriptions like smells, sounds, and sights. For example, residents were asked, "What smells do you remember?" Other questions focused on the Displaced Aurarian Scholarship, what the experience of displacement was like, and how it has impacted their lives and the lives of their descendants in the decades since. Every interview concluded with the question, "What do you want your descendants to remember about you and your time in Auraria?" Interviews ranged from 30 minutes to two and a half hours. The interviews contain 11 female interviewees and 10 male interviewees. Most residents (19) used language such as Hispanic, Latino/a, Indigenous, Mexican, Mexican American, New Mexican, Chicano/a, or a variety of these terms to describe themselves, while two residents described themselves as descending from Eastern Europe. Although this sample is small, it can still shed meaningful light on the long-term experience of displacement from the Auraria campus.

Each audio file was listened to at least twice to capture the themes between them, utilizing transcripts to confirm this information. Key terms related to events, places, and people that were mentioned by two or more interviewees became themes between the different interpretations of events. Places, such as St. Cajetan's Parish, provided insight into the role of community centers and how they included or excluded the interviewees. People, including public figures such as Corky Gonzales, and community leaders like Father Garcia, clarified information on the political network the community was situated in. Finally, important events such as the Bazaars hosted by St. Elisabeth's and St. Cajetan's parishes, as well as the official notice of displacement, served as markers to provide context to the timeline of events in the interviews, as well as points to compare

the experiences different individuals had with the same event. Using the transcripts as well as the Colorado History Museum's database allowed me to verify information and compare these oral histories to the physical changes of the neighborhood during, before, and after the displacement.

5 FINDINGS

The findings of this paper are broken down into the social and economic consequences that the displaced Aurarians and their relatives experienced after the displacement and the way that different remedial promises impacted these experiences. This allows for an understanding of the long-term impacts of displacement upon the residents' descendants as well the role of generational trauma, broader cultural and political changes in the community, and the shortcomings of the displaced Aurarian scholarship and other remedial measures promised to the community. Linked fate provides a framework to understand the change in political consciousness for the interviewees throughout the displacement and in the time after. This allows us to understand how gentrification changed the makeup of the community, changing the sense of a shared struggle between members of the community.

5.1 Long-Term Impacts Upon Social Networks

The process of displacement changed the physical and human geography of Auraria, disrupting the sense of community that Aurarians felt amongst each other. The displacement fractured the once-close networks of the West Denver community, disconnecting families from each other and from the resources they relied on. The displacement thrust Auraria residents into chaos, forcing them to quickly make new housing arrangements. One resident described what she remembered shortly after the displacement, explaining,

A lot of people are just homeless on the street. I don't think they had any choices. I think they lived with people until that money, or whatever was given to them at the time, ran out, and then they were out¹⁰.

The social consequences of displacement are largely tied to the isolation and disconnection of mutual aid networks that connected residents before and during the process of displacement. Several interviewees described losing the opportunities for their families to stay together in physical proximity. One resident described her feelings of isolation after moving away from Auraria. She explained,

I didn't feel like it was just us. It was, you know, like the neighbors. My mom knew all

the neighbors. And of course, we knew all the kids in the neighborhood. And even as far as probably blocks down, you know, like it could be down two, three blocks. And we still knew all the kids from all the surrounding area¹⁰.

The displacement of West Denver meant that the physical spaces that connected residents to a larger network of resources were dismantled. Some organizations and structures collapsed. For instance, St. Cajetan's removal meant that lower-income communities could no longer access the private Catholic school resources that St. Cajetan's provided.

One resident explained the financial burden of education that was placed on the Aurarians after losing access to these Catholic school networks. He described, "the only option we had was private education. St. Cajetan's was, how am I going to put it? Their cost to go to school was considered affordable because they knew the community couldn't afford private [school], really"¹⁰. Essentially, the only educational option residents felt they had for upward social mobility was through private Catholic institutions. Residents expressed that they participated in walkouts at their public high schools later because they felt they were being intentionally prevented from preparing for post-secondary education and encouraged to pursue lower-paying occupations directly out of high school¹⁰. Since St. Elisabeth's did not have a Spanish-speaking priest, and St. Cajetan's was more affordable, many of the interviewees who were teenagers during the displacement, attended this school at some point during their education.

Although the schools provided important resources, they were not always conducive to preserving Mexican cultural identity for community members. Several residents remembered instances of discrimination within St. Elisabeths, describing, "They were prejudiced, they were discriminatory"¹⁰. This resident similarly explained it was difficult for his parents to access information from the institutions relating to the displacement, because there were no Spanish language or additional language options provided or accessible¹⁰. Although the religious institutions could provide some resources, the spread of information and accessibility of these resources varied for the residents. Another resident described similar discriminatory experiences at St. Cajetan's before the displacement, explaining:

At St. Cajetan's in the first grade, we were caught speaking non-English, and that's where everything changed. And that's when Sister Guadalupe, I think, had already warned us that if they caught us speaking any other language or cussing dirty words, that you get your mouth washed out with soap. So she took us down to the boiler room. It was this huge boiler. It looked like a big elephant. And she

had this fresh soap, dial, and she gave each one of us, there were four of us and gave each one of us a bar of soap... after that, I told my parents what had happened and they came and spoke to the nun. And after the meeting, it was English only¹⁰.

Auraria residents consistently faced discrimination from different authorities, particularly relating to the use of non-English languages. This made the role of informal information networks within the community even more prominent and fortified a strong sense of a shared struggle amongst the community. Becoming disconnected from the community could mean cultural isolation, particularly for the younger generation of displaced residents, lessening this sense of community and of shared struggle. This discrimination was exacerbated by the economic outcomes of the displacement, which forced residents into crisis. A once interconnected community that dealt with discrimination and struggles related to migration previously had become further isolated from each other after the displacement, which prevented future generations from relying on these same social and mutual aid networks.

5.2 Long-Term Economic Impacts

Prior to the displacement, Auraria was a nearly prosperous district. One interviewee described Auraria as "a community on the brink of success"¹⁰. As the Chicano community in Auraria had been established for quite some time, the residents had taken root, allowing future generations to reap the benefits and form a sense of upcoming economic prosperity within the neighborhood. One interviewee explained,

When that opportunity came in the late sixties or seventies, people were going to college and that could have easily transitioned that community into, you know, higher incomes, more social mobility because people were getting educated¹⁰.

This sense of a shared, prosperous future was disrupted by the shared experience of displacement. The surrounding businesses, the number of young residents who were planning on attending university, and the stability that the neighborhood had fostered were quickly fractured by the investment projects the city initiated. These projects were determined using the principles of eminent domain to condemn the existing buildings.

Several interviews described how relatives, other community members, and themselves lost their businesses during the late fifties through the early eighties. Due to the changing demographics of West Denver and the population's shopping interests, several businesses had to restructure to support new patrons, move to a different location, or shut down because staying open was

economically infeasible. Many of these businesses were patronized or owned by the local Chicano community. One interviewee explained the feeling of physical loss of the businesses that were displaced. He explained this sentiment as he described a return trip to the campus a few years after the displacement: He remarked:

In '77, no '75, I was walking through the Auraria neighborhood and through the West Side, and I saw those houses [the Golda Mier house and another house next door that was included in the exhibit]. And all of the sudden I felt like what I would refer to as a ghost. I saw the ghosts of a community that had been there¹⁰.

This physical difference is reflective of the traumatic losses the Aurarians experienced as businesses and community spaces were erased.

Some families and small businesses are said to have received financial support from Auraria and Denver authorities during the displacement. The interviews do not include any individuals who directly received financial support in this way, and records of this financial support are not included in the Museum of Memory database. One individual described, "You know, some people got money, some people got, you know, nothing. We didn't get anything. We didn't get any assistance"¹⁰. Clarity about the nature of and written records of this support is difficult to decipher as there is no way to verify who received financial support, what entities provided this support, and where the money came from. This pattern of inconsistency in the remedial measures continues to create issues for the displaced Aurarians and their descendants today.

5.3 The Long-Term Impacts Displaced Aurarian Descendants

The generational trauma of displacement has meant that even the descendants of the displaced Aurarians continue to suffer the effects of the removal long after the events occurred. Sherrie Arguello explains that her house was removed, only for the university to display the house of former Israeli Prime Minister Golda Mier as a historical exhibition in the same location¹⁰. Mier lived in Denver and was involved early in the political discourse around the Auraria displacement, as she is referenced throughout the transcripts. This traumatic reminder of the loss of Arguello's house is combined with a hurtful erasure of her history in Auraria. The removal of her home and history to center a historical exhibit about a different woman who did not live there is particularly symbolic of the historical erasure of the displaced Aurarians' presence in Denver.

Several interviewees described the displacement as a catalyst for their political consciousness as they saw the

effects of Denver's gentrification reflected in a national setting. This history is tied to the formulation of linked fate attachments, connecting the Auraria residents to a national political movement. Many of the interviewees and their parents participated in the Chicano movement, which is an important part of Colorado's political history. Resident Tony Garcia described how the displacement impacted his identity, explaining,

It definitely spurred political consciousness, cultural consciousness, identity consciousness, that that was a change and that was the transition as far as the getting, keeping our spaces, and there were small victories that took place that kept some of the houses¹⁰.

Their activism initially aimed at resisting the gentrification of their neighborhood. Garcia went on to explain that the Aurarian resident's activism predated the famous historical events associated with the Chicano movement in Denver. He goes on to explain his experience a few years into the displacement, during the Denver High School Walkouts of the 1970s.

We always understood the dynamics of the city in that we were marginalized people and there was racism, and that there were places you could go and places you couldn't go. We always understood that. But I think that there was this illusion that somehow, we had figured out how to circumvent it and actually live lives. And I think what was beginning to evolve out of that was this, this awareness that unless we organized ourselves and we fought, we would just disappear. And it became the first steps of my consciousness as a Chicano¹⁰.

The displacement catalyzed Garcia and other displaced Aurarians into a political consciousness in the context of a national social movement. For residents who were not intertwined in the political movements of West Denver, the displacement seemed to awaken political consciousness in the same way that it did for residents like Garcia.

However, not every resident described a sense of linked fate with the members of the neighborhood during the process of gentrification. Kathy Prilika, who immigrated from Yugoslavia and described herself as Eastern European, discussed the harmful personal impacts of the displacement and how she felt isolated even because she did not feel integrated into the West Denver community. She was not aware of many of the political actions at the time, meaning that she had to sort out many of the impacts of displacement without the community's support that other residents described as vital¹⁰. For many of the displaced Aurarians who saw themselves as a part of a larger community, their

experience of displacement was guided by networks of resources and information within the community. This was not the same for people who were disconnected from that community, despite living there. Although they experienced displacement at the same time, a sense of shared struggle was not universal among the residents.

An important cultural value, repeatedly discussed by the interviewees, is education. Remedial measures tied to educational attainment became a prominent goal of the activists because of the overlapping process of developing political consciousness and the disconnection from previous educational resources (at St. Cajetan's and St. Elizabeth. institutions that replaced their homes and community. Jay Alire, who described many of his experiences as a teenager involved in West Denver Chicano politics, emphasized how the community values the importance of education combined with the formation of his political consciousness. He describes why he participated in the walkouts at his Denver high school, explaining:

When this bond issue came, we had already started becoming a little bit more politicized... a lot of students walked out of West High School and decided that we needed to take control of our education because it was really obvious that they were they were not preparing us to go to college. They were preparing us for manual labor jobs and jobs that did not require post-secondary education¹⁰.

Students participating in the walkouts across the city protested racial inequality in Denver Public Schools. Several of the other interviewees voiced a similar sentiment to Alire, seeing education as the best avenue to alleviate the long-term effects of displacement, and seeing the disruption of education as a primary long-term effect. The Displaced Aurarians scholarship sought to remedy the long-term impacts of gentrification upon the Aurarians and their descendants by providing them with access to education.

5.4 Education as Resistance: The Displaced Aurarian Scholarship

The scholarship was formed to remedy the hardships the Displaced Aurarians faced, but its shortcomings continue to impact the Aurarians and their descendants. Another resident described the community values around education, explaining,

When we talked about how we value education, that we have the evidence of some of very successful people that came out of that area only because of our educational value,

and that was demonstrated by Saint Cajetan's, the commitment many families made to Saint Cajetan's to get our education¹⁰.

Connecting the loss of important educational resources to the long-term impacts of displacement is vital to understanding why these remedial measures were developed. This sentiment is in part why the scholarship was so important for community members; however, the way the scholarship was implemented prevented it from truly alleviating the long-term harm that the displacement had on the educational attainment of younger generations.

Several residents who were displaced at the time could not access the scholarship at all, which is why the scholarship was expanded to include more generations and eventually all direct descendants. This came only after the persistence of Auraria activists. One interviewee explains,

We didn't use the scholarship because at that time, there were no buildings on the land. And that was one of our arguments about how the scholarship was so incomplete. I mean, we're supposed to go to take classes in buildings that weren't there¹⁰.

However, even when the scholarship was expanded to address the needs of the residents, the actual implementation of the scholarship continued to fall short of meeting the displaced population's needs.

For instance, the scholarship initially only provided funding for degrees up to a bachelor's degree. Eventually, after the efforts of displaced activists, it was expanded to cover graduate degrees. Katelyn Puga, one of the first residents to receive a master's degree using the program explained,

I specifically requested that they support me through my master's program. And they did. And so, I think that was probably the first sign of opening the door for endless education, lifelong learning opportunities for us as Displaced Aurarians¹⁰.

Puga had faced difficulties using scholarship funds for her undergraduate degree previously. Accessing this scholarship meant that Puga and her siblings were able to break some of the barriers to upward mobility that their parents faced.

For those who were able to access it, the scholarship made all the difference. One of the children of a displaced Aurarian explains,

Some of my siblings have children. And so, knowing that it can be passed on to them is a really big deal. And their kids and their kids, it's breaking cycles and helping to just propel

our family forward through education is a big deal¹⁰.

However, Puga, her siblings, and her father still faced obstacles to accessing these resources. Since her father did not have records with the primary schools in Auraria to prove he lived there, he struggled to prove his kids qualified for the scholarship. However, his siblings and their children had been approved for the scholarship. Extending the scholarship to three generations allowed Puga to qualify because of her grandparents' connection to Auraria rather than her father's. Puga's sister continues:

I come from Displaced Aurarians who already valued education before they even knew that that was something that I may benefit from, because of their sacrifice is amazing to me. And I think that when I'm on that campus, I feel empowered as a student and as a person because I know all of the history involving my family there¹⁰.

Several other interviewees discussed struggling to spread information about the scholarship and trouble accessing it themselves. Francis Torres described how information about the scholarship was intentionally unclear or misleading, which made it difficult for individuals to even know it existed. She explained, "I just heard from a 53-year-old gentleman who lived there and moved as a young child that he said it would have made all the difference in the world if he would have known about"¹⁰. Many residents mirrored this sentiment, explaining that this scholarship would have alleviated some of the financial burden of displacement.

Another resident explained,

There's a gap between when that conversation [when residents were made aware of the scholarship] took place and when it was implemented. . . I was having a hard time finding out where the documents were¹⁰.

Similarly, the daughter of Kathy Prilika explained that they did not know about the scholarship until at least 30 years later, when her son was already enrolled at Metropolitan State University¹⁰. She expanded, "I called the school and asked about the scholarship and got some information. And that set us on the path to where now we know we're part of a community of others"¹⁰. She had to pursue this information directly and only heard of the scholarship by chance. Dispersing information about the scholarship continues to be an issue for Auraria descendants who may not even be aware it exists. Implementation of the scholarship was left to the discretion of the different institutions on the Auraria campus. This meant that there were huge disparities in how the scholarship was applied to individuals. The

displaced Aurarians and their descendants had to navigate different hurdles to access the scholarship. One resident explained her grandson's experience, describing "But my grandson, he got the runaround, and he never got anything. Everybody keeps saying, 'we're not sure what you're talking about.'" And they said this, too, from the very beginning,"¹⁰. This inconsistency in implementation and communication means that there is no clear path for individuals to follow to access the scholarship.

These findings suggest that many of the remedial measures that provided long-term benefits to the residents occurred through the diligent activism of West Denver residents. In pursuing these remedial measures for their community, some Aurarians developed a political consciousness tied to Chicano political identity. In a national context, the struggles of the displaced Chicano community in Denver reflect a national struggle of discrimination, identity, and gentrification.

6 CONCLUSION

The development, implementation, and dispersal of information about remedial measures after displacement required the tedious labor of West Denver activists without the cooperation of City authorities and the academic institutions involved. These remedial measures included financial compensation, preservation of important cultural sites, and the Displaced Aurarian Scholarship. This reflects a historical pattern in Denver's Chicano population, which saw waves of activism and political organizing in tandem with waves of gentrification. Remedial measures were spearheaded by the activist community of displaced residents, not by the urban renewal authorities. This dynamic meant that the city's measures failed to address the harm done by displacement, because the city did not intend to address this harm. The linked fate framework explains how the activism of displaced Aurarians and the cultural values tied to their resource networks encouraged others to pursue the Displaced Auraria scholarship. Similarly, linked fate provides a framework to understand how the displacement drove activists to pursue remedial measures.

Linked fate is highest among Latinos who predominantly speak Spanish and live in Spanish-speaking communities, shared language as motivator of group consciousness for Latino people⁹. The displaced residents repeatedly discuss language, erasure of Spanish and indigenous languages, and the role that the language plays in connecting communities. Residents who did not speak English or Spanish experienced a lower sense of connection to the Aurarian community. Linked fate explains that the context of a shared identity around language could have played an important role in forming the political consciousness that spurred Chicano

activism in the community, and why this may have been different for people without that identity. As such, Linked fate, tied to the experience of displacement, catalyzed Aurarian activists to push for the educational remedies that were established.

The discrimination experienced by many in the community before the displacement was exacerbated by the economic outcomes of the displacement, which isolated residents from each other and the vital networks they had formed to connect to resources. When the community was disrupted, a once interconnected network that helped with struggles related to migration became further isolated, preventing future generations from relying on these same social and mutual aid networks. The shortcomings of remedial measures thereafter were justified by the same narratives of eminent domain that allowed for displacement in the first place. Younger generations who were not alive for the displacement may not have the same experience of linked fate as their parents and grandparents because they did not experience the close-knit community networks, the context of the broader Chicano movement in the 1960s, and the catalyst of displacement all at once. Activists during the displacement connected their experiences to the experiences of their relatives and ancestors. Similarly, the Aurarian descendants today can connect their experiences to their parents and grandparents as the displaced Aurarian descendants continue to prioritize education as a cultural and personal value. To more fully understand the shortcomings of the remedial measures, it is necessary to consider the context of the Auraria Memory Project, the activists involved, and their connections to the resource networks created during the gentrification in Denver from the early 1950s to the 1970s.

The experience of the displaced Aurarians functions as a microcosm of national political, social, and economic discourse around education, immigration, racism, and gentrification. Their stories provide a window into the politics of urban renewal and removal in Denver and elsewhere. These findings suggest that the long-term benefits of the scholarship came from the persistence of Auraria activists, who faced barriers from the city of Denver and the Auraria Center for Higher Education at every step. In pursuing these remedial measures for their community, some Aurarians developed a political consciousness tied to Chicano political identity. Today, descendants of the displaced Aurarians are continuing the legacy of their elders by pursuing their education through the long-fought-for Displaced Aurarians Scholarship.

7 FUTURE DIRECTIONS

In the future, it is worth considering how the formation of linked fate attachments might occur differently between each generation, if at all. More research should

be done to understand how the political consciousness of the displaced residents formed, and how this has impacted their children and grandchildren. Past research touches upon the shortcomings of the remedial measures on paper, expanding how they impacted the city of Denver. These findings illustrate the interconnected nature of the long-term impacts of gentrification in cities like Denver. Although the remedial measures Denver authorities tried to implement had the potential to help the Displaced Aurarians, the displaced individuals had exhaustively fought for every piece of these remedies.

Understanding the behavior of displaced Latino neighborhoods, through the formation of linked fate and the processes that lessen this link, could inform future research to expand on the long-term effects of gentrification more broadly through the lens of political consciousness. Future research could delve further into the specific features of the long-term impacts of gentrification, utilizing the Displaced Aurarian Memory Project to contextualize the robust database that History Colorado created. This data includes specific economic information that could provide insight into the long-term economic impacts of displacement upon the specific families in the sample¹¹. Detailed analysis of the economic impacts on the displaced population is difficult to pursue because the population records are unclear, which is one of the main issues the city faces in implementing remedial measures. The dispersal of the community meant it was difficult for the Auraria Memory Project to incorporate a large sample of people to interview, so accessing detailed information related to the long-term economic impacts on this population who lived in other parts of the neighborhood could prove similarly difficult. However, work could be done using quantitative methods to examine the scholarship and the concrete features of its implementation, accessibility, and lasting effects on the educational attainment of the West Denver community across generations.

8 EDITOR'S NOTES

This article was peer-reviewed.

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Rocky Mountain National Park by Gabrielle Mansour



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1 WHAT INSPIRED YOU TO PURSUE RESEARCH IN EVOLUTIONARY ECOLOGY?

I think just a love of nature. I have always been fascinated by animals, I've always wanted to learn more about them, how they work, where they live, what they do. From a young age I was interested in working in some way with them, understanding them, observing them in their natural habitat. When I was in college I took some classes in physiological ecology- which is the study of how animal physiology is adapted to different environments, and how animal physiology varies across the globe. That sort of solidified my interest. Then I had a professor who told me about grad school- I didn't really know that studying evolution, or physiology, or ecology, was like a job. So after that I just thought, "I think I want to make this my job," and then

that was almost 20 years ago.

2 WHAT DOES YOUR RESEARCH PROCESS LOOK LIKE?

In general, I think like anyone's, we start with a question. And that question comes from either something that I read in the literature, or an observation in the field, because we work with wild animals. If we're out there observing wild animals, then we might have a question that arises. I can give you an example- we have been studying a native rodent called the deer mouse and how it's distributed across elevation and what adaptations it has due to the conditions of high elevations, so it's low oxygen and cold. In doing that we noticed that there was one site in particular that we were working at where these animals got a parasitic infection only in the fall. It's of a flesh-eating parasite called a botfly, and it's the larvae of the botfly- they go in through the nose and then they migrate to the back of the animal, and then eat a hole into the outside of the animal so they can breathe, and then they feed on the interstitial fluid, and the blood, and necrotic tissue, and then they burst out of the animal like a month later and pupate over winter. We noticed that we only saw those animals at this one site and so that led to a whole bunch of other questions. We knew that they had also been seen at lower elevations, like in Nebraska, where I had seen them a few times before but just sporadically. That led to a whole bunch of questions such as, "How does this infection differ across elevation?" Because what we were observing at this high elevation site was very different from what we found in the literature. So the question generation there came from a direct observation in the field plus looking at the literature. And then the hard part is devising ways to test that hypothesis that is generated from that question. Once that happens, usually I then write a grant to some federal agency to get money- because it costs money to do these things- when I get money I can hire people to actually do it. And then once we do it, it becomes the grad student's or postdoc's project, but it can also become part of an

undergraduate's project. Usually an undergraduate will carve out bits. I have an undergraduate right now working on that particular project- so that came out of this whole observation, hypothesis generation, figuring out a way to test it, and then something comes of that, a question, a sub-question, and an undergraduate works on that. Then a bunch of data gets collected, interpreted, and then they write it up and send it to the DUURJ, or wherever.

3 CAN YOU TELL ME SOME MORE ABOUT RESEARCH YOU'VE DONE IN THE PAST?

The lab primarily works at high elevation, on mice and adaptations like I said. We also study migratory fishes. They are what's called a diadromous fish- that's a special term that means fish that breed in one salinity environment but grow in another. These particular fish are a kind of herring, and they breed in freshwater ponds in coastal New England- actually, all across the eastern seaboard- but they migrate to sea when they are just a few months old, and then they grow there for a few years, and then they return to freshwater to breed. And they can do that a few times in their life- they're kind of like salmon, but they're very different than salmon, they're 200 million years divergent. And they have very different evolutionary history. They evolved in the ocean, whereas salmon evolved in lakes and ponds, in freshwater. The way that they migrate is actually kind of opposite, or the way that they evolve. We are studying that behavior- the migration- how it works, how it's different than salmon. We are also studying these special populations that have become trapped in freshwater by dams that were built when colonial New Englanders were modifying the landscape for the first time, and they built a lot of mill dams in New England. These mill dams trapped the baby herrings behind dams and kept them in freshwater, and they've been evolving there for the past few hundred years. We have been looking at those populations, comparing them to the migratory ones, to see how their system of tolerance of that environment- that freshwater pond environment- throughout their whole lifetime differs from an animal that is essentially a marine animal that comes into freshwater just for a month to breed and then leaves. Both of those things are still ongoing in the lab.

4 WHAT MADE YOU WANT TO BE A PROFESSOR?

When I took this physiological ecology class in undergrad, I was just really interested in it and my professor was great. I asked if I could do research in his lab and he was studying bird stress hormones- how birds respond to stress. I got involved in his lab, we trapped

birds and took their blood, and measured their stress hormones in different conditions. He took me to Central America where we studied birds for a summer, and I kinda thought, "I wanna do this, I want this guy's job, it seems really fun." And you just get to study animals, and like I said I really just wanted to be around animals, and work with them, and understand them, and so I realized then that I could do that as a job. I got the research experience as an undergrad doing that, so I think I decided then. I also remember graduating and asking my English professor- I saw him at the gym or something and I asked him if he thought it was a good life to lead, and he said, "It's the best life to lead." That, plus all my experience, two people I trusted telling me that they loved their jobs, and that I would get to study animals- I just decided then, so I applied to grad school and that was it.

5 WHAT IS YOUR FAVORITE CLASS TO TEACH?

I teach a class called Environmental Physiology of Animals- that's the same class as physiological ecology, just different names for the same topic, basically- which is the same class that I took as an undergrad, with some modifications that led me to the place that I am today. Since that class, I've decided that that's also what I want to teach and like to learn about. I teach that class every winter, it's for upper-level students. Mostly biology, ecology, environmental science majors. It's my favorite class to teach because it's the subject that I love the most, but also because we do real hands-on work. We read eight papers in a ten week course- so it's almost one paper per week. Students dissect the papers, and we discuss them in class, they discuss them as groups. I love that, because they get to read primary literature and learn how to really dissect it. The lectures are pretty interactive, we do a lot of team work, and we do a project at the end where they get to create an actual research proposal that I tell them- and this is 100 percent true- could be submitted to the National Science Foundation for their own research fellowship award. So it's not only in the style of this thing called the Graduate Research Fellowship Program, but it literally is a graduate research fellowship award. That's awesome because I read those every year for my students and I also serve on panels where we read them for actual applications, and so it's very practical- I'm actually having them do the proposal, the hypothesis generating, the experimental design generating that I told you was part of the process- and they get to actually do that process. It's two pages, which is awesome because- it's a huge amount of work but it's not a huge amount of actual reading or writing for them, but they get the skills of putting those things together and then I get to read them and figure out what's going on in

their brains. I get to read a lot of cool ideas. I guess the culmination of both the content for that course and also the other skills, like reading, and writing, and proposal generating that we do- that one's my favorite.

6 IS THERE ANYTHING ELSE YOU WOULD LIKE TO ADD?

I would encourage all undergraduates to pursue research, even if the topic is not something that they maybe have the most interest in. Because topics don't matter as much as process. In STEM, what matters is the scientific process- this matters everywhere, not just in STEM, to me, but I'm a scientist- the scientific process matters. Critically evaluating data and information, generating a hypothesis. I would encourage all students to get involved in that- writing, reading, making figures, all of that stuff. It doesn't really matter what the content is. It matters that the process is done. That looks good for grad school, med school- I mean, that's just good for your life. Especially now in the age of AI, where AI can do this for us, but it can't do it like us. I think learning those skills actually is more important now than ever- because we can still do that with a real human aspect that's better than AI, I think. That process will help students in their career and just be better observers of the world. I think that all undergraduates should pursue research if they can, and I think that this is a pretty easy place to be doing that.



Abstracted Labyrinth by Lauren Siegfried

Dr. Kacey Grauer

Department of Anthropology, University of Denver

Katelyn Trimble¹, on behalf of the Editorial Board

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1 WHAT INSPIRED YOU TO PURSUE RESEARCH IN ARCHAEOLOGY?

I was taking archaeology classes as an undergraduate at CU and I always thought that archaeology was really cool, and exciting, and I went to field school, and it was awesome, but I had this existential struggle of, "Why actually do archaeology?" Does it actually help people, other than just being interesting? And then I started taking classes with a professor who really inspired me by showing me that you can actually use knowledge from the past to address problems in the present. He specifically was looking at environmental archaeology and questions of sustainability, so then I was like, "Oh I can do this really cool thing and it can also make a real impact on the present." So that solidified it for me, that archaeology was something I wanted to go into.

2 WHAT DOES YOUR RESEARCH PROCESS LOOK LIKE?

Community engagement is a really important part of my research process. I've been working with the same community in Belize for over 10 years now, and I really make sure to do research that people who are actually impacted by the research care about, and want done, and am very active in knowledge production. So it's very collaborative in that sense, also. My research is really field work based. I go to the field in Belize to conduct research, and I use a lot of different methods. I use pedestrian survey, which is basically just walking around and looking for something to landscape with archaeological material, excavation- a classic archaeological method- and I've used archaeobotanical analysis, which is looking at plant remains in archaeological context. Increasingly I've been using a lot more digital methodologies, so I use a lot of GIS- geographic information systems- to make maps and understand spatial relationships between things. I'm also getting into LIDAR, and drone imaging, and photogrammetry. I've been doing 3D scanning of artifacts and printing of artifacts, so that's been really fun. And a lot of that we're doing for community engagement, education, and outreach. We do most of our analysis of archaeological material in our lab in Belize, and we present our findings in Belize at an annual archaeology fair and a semi-annual archaeology conference.

3 COULD YOU TELL ME ABOUT WHAT YOU ARE CURRENTLY WORKING ON?

I'd love to! I just started a new project. It's in Belize- the same area that I've been working for a long time- and it's on this small community that is located on a river, and the reason we're really interested in looking at this community is because people in the area are interested in learning more about it, and it comes from this time period called the post-classic of Maya history- I'm a Maya archaeologist- and a lot of Maya history really focuses on what's called the classic period- which is where you get the really big temples, and a lot of really fancy

looking art, and there's all the divine kings. But that's just a small part of Maya history, and there's been a lot of continuity from the classic all the way up through the present, so by looking at the post-classic period I'm kind of connecting that classic Maya history up through the present. Descending communities are really interested in that, in showing indigenous persistence in the landscape. It's kind of twofold, we're interested in it for intellectual reasons and also for advocacy-based reasons. We're just getting started on that. We did our first excavations last summer, which was really exciting, and I'm actually really hoping to start a field school class to hopefully bring some DU undergraduates down to participate in research in 2027, that's the goal. So hopefully that will happen.

4 WHERE WOULD YOU SEND STUDENTS WHO ARE INTERESTED IN LEARNING MORE ABOUT THE KIND OF RESEARCH YOU ARE DOING?

Take archaeology classes at DU! We often have opportunities for students, such as field schools. Field schools are a great way to gain hands-on experience and training that can lead to research involvement. There is the Council of Colorado Professional Archaeologists, CCPA. It's a society of professional archaeologists who work in Colorado and they have an annual conference where people share their research, and there's always networking events. Also, we have some alums from the DU masters program in anthropology who- it's called Community Connections LLC, the name of the organization that they started- and they're very involved with public archaeology, and they organize archaeology meetups, and they're still very active in the DU community and DU network, so they're great people to get in touch with as well.

5 WHAT MADE YOU WANT TO BE A PROFESSOR?

I love teaching, and I love doing research. I knew that being a professor was the best way for me to be able to continue my research project in Belize and still get to work with students. That's the great thing about DU- there's a real emphasis on the teacher-scholar model, so we get to focus on both things equally. As an academic, I honestly believe that the biggest audience I'll ever reach is my students. That means that the people I have in my classes will carry forward some of what they've learned about my research and the lessons we can learn from archaeology out into the world. I also love bringing my research into the classroom. Since archaeology is very hands-on, there are a lot of opportunities to have really engaging activities and experiential learning.

6 WHAT IS YOUR FAVORITE CLASS TO TEACH?

I'm going to cheat and talk about two classes. The first one is Fundamentals of Archaeology, our introduction to archaeology class. Students often take it for the same reason I took my first archaeology class: they think it sounds cool. A lot of people have specific ideas about what archaeology is, and in Fundamentals, I kind of dismantle the whole "Indiana Jones" thing while also acknowledging the colonial roots of archaeology. We spend a lot of time talking about the relevance of archaeological research to present day issues. That's what got me excited about archaeology when I was a student, so I hope to pass that on. The other class is a new one I just taught in the Winter Quarter called "Collapse, Resilience, Persistence." In that class, we cover various case studies that are really popular in the public imagination as examples of "collapsed" societies. We then look at the archaeological data to see if it does (or doesn't) support a collapse narrative. A big part of that class is writing for diverse audiences, and we talk about why certain stories we tell about the past become more popular than others, and importantly, what impact those stories have on the present.

7 IS THERE ANYTHING ELSE YOU WOULD LIKE TO ADD?

I'm brand new to DU, I started in the fall, but I love being here. Everyone's amazing, the students are awesome, my colleagues are great, and it's been really fun developing new classes and seeing the students get excited about things.



Golden Dynasty by Alexandra Mele
Oil on canvas

Dr. Scott Phillips

Department of Sociology and Criminology, University of Denver

Katelyn Trimble¹, on behalf of the Editorial Board

¹DUURJ Editor at Large, University of Denver



1 WHAT INSPIRED YOU TO DO RESEARCH IN CAPITAL PUNISHMENT?

Well, it wasn't the first topic that I studied. For my dissertation, I went into prisons and interviewed inmates who were incarcerated for murder that stemmed from arguments and disputes that escalated to violence. I asked each person, "Tell me about the murder that led to prison." More specifically, the conflict, and then "Did you ever have a similar conflict around the same time that you handled non-violently?" For example, a lot of the men that I interviewed had been drug dealers and a common scenario was, "I gave a person drugs and he said, 'I'll pay you on Friday when I get my paycheck,' and then I saw him partying at the club and he hadn't paid me." So argument escalates, violence, victim ends up dead. I would then say, "Was there any other time

that someone didn't pay you when they were supposed to, but you handled it nonviolently?" The question was, "What are the elements of the situation that lead to escalation?" And the key- from a methodological point of view- is that I have two conflicts nested within the same person. Let's say that person is named John. I have a violent conflict from John and a nonviolent conflict from John, and John's individual characteristics can't explain the difference because his individual characteristics are a constant. His temperament, his personality, they're the same for both conflicts. The same for the neighborhood he grew up in. In research, we're always trying to isolate the variables of interest and eliminate the confounding variables. We can do that by making the confounding variables constants. So his individual traits are a constant, his neighborhood is a constant, we're down to the situation itself. There are lots of findings- one that I thought might be the most interesting is that what really matters is who else is present. Those people can push the conflict toward peace or toward violence, and men surrounded by their friends and allies tend to become violent much more often. Which might explain part of why violence has been declining for a long time- meaning long-term human history- because men used to live near their fathers, brothers, cousins, uncles, so men were performing before audiences and had allies to back them up. Now, men often don't live near their fathers, brothers, cousins, and uncles. My dad lives in Louisiana, my best friends from college live in New York and Texas. They're not going to fly into Denver if I get into an argument with someone today. That might be part of the explanation for why violence has declined across human history, because males- who commit most of the violence- don't have as many allies at the ready as men did for most of human history. The men who would back them up are scattered. Modern gangs are the exception that proves the rule. So, my research didn't begin with the death penalty. But then I took my first job in Houston, Texas, and Houston leads the nation in executions. A friend of mine said, "You should study the death penalty, you should shift your focus." And I said, "That doesn't make a lot of sense

to me, because lots of people have studied the death penalty, there's really nothing new to say." He said, "But you live in Houston." If Houston were a state, it would rank second in executions behind Texas. Houston, just the city. I lived in Houston, I thought that was compelling, I thought I would do one study of the death penalty, and that turned into the last 25 years. I had every intention of studying why some interpersonal conflicts escalate to violence and others don't, moved to Houston, and switched to the death penalty. I thought it was interesting because the stakes are so high. The stakes are high in any criminal case, obviously, but in a death penalty case- there is nothing more extreme than the government taking the life of one of its own citizens. Studying that process- whether it's fair, whether it's equitable- just struck me as interesting.

2 WHAT DOES YOUR RESEARCH PROCESS LOOK LIKE?

In death penalty studies, I tend to gather data on a set of cases and follow them through the process. For example, in my study of the Houston death penalty I started with defendants who had been indicted by the grand jury for capital murder, because once a person is indicted for capital murder the district attorney has the option of whether to seek the death penalty or not. If the district attorney decides to seek the death penalty, then it's headed to a jury and the jury will decide whether to impose a death sentence. If the jury imposes a death sentence, then the person is convicted, sentenced to death, and it enters the appellate courts. There are three different types of appeals- those go up and down the chain, perhaps all the way to the Supreme Court, and the person might or might not eventually be executed. The death penalty is a system with a lot of exits. Meaning, the grand jury might not indict you- that's rare- the district attorney might not seek the death penalty, the jury might not give you a death sentence. Even if you go to death row, you might get your conviction and/or your sentence overturned on appeal. So in many studies what I've done is looked at the effect of race on that process. A lot of people would assume that, in the modern death penalty, there's bias against black defendants- which, that has been found in some studies in some places, but the effect is not very consistent. It occurs in some places, at some time periods. What tends to be universal is that the victim matters. If you killed a white victim, you're more likely to get the death penalty- especially a white woman, especially a high status white woman. So what the system really turns on is, "Did you kill someone who 'matters' to society?" Part of that is probably a product of labor. The average time between a murder and an execution is now more than 20 years. If a prosecutor is going to decide, "I want to go for the death penalty," that is a decision to devote resources to

a case for decades. From picking a jury, to presenting a case, but even more so the decades on appeal. So, whose life and death is worthy of that amount of effort? The people running the system- even today, but certainly in the past- were white men, and the deaths of white victims were more likely to spur them to take on a 20 year project to see someone punished in the most extreme way. My research tends to be quantitative, and what I'm doing is I'm estimating statistical models that tell us: Does race affect the process I just outlined, even after we consider other factors such as the heinousness of the crime, the defendant's criminal history, whether the person was able to hire a lawyer, and so forth. And the results are consistent- what really matters is the social characteristics of the victim.

3 COULD YOU TELL ME ABOUT WHAT YOU ARE CURRENTLY WORKING ON?

I am currently working on a study of historical lynchings. A lot of people have argued that the modern death penalty is analogous to historical lynchings, and it's an interesting question, to what extent there are parallels versus differences. There are some key differences. For example in historical lynchings there tended to be a notion of collective liability. The mob would prefer to kill the person who allegedly hurt the victim, but the person's brother might be good enough if they can't find the person. In modern executions, it's individual liability. We're not going to execute the brother of the offender. On the other hand, there are a lot of similarities. And the similarity that I've been studying is- I just mentioned that you're much more likely to get the modern death penalty if you kill a white woman- so I've been studying, in terms of historical lynchings, "Are you more likely to suffer the most gruesome lynchings if you allegedly hurt a white woman?" To be clear, all lynchings were gruesome and horrendous, but you could argue that some were even worse than others. Most lynching victims were killed with bullets and ropes. And in fact, firing squads and hanging have always been legal methods of execution by the state. What I'm looking at is, "When did the mob go beyond guns and hanging, to do things like burn someone at the stake?" Some lynching victims were tied to ropes behind horses, and they would send the horse off and drag the person to death as they bounced along rocks and stumps. Later, people used cars for the same exact purpose. Some lynching victims were stabbed to death, some were beaten to death, some were castrated, some were decapitated, so if we're looking for parallels between historical lynchings and the modern death penalty, one place to look is: Does allegedly hurting a white woman lead to the most extreme punishment in both what people call popular justice by the mob and state justice by the government. Last quarter, the stu-

dents in my statistics class helped collect and code data on this question. We have a dataset that was collected by other people- who made a herculean effort to look up every lynching that occurred in the South between 1865 and the present. The original dataset includes a description of what happened, a narrative account. Our students read the narrative account, we developed a codebook, and we coded variables based on the narrative account plus other information. And sure enough, we found that there are parallels between historical lynchings and the modern death penalty, because if you hurt a white woman, you're considerably more likely to suffer the most extreme pain and the most extreme punishment. So that's what I've been working on lately- parallels between historical lynchings and the modern death penalty.

4 WHAT MADE YOU WANT TO BE A PROFESSOR?

The honest answer is that I was on the debate team in high school, and I wasn't a very good student in high school, but I loved the debate team. I would spend countless hours preparing for tournaments, writing arguments, writing responses to potential arguments by the other team- in fact, in high school I usually had two notebooks on my desk, one for taking class notes and one for writing arguments, and I was usually not paying attention, because I was writing arguments. So I was involved in this really academic pursuit while simultaneously not doing well in school. I probably got into college on the strength of my debate record, not my school record. And in college I was thinking about a career and I always thought, "Well, being a lawyer is the closest thing to being on a debate team, and that was a lot of fun." But then I realized- that's true of some lawyers who go to court, but a lot of lawyers never see the inside of a courtroom. And I thought, watching my college professors, that's a lot closer to being on a debate team because I get to decide what I want to study, I get to collect the data, analyze the data, put together an argument, try to make a compelling case, no one tells me what to do, I just get to decide what I want to study and how I want to study it. And teaching a class means trying to explain complicated ideas in the most articulate way you can- another parallel. It sort of dawned on me as an undergrad that what I had enjoyed so much in high school was much more similar to being a college professor than to being a lawyer. I had applied to law school, I was headed to law school, and one of the last classes I took was social psychology by a professor named Dr. Katovich. He was smart, and hilarious, and he really looked like he liked his job, and I thought, "Maybe I'll just do that." I also worked with another professor named Dr. Kinkade- he was a criminologist and gave me some opportunities to get involved in research,

and took me to the American Society of Criminology meeting as an undergraduate. And I looked around at Dr. Katovich and Dr. Kinkade and thought, "They look like they're having fun."

5 WHAT IS YOUR FAVORITE CLASS TO TEACH?

I like teaching statistics because I like the fact that I can make it about cause and effect, which I think is one of the central questions in social science, and not about chugging through formulas. So, how do we know if A affects B, how do we do sound research that establishes causal relationships- establishes is probably too strong of a word- and I like showing students how to design a research project, how to implement a research project, how to analyze data, how to reach conclusions that are defensible. I also like my class called Conflict and the Law because it is a very theoretical course. It covers the ideas of a sociologist named Donald Black, and I think he was brilliant and even revolutionary. He developed his own paradigm, his own theories, and what he did is very different than a lot of modern sociology. I always liked what he was trying to do, and I think that's an interesting challenge, to teach that class, because you're trying to teach students how to apply abstract theoretical ideas to concrete situations. And then of course, I love my death penalty class because that's the topic I've studied. That's where the theory and the statistics come together, applied to a particular topic. That class is interesting because we can talk about landmark Supreme Court cases, deterrence, retribution, innocent people being executed, racial disparities, class disparities, and all sorts of interesting topics.

6 IS THERE ANYTHING ELSE YOU WOULD LIKE TO ADD?

I think this job is really about creativity and solving puzzles. Because to come up with an idea, to come up with a question, that hasn't been answered, is tough. In the course of my career, I think I've had a couple of really good ideas, but the rest were just good ideas. They weren't all that special. And it takes a long time to land on something that is an especially good idea, and it comes like a lightning bolt out of the blue. For me, it only happened a couple of times in my career. I had plenty of good enough ideas. Good enough ideas are sufficient to publish a paper, to develop a record, to get tenure, to be promoted- but the reason I'm bringing this up is because getting an idea that's really good is unbelievably exciting. "Damn, that's a really good idea." That's not just a decent idea. And in this business that goes a long way. I've only had a few, but it was very satisfying. So if you're the kind of person who likes solving puzzles- in this case, research puzzles-

and you like to spend your time thinking, and you're really excited by ideas, this is a great career. It also just gives you the flexibility and the freedom to work on what you want to work on, it gives you the chance to work with a lot of smart undergraduate students, and to do whatever you can to help them along their way. It has been fun. Just as I thought it would be.



Lighthouse by Riley McCarthy

DU Undergraduate Showcase: Research, Scholarship, and Creative Works

PAGES AND PAWS: AN EXPLORATION OF THE BENEFITS OF MENTORSHIP BASED READING

Sophia Wismar¹, Henry Staats¹, Allison Metzler¹, Chloe Puckett¹, Rachel Levine², Christa Kilpatrick³, Scott Wolf⁴

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Our project focused on the poor literacy rates in the Denver metro area. Through extensive research with public organizations and nonprofits we learned that lower literacy rates are partly caused by children having low motivation to engage with books. To address this we partnered with the nonprofit Humane Colorado to bring students from the Denver Public School District into shelters to read to animals and engage in mentorship based reading projects. The increase of apathy surrounding literacy and reading, caused by a lack of engagement and structured education, is creating lower literacy rates and decreased motivation to read. Thus, we wanted to explore how to build an increased motivation to engage with reading and community. We conducted ten weeks of interviews and research, which we used to write a thesis on our findings and our plan to engage with local communities to improve reading engagement. Then, we reached out to various nonprofits such as Humane Colorado and Burning Through Pages to coordinate an event based in a local community where students from Denver Public Schools will participate in mentorship style reading engagement. Our project encouraged children to read, connected them with local communities, and provided them with avenues to continue their reading.

ECO-ENGAGEMENT THROUGH YOUTH PROGRAMMING IN THE NEXT GENERATION OF CLIMATE LEADERS

Joe Walsh¹, Grace Doolittle¹, John Engebreston¹, Zoe Lopez¹, Christopher Aaby²,

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²Community Collaborator, Senior Program Director of Generation Wild and with Great Outdoors Colorado

As climate change becomes a topic requiring urgency and action, our group discovered that 1/3 of today's youth are considered "eco-disengaged," meaning they have low action, low awareness, and low concern for the issues facing our planet. Through our primary and secondary research, it was identified that students are wishing for more eco-involvement in terms of outdoor education and community members identified that there are gaps in Colorado's environmental education system. Given the need for more environmental awareness, our group strived to create a curriculum centered on engaging youth in age appropriate, climate related activities. Through hands-on mini labs, such as a sound safari and an urban heat walk, youth were able to connect to the changing climate and understand the significance of anthropogenic impacts. Youth learned basic ecology to connect the climate issue to the places they know and love. By delivering information to youth in an engaging and light hearted manner, the conversation of climate change can become educational and plant the seeds for the next generation of climate leaders. How can youth become knowledgeable and engaged in climate activism in an age appropriate yet effective way? This question is the culmination of many ideas shared through primary and secondary research, expressing the need for more climate awareness in youth to foster leadership moving forward. We met with key members of the climate and environmental science community, understanding how youth disengagement in climate activism has created an impact. Each meeting brought up the same idea, youth need hands on ways to learn about the risks our climate faces, leading to the creation of a curriculum and event centered around hands on environmental education. Our project met our goals of climate engagement as it created understanding and interest in the effects of climate change on the planet. Through mini labs, youth were able to enjoy the activity while learning how their actions have an effect on the environment.

"THREE IN A JEEP": EXPLORING THE CONDITIONS FOR SUCCESSFUL MANDATE ATTAINMENT IN UNITED NATIONS SPECIAL POLITICAL MISSIONS

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This thesis examines a specific type of United Nations peacekeeping operation, referred to as Special Political Missions (SPMs) and their progress in transitions from war to peace. While traditional peacekeeping has made advances in separating conflict and human rights development, SPMs provide concentrated specialization in areas, including electoral support, government mediation, and disarmament. Through a Structured Focus Comparison of three unique SPM case studies, this research explores what key dimensions are involved in successful Special Political Missions. By comparing the United Nations Mission in Nepal, United Nations Mission in Colombia, and United Nations Observer Mission in Bougainville, this thesis intends to learn why certain SPM missions complete their mission mandates and why others struggle to see progress. Under what conditions do United Nations Special Political Missions contribute to progress in transitions from war to peace? The following thesis utilized a Structured Focus Comparison to compare key dimensions between three distinct case studies. Each case was evaluated based on its completion of relevant factors in order to determine if the mandate was a success, partial success, partial failure, or failure. Ultimately, this thesis concludes that SPM outcomes are likely more successful when a mission has a positive relationship with the local host government and calls the UN to prioritize local stakeholder partnerships within their peacekeeping operations.

MOTHERS CHILDHOOD MALTREATMENT AND DEVELOPMENTALLY APPROPRIATE ATTRIBUTIONS OF 12 MONTH-OLD INFANTS

Katelyn Lamberton¹, Angela Narayan²,

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By integrating knowledge on mothers' histories of childhood abuse and neglect, parental attributions of their 12-month-old infants, and their reflective functioning of infants, this research aims to understand how maternal childhood trauma influences early appraisals of infants' developmental capacities. Identifying and deterring links between childhood abuse and neglect and inappropriate expectations of one's own young children is an important step in breaking the cycle of maltreatment across generations. With the focus on developmentally appropriate expectations and parental reflective functioning, this study provides crucial insights into how mothers with trauma histories may interpret and respond to their children's needs. Findings aim to inform interventions to promote resilience and positive parenting behaviors. For instance, knowledge gained from this study could shape parenting programs that encourage parental attunement, warmth, and responsiveness. Overall, this research contributes to the broader effort to support parents and caregivers in creating nurturing and positive relationships with their children that promotes healthy development. This study examined associations between developmentally appropriate attributions (DAAs), a novel construct, with maternal childhood maltreatment and maternal reflective functioning (RF) with their 12-month-old infants. The study objectives were to examine if 1) DAAs were associated with parental reflective functioning at 12 months, and 2) higher levels of maternal maltreatment history were associated with lower DAAs. Participants were 156 mothers (40.0% White, 25.5% Latinx, 14.9% Black, 5.5% Asian, 2.1% Native-American, 12.0% biracial/multiracial) and their 12-to-15-month infants. Childhood maltreatment and RF were assessed by parental self-report at three-months and 12-months postpartum, respectively, and parental DAAs were assessed with the Five-Minute Speech Sample (FMSS) at 12 months, audio-recorded, and later coded by trained raters. Current findings revealed that while DAAs and RF were not significantly associated, maternal childhood maltreatment significantly predicted lower maternal DAAs of 12-month-old infants. Exploratory analyses showed that, of the childhood maltreatment subtypes, maternal history of childhood abuse, and particularly emotional abuse, predicted lower DAAs.

THE QUALITY OF EDUCATION: CONNECTING ACROSS DIFFERENT BACKGROUNDS

Gilkah Argueta¹, Habiba Samir¹, Girena Tesfazghi¹, Genet Kenore¹, Sinit Tesfamariam¹, Effley Brooks², African Leadership Group (ALG)³, Breakthrough Collaborative at Kent Denver³

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³Community Collaborator

Our team wants to advocate for the quality of education for students from immigrant backgrounds. Using our partnerships with ALG and Breakthrough we have created a training workshop. Breakthrough provides a pre-collegiate summer program for students from underrepresented backgrounds starting from 7th grade. For these summer programs, they hire teaching fellows which are usually undergraduate or graduate students pursuing a career in education. We are going to be presenting our training workshop on connection and empathy to these teaching fellows. Due to teaching fellows being of different backgrounds from their students, we want to make sure they still establish a connection with them and a mutual respect. We want to address cultural barriers and make the classroom a positive environment where there isn't tension between students and teaching fellows. How can we improve the quality of education for students from underrepresented backgrounds in our community in a sustainable way? We first found partners who knew more about the subject, we learned more about Breakthrough and ALG helped us with setting up our workshop. Since we were students who had cultural barriers with our own educators, we want to share that perspective with incoming educators, so they prioritize how they connect with students. Our workshop will be presented to teaching fellows of Breakthrough this summer, and it will also be presented to graduate students at DU before then. We are hoping this workshop speak to those who listen and will be hosted annually.

CARE FOR THE CAREGIVERS: STRENGTHENING DEMENTIA SUPPORT SYSTEMS

Abi Newell¹, Megan Doherty¹, Natalie Baer¹, Lexi Blood¹, Talya Riciputi¹, Effley Brooks², Morning Star Assisted Living³

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³Community Collaborator

With each team member having a personal connection to dementia, we decided to pursue the goal of helping somehow in this community. Through primary research, we have been in contact with many stakeholders in the dementia care community and have found that an area that can use more support is caretakers specifically. We have created connections at local assisted living communities to talk with staff, and these conversations have led to tangible ideas for change and improvements within support of caretakers both on a peer-to-peer and leadership-to-caretaker level. We are now working with families and leadership to implement these ideas to create sustainable change within these communities.

RESISTANCE AND CARE: TOOLS OF MOVEMENT BUILDING

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This poster details research conducted by the Documenting the Past Fostering the Future project, focused on spotlighting Chicano resistance and movements that flourished in Southern Colorado and Northern New Mexico. Through oral histories and exploring a community run newspaper, a rich and lesser-known history of El Movimiento/The Chicano Movement emerges from listening to voices often overlooked. What does El Movimiento mean across Colorado and New Mexico? Qualitative Research Methods, including oral histories and archival research. Our project has had the impact of creating a nuanced understanding of Chicano identity, struggles, and El Movimiento. While exploring both past community efforts and engaging in meaningful conversations with community elders today, this project has helped to bridge local history with an ongoing dialogue and understanding of identity and movement building.

THE STUDY OF THE COPATHOLOGY OF TAU AND α -SYNUCLEIN ASSOCIATED WITH LEWY BODY DEMENTIA

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My project focuses on understanding how two proteins, tau and α -synuclein, contribute to Lewy body dementia, a brain disorder that affects memory, movement, and behavior. I study how these proteins clump together on their own and when combined, and whether small molecules, called ligands, can influence this process. A central part of my work involves producing full-length tau protein, which is normally difficult to make in the lab. By

optimizing the production process, I was able to obtain enough high-quality tau to perform experiments that better reflect human disease. I then analyzed protein aggregation using biochemical assays to measure clumping under different conditions, including the presence of potential therapeutic ligands. This research helps reveal how tau and α -synuclein interact to drive neurodegeneration and provides insight into potential strategies to slow or prevent disease progression. My project addressed how tau and α -synuclein, two proteins linked to Lewy body dementia, interact and aggregate, and whether small molecules can influence this process. Understanding these interactions is important because they contribute to neurodegeneration and may reveal strategies to slow or prevent disease progression. I produced and purified full-length tau and α -synuclein proteins in *E. coli* and measured their concentrations for consistency. I then monitored protein aggregation over time using Thioflavin T fluorescence, comparing tau alone, α -synuclein alone, and a mixture of both, with and without potential therapeutic small molecules. I developed an optimized method for producing full-length tau protein, enabling more consistent experiments. Aggregation assays revealed a synergistic relationship between tau and α -synuclein: while each protein alone aggregated moderately, the mixture showed a rapid and significantly higher increase in Thioflavin T fluorescence over 120 hours, indicating that tau accelerates α -synuclein aggregation.

CYTOSKELETAL PROTEIN DYNAMICS IN ZEBRAFISH HEART REGENERATION

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Heart disease is one of the leading causes of death worldwide because the human heart has very little ability to repair itself after injury. In contrast, zebrafish can fully regenerate their hearts without forming scar tissue, making them an important model for studying how heart repair could be improved in humans. This project focuses on understanding how specific proteins behave during heart regeneration in zebrafish. I studied two proteins, VASP and Moesin, which help maintain cell structure and movement, to see how they change after heart injury. Using fluorescence imaging, we compared healthy hearts with hearts regenerating after injury. We found that Moesin increased in heart muscle cells during regeneration, suggesting it may play a role in rebuilding heart tissue. In contrast, VASP did not show significant changes. Additionally, neither protein showed major changes in blood vessels. These findings suggest that structural proteins like Moesin may be important for how heart cells reorganize and repair themselves after injury. Understanding these processes could help guide future research aimed at improving heart regeneration and developing new treatments for cardiovascular disease in humans.

USING MULTI-SENSOR SATELLITE IMAGERY TO DETECT AND TRACK TAMARISK INVASION ALONG RIPARIAN CORRIDORS IN THE SW UNITED STATES

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Tamarisk is an invasive shrub that has taken over riparian corridors across the southwestern United States, pushing out native plants and making restoration incredibly challenging. This study uses aerial and satellite imagery to detect tamarisk, depict its current distribution, and track its spread over the past two decades. Field measurements of tamarisk cover collected in 2024 at 10 sites across southern Utah and Colorado, along the Dolores River, San Miguel River, Salt Creek, and Colorado River corridors, were used to train a computer-based image classifier to identify three vegetation types: tamarisk, native riparian plants, and bare ground. Three different image sources were compared. NAIP aerial imagery at very high resolution (0.6 m), Sentinel-2 (10 m), and Landsat (30 m) to test which sensor best detects tamarisk from above. The classifier was then applied to past historical satellite imagery from 2000 onward to identify where tamarisk was newly established over time. Results suggest that the finest resolution imagery captures tamarisk most accurately, and that two decades of satellite data reveal clear patterns of spread and decline at treated sites. Overall, these explore how land managers and conservationists can use freely available satellite imagery to monitor the spread of invasive species, validate restoration outcomes, and prioritize future treatment areas across riparian ecosystems.

GENDERED JUSTICE: THE ROLE OF WOMEN'S CIVIL SOCIETY ORGANIZATIONS IN SHAPING CHILE'S TRUTH COMMISSIONS

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Scholarly literature has increasingly recognized that the inclusion of women and gender in formal transitional justice processes is essential for addressing the gendered nature of mass atrocities. This thesis seeks to contribute to the existing literature on how and why some transitional justice processes have come to address women and gender by specifically studying Chile's Rettig Commission and Valech Commission. Several hypotheses have emerged from the literature for why the Valech Commission addressed gender to a greater extent, including that women's civil society organizations, diffusion of international norms, and shifting domestic politics each played a role. Grounded in an anti-reductionist approach, this research utilizes the method of contribution analysis to strengthen and revise the theory that women's civil society organizations contributed to increased inclusion of women and gender in Chile's Valech Commission. The results of this analysis reveal that women's civil society organizations contributed on two levels: through formal collaboration and through public demonstration. By illuminating these strategies alongside inherent complexities and interactions in the case, this thesis contributes to a more nuanced understanding of how transitional justice processes come to address gender. Why do some formal transitional justice processes include women and address gender while others do not? Specifically in the case of Chile, why did the first truth commission (the Rettig Commission) not address gender, while the second truth commission (the Valech Commission) did? These questions are important for addressing the gendered nature of conflict and mass atrocity in the post-conflict setting. Grounded in an anti-reductionist approach, this research utilized a contribution analysis in order to better understand how women's civil society organizations contributed to Chile's Valech Commission addressing gender. In order to conduct the contribution analysis, where a theory of change is tested against new evidence, data was collected from primary source documents (newspaper articles, government documents and reports, organizational statements and documents, published interviews) accessed through digital, public archives in Chile in order to trace the processes of contributions made by women's civil society organizations. The results of this thesis advance new understandings of how women's civil society organizations contributed to greater inclusion of women and gender in Chile's Valech Commission, offering important implications for the broader field of gender and transitional justice. Beyond strengthening the initial theory of change, the findings of this contribution analysis offer critical revisions and nuances to the contribution story by demonstrating that women's civil society groups, through the processes of public demonstration and formal collaboration, contributed to the inclusion of women and gender in the Valech Commission.

ASSOCIATIONS BETWEEN MATERNAL FEEDING PRACTICES AND CHILD DIETARY PATTERNS: A COMBINED OBSERVATIONAL AND SELF-REPORT APPROACH

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This project explores how the way mothers encourage their children to eat in a lab setting relates to what those children eat in everyday life. We observed mother-child interactions during a structured eating activity, focusing on behaviors such as encouragement, pressure, use of rewards, and overall engagement, and then compared these observations to parent-reported information about the child's usual diet. By linking what parents actually do with what children typically eat, this study aims to identify which feeding strategies are associated with healthier eating patterns and provide practical insight for improving child nutrition. How do maternal feeding behaviors observed in a controlled laboratory setting predict real-world dietary patterns in young children? This question asks whether the ways mothers encourage or guide their children to eat in a controlled lab setting are linked to what those children actually eat in their daily lives. It aims to determine if observed feeding behaviors can help predict real-world dietary patterns in young children. This study examines whether mothers' feeding behaviors observed during a structured lab interaction are associated with their children's real-world dietary patterns. Observed behaviors were then compared to parent-reported data on children's usual diet using a standardized questionnaire. Regression analyses will examine how different maternal feeding behaviors (verbal prompts, physical prompts, bribery/negotiation, and engagement) are associated with children's intake of fruits, vegetables, added sugars, and processed snacks. These models will control for factors such as child age, sex, maternal age, and family income to better isolate the relationship between feeding behaviors and dietary patterns.

EMOTIONAL EATING IN EARLY CHILDHOOD: THE ROLES OF MATERNAL EDUCATION AND FOOD INSECURITY

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Emotional eating, or eating in response to negative emotions rather than physical hunger, is common in young children, yet its underlying predictors remain unclear. This study examined whether food insecurity (having limited reliable access to adequate, nutritious food) is related to emotional eating behavior in three-year-olds. Using data from the University of Denver's Care Project lab, we observed how children interacted with snacks following a brief frustration task and compared patterns across families with varying food security status and socioeconomic indicators, particularly maternal education level. Contrary to the hypothesis, food insecurity was not a significant predictor of children's emotional eating behavior in this setting. Instead, maternal education level showed a more consistent association with children's emotional eating behavior, with higher education levels linked to greater engagement with food. These findings suggest that early eating behaviors may be shaped by broader family and environmental factors beyond food access alone. While emotional eating is common in young children, less is known about its socioeconomic predictors. This study examined whether food insecurity and maternal education are associated with emotional eating behavior in early childhood, given the importance of understanding how early environments shape children's eating and emotion regulation. We analyzed data from the Care Project study, in which three-year-olds completed a brief frustration task and then were given access to snacks, allowing us to observe how they interacted with food. Using statistical models, we examined whether family food insecurity and maternal education were associated with children's eating behavior, while accounting for other factors, such as child sex. Contrary to our hypothesis, food insecurity status did not significantly predict either the total number of eating events or total duration of food engagement in response to frustration. Instead, maternal education emerged as a significant predictor of both outcomes, with children whose mothers had higher levels of education demonstrating greater engagement with food.

ELECTROPORATION PARAMETER ANALYSIS TO ESTABLISH TRANSGENIC METHODS IN A FRESHWATER SPONGE

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Currently, investigating the origins of multicellularity in Metazoans is currently limited by the lack of genomic tools and model systems. As one of the earliest diverging animal lineages, Sponges (Porifera) are an ideal system for this field; however, there is a gap in sponge research resulting in few genomic databases and genetic tools. Recently, developments in genomic databases and cell-type specific markers have allowed for starting a larger project for establishing transgenic methods in freshwater sponges. The first step of this project is to improve efficiency of the recent discovery in electroporation tools. The goal of this research is to test electroporation parameters in the freshwater sponge *Ephydatia muelleri* to improve the efficiency of transgenesis in sponges; I aim to study the molecular biology of animal cell differentiation by developing a high-efficiency electroporation protocol as the first step of a broader project into the genetic basis of multicellularity. The project focused on developing and increasing efficiency of transgenic methods in freshwater sponges. We are testing the uptake and expression of foreign mRNA injected and electroporated in sponges. We designed plasmids to test their efficiency for injections and electroporation. These use fluorescent marker colocalization and nanoluciferase assays in plasmids to quantify levels of expression. Preliminary data before the research confirmed that electroporation was possible in *E. muelleri*. Throughout the project, efficiency was significantly increased through investigation into parameters and plasmid design. mRNA expression in sponge cells increased by 900% in Nanoluciferase assays and we are continuing to research injections with dual expression plasmid DNA with fluorescent markers.

GRANT RESEARCH AND PROPOSAL DEVELOPMENT FOR COMMUNITY-BASED CLIMATE ACTION AT ANCA

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³Community Collaborator, Accelerate Neighborhood Climate Action

My project is part of my internship with Accelerate Neighborhood Climate Action (ANCA), a Denver-based organization that supports climate action at the neighborhood level. This quarter, I have been focusing on grant research and proposal support to help the organization identify funding opportunities that align with its mission and current priorities. The goal of this work is to strengthen ANCA's ability to secure resources that can support its programs, partnerships, and future community-based climate initiatives. My project asks how a community-based climate organization can identify and pursue grant opportunities that match its mission, current priorities, and capacity. This question is important because grant funding can directly affect whether ANCA is able to sustain and expand its neighborhood-level climate work. I supported the project by researching grant opportunities, reviewing ANCA's goals and funding needs, and helping shape proposal language around the strongest options. I also worked on the grant-writing side by organizing information, thinking through budget and resource constraints, and helping frame a clear, logical, data-backed proposal that made a realistic case for funding. The project is still in progress, but its impact so far has been helping ANCA move from general funding needs to more structured, realistic grant opportunities supported by organized research, budget thinking, and clearer proposal framing. By helping shape data-backed proposals around the organization's priorities and constraints, my work has supported ANCA's ability to pursue funding in a way that is more strategic, credible, and actionable.

BUILDING TOGETHER: UNDERSTANDING RECRUITMENT CHALLENGES AND SOLUTIONS FOR A HOME HEALTHCARE CO-OP

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This project sought to understand what is needed to create a home healthcare cooperative (co-op) which will give workers like Certified Nursing Assistants (CNAs) a work environment run for and by other workers. Recruitment is one of the obstacles in creating a successful co-op, leading this project to focus on recruitment challenges and solutions for the Wezesha Dada Center (WDC) to overcome, helping the WDC determine recruitment in order to work along side other organizations to aid in the formation of a home healthcare co-op. What challenges and solutions exist when attempting to recruit for a home healthcare cooperative? This project used different preexisting information to understand and estimate some of the challenges and costs for recruiting for a home health care co-op. This project will help deepen The Wezesha Dada Center's understanding and ability to recruit for a home healthcare co-op.

CLIMATE AND MICROSITE INFLUENCES ON TREE SEEDLING RECRUITMENT AT THE MIXED CONIFER-SUBALPINE FOREST ECOTONE

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Climate change is threatening forests in the Rocky Mountains, where temperature and precipitation play a major role in tree regeneration. Increasingly hot and dry conditions may be causing widespread failures in seed germination and seedling survival. In addition, fine-scale variation in things like soil moisture, light availability, and soil temperature can interact with climate to shape regeneration patterns. By tracking first-year germination and survival, this project evaluated how these environmental factors influence the regeneration of six conifer species in the Rockies. This study investigated how variation in climate and microsite conditions influences tree regeneration. This is vital to understand, as first-year recruits are the most vulnerable life stage in a changing climate. We sowed the seeds of six conifer species across a range of microsites in a forest at the mixed conifer and subalpine forest ecotone and followed germination and first growing-season survival for two years. We quantified soil moisture, understory light, and soil surface temperature in each quadrat and used climate data to compare conditions in study years with historic and recent means. Higher germination and survival in 2019 were associated with a wetter and cooler climate, and higher soil moisture also positively influenced germination. Our results show that while variation in microsite conditions can provide microrefugia for regeneration, climate conditions appear to be the overriding factor behind first-year recruitment success.

PERSPECTIVE OF PROFESSIONALS IN ADDICTION-RELATED FIELDS REGARDING LABYRINTH WALKING FOR INDIVIDUALS IN ADDICTION RECOVERY

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My goal was to understand how labyrinth walking might play a role in addiction recovery and to identify research questions of interest to professionals in the area. Based on a review of the literature on meditation, labyrinth walking, and addiction recovery, I conducted five informational interviews of professionals working in addiction-related fields. Professionals were recruited through convenience and referral sampling. Four were conducted over Zoom and recorded using its built-in feature. One was conducted in person and recorded on a mobile device. Interviews ranged from 10 to 45 minutes. Interviews included 17 questions exploring insights on labyrinth walking as a supportive practice in addiction recovery, with a follow-up question based on their response to a previous question. All interviewees viewed labyrinth walking as a potentially helpful tool in the recovery process, and most hypothesized that those earlier in recovery would benefit more from this practice. Some interviewees mentioned that there can be challenges with engaging in seated meditation for individuals in recovery, such as sitting still. Interviewees indicated that meditation can be beneficial for those in recovery, because it fosters mindfulness and reduces impulsivity. I am using the literature review and interview information to work with a community partner to develop a research study to investigate whether labyrinth walking increases certain contributors to addiction recovery and/or enhances them more than seated meditation does. These contributors to recovery include hope, reflection, self-awareness, spiritual connectedness, and perceived social support. Do professionals in addiction-related fields think that labyrinth walking might be helpful for individuals in addiction recovery, and what questions would they have about it? What are the most important practices and factors that benefit individuals in recovery? I conducted informational interviews with five professionals working in addiction-related fields, asking them questions I developed after a review of the literature on meditation, labyrinth walking, and addiction recovery. I selected these professionals through convenience and referral sampling, invited them to meet through email, and organized their responses based on the recorded interviews. All the individuals I conducted informational interviews with expressed that they thought labyrinth walking could be helpful for individuals in addiction recovery, specifically, because those in recovery struggle to sit still during meditation. The project met its goals by identifying key considerations for future implementation when working with a community partner, FREE Recovery Community, on developing a research study investigating the effects of labyrinth walking on individuals in addiction recovery.

REGULATING THE TROUBLED TEEN INDUSTRY: AN ANALYSIS OF UTAH'S LICENSING SYSTEM

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This project seeks to understand the role of the Utah Office of Licensing in regulating and preventing harm in the troubled teen industry, which consists of private, for-profit behavior modification and residential treatment facilities. It provides insight into the regulation of the troubled teen industry by analyzing records from the Utah Office of Licensing, which include incidents of abuse, neglect, and other harmful treatment of adolescents in residential care. This study aims to add to discussions about regulatory structures, child safeguarding, and the responsible use of government funds in adolescent mental health care. The purpose of this study is to better understand the role of the Utah Office of Licensing in preventing child abuse in for-profit residential facilities by identifying common violations observed by the Utah Office of Licensing and the consequences given to violators. This will give insight into how states can build effective oversight frameworks to prevent child abuse in the troubled teen industry. This study analyzed records of ten for-profit adolescent mental health facilities from the Utah Office of Licensing, including inspections, restraint and seclusion records, and reports of abuse to identify themes in violations identified by the Utah Office of Licensing, penalties for violations, and facility responses to sanctions. Beyond a thematic analysis, this study also tracked patterns in the types of incidents reported to the Utah Office of Licensing. While this project is still in progress, preliminary results show several weaknesses in Utah's regulation of the troubled teen industry. Ultimately, these results will promote the public good by providing recommendations for how state regulatory agencies can better protect the rights of youth in residential treatment centers.

GOAL AND INCENTIVE PRESSURES HAVE DIFFERENT EFFECTS ON RISKY DECISION-MAKING

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The notion of pressure is intuitive, yet it is still unclear how different kinds of pressure systematically affect different dimensions of decision-making. For example, sometimes pressure arises from the difficulty of one's goals. Alternatively, pressure can arise when there is much at stake, regardless of how difficult the goal is to achieve. Previous studies have investigated the impacts of goals and stakes on decision-making independently, but their potential interaction has not been examined. Similarly, decision-making behavior may be affected on dimensions including the choices made, the process of making those choices, and the affective experience of doing so, though most previous research has only focused on choice performance. In this thesis, we specifically examined the impact of two forms of pressure: 1) goal pressure, defined as the difficulty level of a goal, and 2) incentive pressure, defined as the bonus at stake if a goal is achieved. We examined these in the context of a risky decision-making laboratory task completed by 66 participants. In each of 4 blocks participants were instructed to attempt to reach a particular level of earnings in that block, and if they did so, they earned a monetary bonus. In addition to a subject fee, participants were paid their actual earnings (including bonuses) scaled by a scaling factor, making all choices, goals, and bonuses consequential. Each block was associated with a different and independently varying combination of goal (low vs. high earnings) and incentive (low vs. high bonus) pressures. We analyzed risky vs. safe choices, decision times as an index of cognitive effort and process, and skin conductance as an indicator of affect. We found separable impacts of goal and incentive pressures on decision-making. As expected, low goal pressure (i.e. an easy-to-reach earnings goal) increased goal achievement, and participants learned to achieve low goals more often over time in the study. We also found a reliable pattern of changes in risk-taking as a function of goal achievement. Participants were more conservative and slower to decide just before surpassing a goal, after which risk-taking and decision speed significantly increased. Incentive pressure, however, had little effect on choices, only impacting expected earnings, which may have influenced decision optimization. These findings suggest that goal but not incentive pressure, is a primary driver of adaptive changes in risky decision-making. How does pressure from the difficulty of achieving a goal versus the stakes of doing so differentially or interactively affect risky decision-making, the cognitive processes underlying evaluation and choice, and people's affective experience? We used a risky decision-making task that required people to navigate uncertainty while manipulating the goal earnings people were asked to reach, and the bonuses they could receive for doing so, to create a compounding pressure environment. We also assessed individual differences to see if specific attributes, like anxiety, goal attitudes, etc., might influence how people coped or responded to the imposed pressures. In our sample, we found that people change their behavior much more in response to differing levels of goal pressure (the earnings level to reach), and showed few effects of incentive (bonus amount) pressure in their choices. These findings highlight the critical importance of separating different potential components of pressure alongside different aspects of decision-making, and more broadly emphasize the importance of goals in dramatically altering behavior and ultimately performance.

INCLUDE OR EXCLUDE: THE ROLE OF GENDER DIVERSITY IN GROUP NORM JUDGMENTS

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Humans are highly attuned to group norms; however, judgements of what is normative can be biased by the behaviors of those that deviate from the norm (i.e., outliers). While prior research shows that behavioral outliers can shift judgments of norms, it is unknown whether this effect depends on social identity. In the current study, I examine how the behavior of individuals with stigmatized identities can influence norm assessments. That is, I investigate if the social behavior of a transgender individual is excluded from group norm judgements. Participants (N = 250) viewed individuals arriving to a teleconference co-working session, with their arrival time highlighted. The group included one time-based outlier which varied by gender identity (cisgender, transgender). Two findings offer initial evidence that participants encoded the trans employee's lateness but did not incorporate it significantly into their norm beliefs. Together, the results aim to clarify the relationship between behavioral outliers, norm judgements and gender, with a focus on how biased group perception can contribute to the exclusion of marginalized groups.

THE CASE FOR SANCTUARY: WHY DENVER, AND EVERY CITY, SHOULD ADOPT PROTECTIVE POLICIES

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Sanctuary policies limit how much local law enforcement cooperates with federal immigration authorities, which can shape trust, public safety, and access to essential services. Through an analysis of existing research and policies in other cities, this project evaluates the legal, economic, and human consequences of adopting sanctuary protections. It argues that sanctuary policies can strengthen community safety and stability by allowing immigrant residents to engage more fully in public life without fear. Ultimately, this work presents a case in favor of sanctuary policies as a practical and ethical approach to local governance. This project examines the role that sanctuary cities play in response to immigration enforcement practices, and the benefits of adopting these practices for both immigrant and non-immigrant communities. The question matters because local policy decisions directly shape the safety, economic stability, and civil rights of these communities, regardless of their citizenship status. This project uses a qualitative literature review of legal scholarship, policy analyses, and case studies of existing sanctuary jurisdictions. It also incorporates local context by examining Denver's current policies and comparing them to established sanctuary models in official sanctuary cities like Chicago and San Diego. The findings suggest that sanctuary policies are associated with improved public safety outcomes, stronger community trust in local institutions, and increased stability. This project contributes an argument for adopting sanctuary protections in Denver and beyond as a means of advancing human rights and the public good.

INVESTIGATING OPTICAL ANALOGUES OF COSMOLOGICAL PERTURBATION DYNAMICS

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This project investigates the possibility of constructing optical analogues of cosmological perturbation dynamics during inflation by exploiting structural similarities between the governing equations of each system. In particular, we analyze the correspondence between the Mukhanov–Sasaki equation for gauge-invariant scalar perturbations and the paraxial wave equation describing the evolution of coherent electromagnetic fields. Both systems can be written as second-order differential equations with time- or propagation-dependent effective potentials, suggesting a formal mapping between cosmological mode evolution and optical beam propagation. Within this framework, conformal time in the cosmological system is associated with longitudinal propagation distance in an optical medium, allowing the evolution of perturbation modes to be interpreted in terms of the transformation of optical field envelopes. We examine how key features of inflationary dynamics—such as mode amplification, horizon crossing, and freeze-out—can be recast in terms of beam evolution, with quantities like the Rayleigh range providing a potential analogue to the cosmological horizon scale. Using Gaussian beam optics and ABCD matrix formalism, we study how sequences of optical elements or engineered refractive index profiles can generate effective potentials analogous to those appearing in the Mukhanov–Sasaki equation. This work is primarily theoretical and aims to delineate both the possibilities and limitations of such analogies. Ongoing efforts focus on determining whether specific inflationary scenarios—such as slow-roll or non-standard models—can be meaningfully approximated within experimentally accessible optical configurations, and on clarifying which features of cosmological perturbation theory can be faithfully represented in a laboratory setting.

AFFORDABLE AIR QUALITY SENSORS: PROMISING TECHNOLOGY OR INSUFFICIENT SCIENCE?

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Air pollution from aerosols and their precursors remains a pressing global health and environmental issue, with significant regional variation. Locally, Denver continues to experience some of the worst air quality in the continental United States, consistently ranking among the top 10 worst regions for ground-level ozone pollution. This project addresses the need for affordable, accessible air quality monitoring tools by evaluating the performance of BlueSky's low-cost ambient aerosol and gas sensors. Low-cost electrochemical sensors, like the BlueSky by TSI, have emerged as an affordable alternative. This project evaluated whether these sensors are accurate and reliable enough to serve as legitimate scientific instruments, using Colorado as the study area due to its notable

air quality challenges. BlueSky sensor readings were compared with a reference-grade state monitoring station, and statistical models were used to test whether environmental factors such as temperature and humidity could explain measurement errors. The results showed that while these sensors can broadly detect whether air quality is good or bad on a given day, their errors were too large, inconsistent, and unexplainable to meet the standards of scientific research. Both the promise and the current limitations of affordable air monitoring technology highlight the importance of rigorously testing research instruments. Low-cost electrochemical sensors are increasingly marketed as accessible tools for monitoring air pollutants like ozone and nitrogen dioxide, but whether they meet the standards required for meaningful scientific research remains unclear. This project examined the accuracy and reliability of the BlueSky by TSI sensor in Colorado to determine whether affordable air monitoring technology can serve as a legitimate research instrument. Three BlueSky sensor readings of ozone and NO₂ were co-located and compared with a reference-grade monitoring station operated by the Colorado Department of Public Health and Environment (CDPHE). Statistical regression models in SPSS and Igor Pro were used to evaluate how well the sensors tracked true pollutant levels and whether environmental factors, such as temperature and humidity, could explain measurement errors. While the low-cost electrochemical BlueSky sensors could broadly detect highs and lows in pollution, analysis showed they lacked the precision required for scientific research. The errors found in the sensor data were largely unexplained and inconsistent, suggesting that, as low-cost electrochemical technology, it is not a reliable substitute for professional-grade instrumentation in research contexts.

OPTIMIZING AERODYNAMICS RELATED TO LONG ENDURANCE AND STATION-KEEPING HIGH-ALTITUDE AIRSHIPS

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High-altitude airships, generally operating at altitudes of around 20 km, are used for telecommunications and remote sensing applications. This research focuses on improving the endurance of these airships by reducing drag forces, which directly impacts energy consumption. Using computational fluid dynamics through Ansys Fluent, this study will analyze drag forces on different airship geometries over White Sands, NM in the winter. Simulations will consider three wind speeds, representing typical wind conditions during winter months, to assess maximum drag forces. Initial simulations will evaluate a predefined airship shape before exploring modified geometries. This research found that increasing the leading length of the airship reduces the drag coefficient and increasing the diameter increases the drag coefficient. One strategy for improving the endurance of high-altitude airships is to reduce energy consumption, particularly by minimizing the drag caused by wind resistance. This project will focus on this idea by exploring how different airship shapes affect drag forces. I altered the diameter and leading length of a standard airship geometry to create various models, which were tested with computation fluid dynamics simulations in Ansys Fluent. Increasing the leading length was found to reduce drag coefficients and increasing the diameter resulted in increased drag coefficients. These relations demonstrate how geometric modifications directly influence drag and provide guidelines for designing high-altitude airships with more endurance.

PLANTS BRIDGING PEOPLE: SURPRISE VALLEY INDIGENOUS TRADITIONAL ECOLOGICAL KNOWLEDGE FIELD DAYS

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³Community Contributor

Plants Bridging People: Surprise Valley Indigenous Traditional Ecological Knowledge Field Days brings together tribal members from the Gidútikäd Band of the Northern Paiute, local community partners, land managers, and university researchers to focus on First Foods, especially yapa, a culturally important root plant. The project looks at how traditional practices like harvesting and cultural burning affect the health and growth of yapa, while also creating space for knowledge sharing between elders, youth, researchers, and the wider community. My own contributions have centered on community engagement, youth-oriented educational materials, and helping communicate the importance of this work in accessible ways. The project goes further than plant data alone, it focuses on relationship building, cultural continuity, and supporting Indigenous knowledge in conversations about land stewardship and public land management. Can community engaged and collaborative anthropological

practices lead to positive outcomes for Indigenous communities in terms of advocating for greater sovereignty in management of resources on ancestral lands? This project utilized community-based workshops, field days, plant monitoring, harvesting activities, and collaboration with tribal members, elders, researchers, and land managers. This project helped strengthen relationships between tribal community members, researchers, and public land managers while supporting the sharing of knowledge across generations. It also contributed to ongoing research on yapa and helped create educational and community-facing materials that make this work more accessible, especially for youth and families.

THE NEUROPROTECTIVE EFFECT OF CDC42 INHIBITION IN THE G93A MUTANT HSOD1 MOUSE MODEL OF ALS

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Amyotrophic lateral sclerosis (ALS) is a progressive and fatal neurodegenerative disease characterized by the selective loss of upper and lower motor neurons, leading to muscle weakness, neuromuscular junction (NMJ) degeneration, paralysis, and eventual death due to respiratory failure. Despite extensive research, effective disease-modifying therapies remain limited, underscoring the need to identify novel molecular targets involved in ALS pathogenesis. Dysregulation of Rho family GTPases has been implicated in neurodegeneration, with Rac and Rho exerting opposing effects on neuronal survival; however, the role of the closely related GTPase Cdc42 remains poorly understood in ALS. In this study, the therapeutic potential of inhibiting Cdc42 was evaluated using ZCL367, a small molecule Cdc42 inhibitor, in the G93A mutant hSOD1 (hSOD1^{G93A}) mouse model of ALS. Treatment was initiated at disease onset and continued until end-stage. Disease progression was assessed through survival analysis, longitudinal behavioral testing of motor strength and coordination using paw grip endurance and rotarod assays, and postmortem histological analysis of NMJs in the gastrocnemius muscle. ZCL367 treatment did not significantly extend survival; however, treated mice exhibited significant preservation of muscle strength, coordination, and endurance compared to untreated and vehicle-treated controls. Additionally, ZCL367-treated mice showed a significant preservation of NMJ size and structural complexity, despite no significant effect on gastrocnemius muscle weight. These findings suggest that Cdc42 inhibition can preserve neuromuscular structure and motor function in ALS, even in the absence of prolonged survival, and identify Cdc42 as a novel contributor to ALS pathogenesis and a promising therapeutic target for slowing functional decline.

This study investigates whether pharmacological inhibition of the small GTPase Cdc42 using the compound ZCL367 can mitigate disease progression in ALS by preserving neuromuscular junction integrity and motor function in a mutant hSOD1 mouse model. More broadly, it asks whether targeting Cdc42 represents a viable therapeutic strategy for slowing functional decline in ALS, even in the absence of extended survival. We treated hSOD1^{G93A} mutant mice with the Cdc42 inhibitor ZCL367 beginning at disease onset and monitored disease progression through behavioral assays (paw grip endurance and rotarod), survival analysis, and postmortem histological evaluation of neuromuscular junction structure. These outcomes were compared to untreated and vehicle-treated controls to assess the therapeutic effect of Cdc42 inhibition. ZCL367 treatment did not significantly extend survival in the hSOD1^{G93A} mouse model, but it led to a significant preservation of motor function, strength, and neuromuscular junction structure compared to controls. These findings suggest that Cdc42 inhibition may slow functional decline in ALS and represents a promising therapeutic target despite not altering overall lifespan.

CRISPR-BASED MULTI-GENE EDITING IN YEAST FOR STUDYING PROTEIN DEGRADATION PATHWAYS

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This project focuses on improving gene editing in yeast, a simple eukaryotic organism widely used to study cellular function. Current methods are relatively inefficient, especially when modifying multiple genes at once. To address this, we developed a CRISPR-based system that can precisely edit several genes simultaneously without relying on traditional selection markers. This approach makes genetic research faster and more scalable, helping scientists better understand processes like protein breakdown and related diseases. Cells must continuously break down damaged or unnecessary proteins to stay healthy, but the genes involved in this process are not fully understood. This project asks how we can improve genetic editing tools in yeast to efficiently study multiple genes

at once, enabling deeper insight into these essential cellular pathways. We engineered a CRISPR-Cas9 system by designing guide RNAs through PCR and assembling custom plasmids capable of targeting multiple genes simultaneously. These plasmids were introduced into yeast cells to evaluate editing efficiency, accuracy, and the ability to perform markerless genetic modifications. This project demonstrates a more efficient and flexible method for editing multiple genes in yeast, especially in cases where traditional approaches fail due to limited selection markers. By enabling simultaneous, marker-independent edits, this system expands the ability to study complex genetic interactions and provide a scalable tool for investigating protein degradation and disease-related processes.

RESEARCH INTO URBAN FORESTRY EMPLOYMENT TREND IN COLORADO

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The Park People has a paid pre-apprenticeship program called TreeForce dedicated to educating people on tree care to prepare them for careers across the industry of urban forestry. My project was to assist this program by conducting research into industry needs, hiring positions, and seasonal trends so that the program can continue to adequately prepare its apprentices for an ever-changing industry landscape. What does the current landscape for urban forestry employment look like season-by-season, and how can TreeForce use this information to best equip its apprentices for careers in this field? 1. Receive guidance from TreeForce on positions/criteria to research. 2. Create a job registry based on online listings sorted by Job title found on platforms like ZipRecruiter, Teal, Indeed, etc.. 3. Analyze data collected from these listings to extrapolate statistics such as average salary, common locations, expected benefits, etc by job title. 4. Incorporate these statistics into a presentation. 5. Share/Present this information to the TreeForce team to be used in their programs. 6. Repeat once for Winter, once for Spring I was able to create presentations that articulated the breadth of the current employment landscape, with common job listings, locations hiring, skills necessary, salary expectations, and much more. This information is valuable to TreeForce because it allows them to adequately prepare their apprentices for this job market, and to adjust their employment expectations realistically after completing the program.

RACE-TO-THE-TOP DATA CENTER POLICY: ELECTRICITY, WATER, AND RATEPAYER PROTECTIONS ACROSS STATES

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My project looks at how the rapid growth of large “hyperscale” data centers is creating tradeoffs for electricity, water, and local communities. Although data centers make everyday tools like AI, cloud storage, email, and streaming possible, their resource use is concentrated in specific places, meaning the impacts are uneven across electric grids, utilities, and watersheds. Because there is no consistent federal framework for managing these tradeoffs, states are key decision-makers in whether data center growth becomes a “race to the top” in clean energy and efficient cooling, or a “race to the bottom” driven by incentives and cost-shifting. To evaluate this, I compare state policy approaches, especially Minnesota’s new data center law (HF-16) and contrasting examples like Virginia, to identify what governance tools best protect ratepayers and environmental resources while still allowing necessary infrastructure to expand. How can state policy can guide data center growth toward a “race to the top,” where new facilities support clean energy and efficient water use, instead of shifting costs onto ratepayers or stressing local resources. Data center electricity and water use is already growing rapidly, and state-level policy decisions are increasingly determining whether that growth supports or deters decarbonization goals and equitable outcomes. I used a multi-state comparative case study method, combining policy analysis of statutes and regulatory structures with targeted case examples to evaluate how states govern data center impacts on the grid, water, and communities. I then synthesized these findings to identify which policy tools best prevent cost shifting, support clean energy, and improve water governance as hyperscale projects expand. For my final tangibles, I wrote an essay, and am creating a data center policy state-by-state scorecard. My results show that impacts are directly correlated with maturity of states’ policy. Minnesota’s HF 16 bundles clean electricity compliance, ratepayer protection, and water-related permitting conditions into an early-stage governance framework, while other states with entrenched industries, like Virginia, face more reactive and fragmented policy debates. As an applied example, Minnesota’s approach is already shaping growth, including a case where a proposed Google facility is paired with

large additions of wind, solar, and long-duration storage funded by the company rather than ratepayers.

IMPROVING ACCURACY OF SUPER-RESOLUTION IMAGING

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This project aims to enhance super-resolution imaging techniques for deep tissue analysis. Current imaging methods are limited to superficial layers, which limits our understanding of activity of molecules in deep tissue, such as neurons. Imaging neurons in deep tissue can further our knowledge of learning processes. The Siemens Lab has demonstrated an imaging method that can image through 100 μm using spiral vortex super-resolution, but the resolution of the imaging is limited by how well the vortex is centered, and the current spiral being used does not take data from the full center of the beam. The research done in this project seeks to refine the previous method for deep tissue imaging. 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 used 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. The phase reconstruction reveals a clear vortex singularity and uniform azimuthal phase progression, enabling precise identification of the beam center. Unlike intensity-based methods, which lack sensitivity to phase discontinuities, this approach directly captures the vortex structure. These results support the hypothesis that combining phase and intensity measurements improves centering accuracy, which is critical for enhancing resolution in deep tissue imaging.

ASSOCIATIONS AMONG EMOTION REGULATION, INTERPRETATION BIAS, AND PANIC SYMPTOMS IN COLLEGE STUDENTS

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Panic is a highly distressing domain of anxiety, with some people experiencing panic symptoms or attacks, as well as some people meeting criteria for a full diagnosis of panic disorder. Previous work has found a tendency to interpret ambiguous stimuli (interpretation bias) as threatening to be a consistent correlate of anxiety, and prior research in some domains of anxiety, as well as other symptom domains, has found emotion regulation to be a correlate of symptoms. Given that many models of anxiety and panic propose integrated mechanisms working together to contribute to symptoms, understanding if and how emotion regulation and interpretation bias may interact and associate with panic symptoms is relevant. This project tests several aims related to the above constructs with panic symptoms in college students in an online study. This study examines associations between interpretation bias and panic symptoms, emotion regulation and panic symptoms, and whether interpretation bias and emotion regulation interact to predict panic symptoms. This work may advance the literature by combining previously distinct research domains in interpretation bias and emotion regulation in the context of panic symptoms, and may ultimately lead to an improved understanding of how correlates of panic may also relate to one another. College students completed self-report measures of emotion regulation and panic symptoms, as well as a computerized task assessing interpretation bias for threatening content relevant to panic. The results describe associations between different dimensions of emotion regulation and panic symptoms, as well as how emotion regulation and interpretation bias interact in the context of panic.

GEOGRAPHIC HISTORY OF DAIRY FARMING IN MINNESOTA

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This project aims to view how the geography of dairy farming has changed in Minnesota and to compare the

geographic landscape of areas of high and low counts of dairy cattle. It was thought that the landcover of areas with more dairy cows would be mainly prairie allowing for more space for cattle, while areas with less dairy cows would be heavily forested as these areas provided much less space for cattle. It was also thought that the types of landscapes where there were high counts of dairy cows would change from 1860 - 2022 as technologies change and population increases. Utilizing GIS methods of analysis, the geographic landscape of high counties and low counties were statistically different, painting a picture of what areas are suitable for dairy farming in Minnesota. The landscapes also changed as flat cropland became dominant in the modern period while landscapes were more variable during early settlement. However, when comparing pre settlement landcover with the counties where there are high and low counts of dairy cattle in the modern period, there is not much change. How has the geography of dairy farming changed in Minnesota? How could this inform about the future of dairy farming as human activity continues to change the landscape? Compiled data from US Census of Agriculture into ArcGIS Pro along with landcover data from the Minnesota Department of Natural Resources. Used spatial autocorrelation methods to find areas of significance for each year, then used a chi square analysis to determine if the landcovers of significantly high areas were different from significantly low areas. Areas with high counts of dairy cattle had significantly different landcovers than those with low counts of dairy cattle in both the pre settlement period and the modern period. This gives a better insight into how dairy farming potentially changes the landscape of Minnesota and what are the aspects of the Minnesota landscape that make it great for dairy farming.

MY WORK WITH DENVER INC

Mateo Mazariego-Halpern¹, Cara DiEnno², Keith Meyer³

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³Community Collaborator, Denver INC

My project is going to be highlighting the impactful work I have conducted over the past year working as a development intern for Denver INC, where I conducted research on grant work and sponsorship that can help with the organization's mission.

UNDERSTANDING THE USE OF HUMOUR IN DIGITAL ACTIVISM

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As the world continues to change, young content creators on social media platforms are adopting the concept of the original intent of sharing and discovering humorous ideas, specializing in meme culture, to garner attention from the public discourse. This study investigated the impact of utilizing memes in combating social injustice, with a focus on the Israel-Palestine conflict, using quantitative content analysis of 243 TikTok videos posted since October 7, 2023, and tagged with hashtags #israel and #palestine through analyzing numerous frames, elements, and emotional tones of the videos. The data show that (1) framing the event as a war, though commonly found in the set, decrease interaction significantly, contrasting past insights showing that negativity drives engagement, and (2) employing humor to discuss and spread information about heavy topics significantly increases interactions. This study suggests that using humor in social movements is effective in widening its ability to reach the public, but the impact of humor left on the audiences is currently unclear. The finding highlights a contrast that humor invoked between the seriousness of social movements and platform-driven virality. Therefore, the study invites digital activists to be aware that using humor can desensitize the audience from witnessing pain and suffering, while encouraging media consumers to have a critical eye toward media portrayals.

INSTITUTIONAL CONSTRAINTS AND LEGISLATIVE AGENCY:HOW PARTY, INSTITUTIONS, AND COURTS SHAPE WOMEN'S HEALTHCARE POLICY POSITIONS

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This research addresses a significant gap in the literature by linking gendered legislative behavior to judicial rulings as policy-shaping events. While women's representation in healthcare is well documented, less is known about how judicial interventions function as critical junctures that reshape institutional incentives. The research will examine how legislators' stances, as captured through votes, correlate with policy actions, such as bill sponsorship

and committee leadership. Employing a mixed-methods strategy, the research also incorporates process tracing of legislative actions at the congressional level in response to significant rulings and bills, such as Planned Parenthood v. Casey (1992), the Partial Birth Abortion Ban Act (2003), the Affordable Care Act (2010), and NFIB v. Sebelius (2012). Although party affiliation remains the strongest predictor of healthcare voting behavior, women legislators, particularly those with institutional authority, can meaningfully shape and advance healthcare policy when judicial rulings alter the legal and political landscape. In these moments, leadership positions enable women to translate judicial constraints or openings into legislative action, framing, and agenda control that would not otherwise be available. This project is necessary because it moves beyond static analyses of representation to explore how female legislators respond dynamically to external factors besides party affiliation, offering a novel intersection between judicial politics and gendered policy behavior.

EVALUATION OF DPPH ANTIOXIDANT ASSAY IN THE BEER INDUSTRY

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Beer is a beverage that has been enjoyed by many different peoples across human history. In the modern world, beer is produced in vast quantities and may be stored for months before reaching the consumer. For the product to have its intended properties when it reaches the consumer, brewers must be attention to the shelf-life of their beer. An important class of compounds that contribute to shelf-life are known as antioxidants, which react with species that want to oxidize and thus degrade the beer. Many studies have been done on the antioxidant capacities of beer and other foods and beverages. A popular method is known as the DPPH assay. DPPH is a very strong oxidizer that is purple in solution, but when it is reacted with antioxidants, the color changes to yellow. Thus, one can measure the amount of light absorbed by the sample at a specific wavelength before and after the reaction happens and get information on how well the sample resists oxidation based on the absorbance changes. This works great for many applications, but there have been questions about the accuracy in a complex medium like beer. There is potential for side products or other compounds present to absorb at the same wavelength as DPPH, thus causing one to underestimate the amount of DPPH reacted. DPPH can be detected more precisely using spectroscopy such as Electron Paramagnetic Resonance (EPR). This project compares the data obtained from a DPPH assay in beer between the absorbance measured on a UV-Vis spectrophotometer and the intensity measured on an EPR spectrometer to evaluate the accuracy of UV-Vis as an analytical instrument for this application.

DEVELOPING A COMMUNITY NEWSLETTER FOR DRIVEN BY OUR AMBITIONS

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⁴Community Collaborator, PlaceBridge Elementary School

Assisting a local community organization in outreach and exposure to aid at-risk community youth in getting emotional and behavioral therapy. What resources are available to mitigate youth recidivism? After research, we reached out to various local stakeholders to evaluate what methods were in place to mitigate the high rates of youth recidivism. We then partnered with Daniel Sampson from DBOA to support him in his efforts to provide emotional and behavioral resources and a third space to Aurora youth. Our preliminary research yielded that youth recidivism rates are high, especially in disproportionately impacted communities. Working with Daniel, we created a community newsletter which highlights alternative spaces for youth to spend free time and receive mental health and wellness support from professionals.

THE WORLD OF GRANT-WRITING:FUNDRAISING FOR SUSTAINED FARMS

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The question my project seeks to address is: what strategies can be employed to optimize efficiency and effectiveness in securing grants, while upholding the general values of a non-profit? Non-profit work has arguably

become more important than ever due to compounded need, yet funding in the grant-giving world is increasingly limited.

THE FEASIBILITY OF AN AQUAPONIC INTEGRATED ECO-PARK AS CLIMATE RESILIENT INFRASTRUCTURE FOR DENVER COMMUNITIES

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In collaboration with residents of the Valverde Neighborhood and Center for Community Engagement (CCESL) at the University of Denver, this research project demonstrates the necessity and potential success of infrastructure designed to bring native ecosystems to urban areas, combined with food-security (agroecology) and natural disaster resistance measures (green engineering). Informed by successful and well-known conservation and urban gardening infrastructure of floating treatment wetlands and aquaponics, this demonstrates applying existing knowledge in new ways. Focusing on building and co-designing ecosystem and food security with the community, a large part of this project was participatory service and learning. As a part of the friendship and collaboration with Valverde that emerged, the Platte People's Project interviewed neighborhood leaders, conducted river walks, and began making zines to initiate conversations. The goal of this project was to design a way to provide extremely local tangible solutions for the most extreme consequences of climate change in Valverde: biodiversity loss ("loss of life"), systematic shocks to a large-scale food system, and exposure to extreme heat and other natural disasters. This idea helps answer calls from intergovernmental and local agencies for community-rooted solutions to these crises. The Platte People's Project was created to educate and advocate for an Aquaponic-Integrated Eco-Park (AIEP) for the South Platte River, co-designed with the Valverde Neighborhood during the summer of 2025. An AIEP combines the idea of reconstructing wetlands using floating platforms with aquaponics, the method of growing food without soil by fertilizing plants using nutrients from fish waste, and eco-parks (parks designed to rehabilitate the native ecosystem). PPP demonstrated the environmental, social, and policy feasibility of an AIEP to restore the river ecosystem of the South Platte River as it passes through Denver. This project studied the environmental, policy, and social feasibility of this idea. It concluded that an AIEP directly aligns with the environmental needs of the South Platte River, is supported robustly by the community and can be directly aligned to their interest and goals, and meets existing goals for sustainable development and resilience outlined in the Denver 2040 Plan. When presented to City of Denver Councilpeople and the South Platte River Committee, it garnered support. The project is now moving on to prototyping and expanding its team.

SEX EDUCATION IN COLORADO

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Adolescent sexual health education in Colorado is shaped by a policy landscape that supports comprehensive, medically accurate, age-appropriate, and inclusive instruction, while still allowing local districts to decide whether sexuality education is offered at all. This project evaluates the effectiveness of current adolescent sex education programs in Colorado from 2018 to 2026 in light of the recent legislation on sexual education curriculum. Given differing instructional policies across local districts, the landscape forms inconsistencies in health outcomes and equity. Despite advancements in the state's curriculum, disparities in knowledge, attitudes, and behaviors persist among youth, influenced by factors such as cultural context, socioeconomic status, and access to resources. Drawing on policy documents, state reports, organizational materials, and published literature, we comparatively analyzed adolescent health outcomes in relation to district-specific curricula. The study identified gaps, including limited resources for LGBTQ+ students, inequities in rural areas, and limited access to data. We aimed to address these disparities through an awareness campaign, including creating an informative pamphlet and partnering with local campaigns. The research seeks to contribute to the ongoing discourse around adolescent health education in Colorado, aiming to enhance the overall effectiveness and accessibility of sexual education for all youth. Recognizing the importance of medically accurate and inclusive education in promoting adolescent health equity, the research aims to assess the consistency with which current curricula support students' informed decision-making.

SPECIAL OLYMPICS COLORADO X DU CLUB SPORTS FIELD DAY & LONG-TERM PARTNERSHIP

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Our project is part of the Pioneer Leadership Program's Community Change Initiative series. It involved identifying a social issue and a need for sustainable change regarding an issue in our community. We identified a lack of social inclusion for disabled individuals as our main issue and chose to address that through extracurricular sports and activities. A large portion of the process included stakeholder interviews with potential community partners, such as National Sports Center for the Disabled (NSCD) and Special Olympics Colorado (SOCO). We chose (SOCO) and identified an opportunity to foster a longstanding partnership between DU Club Sports and their organization. We planned and carried out a Field Day for Special Olympics athletes and participants, collaborating with DU Club Sports and other on-campus organizations. This field day included stations with a variety of sports and activities for the athletes. A central aspect of this event was creating teams with a combination of disabled athletes and Club Sports athletes to emphasize the theme of community and sustained partnership. Furthermore, we intend for this to be an inaugural event that can be replicated in future years, along with a kickstart event for a Unified Club Sports Team as a part of DU Club Sports. The question our project addressed was "How can we attain higher levels of social inclusion for disabled individuals at the University of Denver by way of sport and activity, to foster a stronger sense of community within DU, as well as in the broader community of disabled athletes." Our team gained knowledge of the issue through stakeholder interviews, connecting with potential community partners. We connected SOCO with DU Club Sports and put together the Field Day as a kickstart event for the long-term partnership between DU x SOCO that will be a unified sports team as one of DU's club sports going forward. Our project's impact entailed connecting our community partners, putting on a successful kickstart event involving the DU community and spreading awareness, along with fostering a long-lasting, sustainable partnership between SOCO and DU.

ENHANCING COMMUNITY ENGAGEMENT THROUGH STRATEGIC COMMUNICATION WITH MDNA

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This project focuses on improving how a regional environmental organization connects with its community through accessible and clear messaging and more effective digital platforms. Through the strengthening of social media outreach, relationship maintenance with regional partners, and redesigning the organization's website, the project is trying to increase organizational awareness and accessibility as the organization gears up for the implementation of new projects. MDNA's mission is to "co-create a thriving region for people and nature" through the promotion of equitable access to flourishing outdoor spaces, acting as both a leader in their own projects and as a connective organization to bring together various nature and people-centered organizations. The project addresses how strategic communication enhance community engagement and awareness of environmental organizations, specifically MDNA, hoping to directly increase public participation and support for their sustainability efforts. I analyzed the existing communication strategies and digital content and then developed and implemented improvements to social media messaging and website structure to increase accessibility and engagement while still aligning fully with the organization's vision. The project helped to strengthen the organization's communication strategy by creating more consistency in communication and accessible messaging. Additionally, increasing coordination with regional partners and intentional promotion of their work helped to build stronger relationships for the organization and foster a collaborative environment, two keys to MDNAs work towards a regional vision for people and nature.

ECONOMIC DISPARITIES AS A PERPETUATING FACTOR IN INDIVIDUALISTIC PROBLEM SOLVING

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Economic inequality, or the gap between the rich and poor, has more than doubled since 1989 (Schaeffer, 2020). This widening gap is associated with societal harms such as increased violence and worse health outcomes (Gramlich, 2022; Pickett & Wilkinson, 2015). Although communal solutions are generally more efficient than individual ones (Frischmann, 2014), inequality may undermine people's willingness to cooperate. Prior work suggests individuals sometimes prefer to solve shared problems alone, even when this choice is inefficient (Gross & De Dreu, 2019). The present study extends this research by directly testing whether inequality drives such preferences. Participants are randomly assigned to high, low, or no inequality conditions before completing a 10-round decision-making game where problems can be solved individually or collectively. By examining how inequality shapes cooperative behavior, this study contributes to understanding one mechanism through which inequality sustains itself—by discouraging the very cooperation needed to address it. Does economic inequality exacerbate people's preference for individual problem-solving for shared problems (as opposed to collective problem-solving)? Previous research has indicated that people prefer to work individually to solve problems, and that this could stifle problem-solving efficiency. The present study utilizes a decision-making game adapted from a pilot study. In groups of four, participants are provided a hypothetical inequality level, and then asked to contribute hypothetical money towards a shared or individual goal through the 10-round game. While data collection is still ongoing, we intend to perform analyses via a multi-level model. We hypothesize that groups in higher inequality will prefer to contribute to individual goals, rather than shared goals, and thus be less efficient at meeting said goals.

MOUNTAIN PINE BEETLE IMPACT ON HETEROGENEOUS PONDEROSA PINE WOODLAND

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The mountain pine beetle (MPB) epidemic, due to decades of fire suppression and drought, has led to widespread ponderosa death across the western United States. Detecting these affected trees and areas early in the process is critical for land stewards to protect the surrounding ecosystem. This project compared two aerial images from 2023 and 2026 and, with machine learning, detected and mapped beetle-killed Ponderosa Pine trees near Floyd Hill, Colorado. We trained a random forest model on aerial RGB imagery to distinguish healthy trees from those showing spectral signs of infestation. Our results illustrate that accessible RGB imagery, combined with machine learning, provides a sufficient and accessible tool for monitoring MPB across ecosystems. Can easily accessible RGB aerial imagery, combined with random forest classification machine learning, accurately map red-stage mountain pine beetle-killed Ponderosa Pines? 1) Created a random forest classification model to detect whether a pixel is a tree and then if that tree has been affected by MPB, using different predictor variables and environmental factors. 2) Ran model on 2023 National Agriculture Imagery Program and 2026 UAV drone imagery. Our project suggested a random forest-based classification model can predict with 90%+ accuracy whether a tree is affected by MPB or not based on high-resolution RGB imagery alone.

GALOIS AUTOMORPHISMS OF CHARACTERS IN $Sp(4, \mathbb{Q})$

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Mathematics often studies symmetry, how objects can be transformed without changing their essential structure. For example, rotating a snowflake or making moves on a Rubik's cube both involve symmetries. These symmetries can be described using mathematical objects called groups. As groups become more complex, mathematicians use tools from linear algebra to better understand them. One such tool is a "character table," which summarizes key information about a group in a structured way. Studying these tables can reveal deep properties of the underlying symmetries. This project focused on how these character tables behave under certain transformations called Galois automorphisms, which reorganize the information in a meaningful way. In particular, I have investigated a recent advancement related to Brauer's Height Zero Conjecture, a major result connecting character tables to group structure. My research examined specific families of groups, the symplectic 4 group, to determine whether known patterns continue to hold more generally. The goal is to better understand how symmetry, algebra, and these transformations interact, potentially extending recent results to new cases. We are trying to answer the conjecture that states that for a given 2-block partition of $Sp(4, \mathbb{Q})$, the characters fixed under our Galois automorphism are equal to the characters fixed and with height 0 if and only if the defect block is abelian. Focused on one block at a

time, and checked if the automorphism would fix the height 0 characters or not and cross check if the defect block was abelian. Ultimately, needed to understand how roots of unity were effected by the Galois automorphism. I was able to show that if q is congruent to 1 (mod 4), then the conjecture is true for $Sp(4,q)$.

SPEAKING CREATIVITY:DEVELOPING HANDS-ON PROGRAMMING FOR BROWNIE-AGED GIRLS IN THE DREAM LAB

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This project focuses on increasing engagement among Brownie-aged girls in the Girl Scouts Dream Lab, a creative and exploratory space designed to spark curiosity and build confidence in young girls. Bryanna and I identified a gap in structured programming for this age group and set out to develop a hands-on creative program to fill it. Our process involved researching successful youth engagement models, visiting other Dream Lab locations to learn what has worked elsewhere, and designing an age-appropriate activity centered around Cricut sticker machines — a creative tool that allows participants to design and produce their own stickers in an accessible and exciting way. The goal of this project is not only to create a single fun activity but to build a replicable program model that Girl Scouts of Colorado can continue to use and build upon, ensuring that Brownie-aged girls have consistent, meaningful access to the Dream Lab and the creative confidence it is designed to foster. How can the Girl Scouts Dream Lab better engage Brownie-aged girls through intentional, hands-on creative programming? Fostering early engagement in creative and exploratory spaces is critical to building confidence, curiosity, and a sense of belonging in young girls at a formative age. In developing this program, we conducted extensive research into existing Dream Lab spaces and youth engagement models, including site visits to other Dream Lab locations to identify what programming approaches have proven most effective for young girls. Drawing on these findings, we designed a hands-on creative program centered around Cricut sticker machines, coordinating with Girl Scout troop leaders to pilot the concept with Brownie-aged girls in a real program setting. Through this project we worked to create an accessible, engaging, and replicable program model that can be used to increase Dream Lab participation among Brownie-aged girls. By introducing a tangible, creative tool like the Cricut machine, we aimed to lower barriers to engagement and give young girls an exploratory space where they feel empowered to create freely.

THE CONTENTIOUS POLITICS OF ABORTION:UNDERSTNAIDNG THE BLACK PROTESTS AND WOMEN'S STRIKES IN POLAND

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In 1993, the Polish Parliament, the Sejm, passed a law called 'The Abortion Compromise' permitting abortion only in cases when there is a serious threat to the life or health of the woman, pregnancy is the result of a crime, or prenatal tests show the fetus to be severely or incurably damaged. The current abortion laws in Poland are the most restrictive in all of Europe. Poland's abortion laws have undergone much contestation in recent years. In 2016, the Black Protests erupted across the country in opposition to a proposed total ban on abortion. In 2020, the Women's Strikes commenced as a reaction to a court ruling that banned abortion on the grounds of fetal impairment. This thesis seeks to understand why these episodes of contention developed. Theories of contentious politics, as advanced by Tarrow, offer explanations for why contention occurs. Tarrow's theory is confirmed by the Black Protests and the Women's Strikes. Zolberg offers explanations for when episodes of contentious politics are successful in achieving their aims. The Black Protests and the Women's Strikes disconfirm Zolberg's explanation. Analysis of Tarrow and Zolberg's theories suggests that Tarrow's theory travels well, but is not universal, that repression does not always deter mobilization, and that outcomes are cyclical, not permanent. Why did the Black Protests and the Women's Strikes develop? How did they achieve, or fail to achieve, their desired outcomes? This thesis applies a qualitative case study analysis. Tarrow's theory of contentious politics is confirmed by the Black Protests and the Women's Strikes. Zolberg's theory of outcomes of contentious politics is disconfirmed by the Black Protests and the Women's Strikes. Analysis of Tarrow and Zolberg's theories suggests that Tarrow's theory travels well, but is not universal, that repression does not always deter mobilization, and that outcomes are cyclical, not permanent.

THE IMPACT OF NOVEL SIGNAL EVOLUTION OF MALE AGGRESSIVE BEHAVIOR

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Male competition is widespread across animals and takes place when individuals compete against one another physically or non-physically with the goal of acquiring things such as mates, territory, or resources. Male competition within a species is a central mechanism of sexual selection, as prevailing individuals are more likely to secure mating opportunities and pass on their genes to subsequent generations. It is compelling to examine differences in male competition when traits are differentially selected for by females and the environment; for example, in the cricket *Teleogryllus oceanicus*, which has experienced rapid radiation of novel signals (songs) in response to an acoustically orienting parasitoid fly. Given novel songs are quieter, we examine whether these novel songs are associated with an increase in aggressive behavior. We examined the relationship between the evolution of quiet songs and aggressive behaviors to address the question of how the evolution of novel signals impacts intraspecific competition. We examined multiple populations with songs with different acoustic features and compared aggression across populations. One population is from Australia and produces the loud ancestral song while four others are from Hawaii, one of which produces loud ancestral song while the other three produce quiet novel songs. Aggression varied by male song type, and aggression totals revealed that Australian males were significantly less aggressive than all Hawaiian males. In contrast, none of the Hawaiian males differed significantly from each other, indicating broadly similar aggression levels among males from Hawaii. This helps to elucidate the impact of the origins of novelty on male aggressive behavior.

PROJECT FOR AFFORDABLE TRANSPORTATION AND HOUSING (PATH)

Lilou Cabrol¹, Eli Barbour¹, Juliet Mendik¹, Selma Myers¹, Zac Wise¹, Paul Kosempel², Department of Housing Stability (HOST)³

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We are completing a yearlong community change initiative, for which we are currently seeking grant funding. The intent is to address the housing affordability crisis in Denver's metropolitan area, and its subsequent correlation to the efficiency and reliability of the city's public transportation system. Communicating with external stakeholders is a significant component of this project. To better understand the complexity of housing and transportation affordability, we facilitated conversations with over twenty community members and stakeholders (government leaders, building and development experts, service and housing support providers, researchers, and community and access advocates). Currently, we are compiling data in partnership with the Department of Housing Stability for Denver (HOST) and the Regional Transportation District, to better tailor solutions to this entrenched problem. Location affordability consists of the combined living costs of transportation and housing expenses. The lack of efficiency and reliability in Denver's public transportation system often forces affected communities to choose between location, cost and/or opportunity. It creates a tradeoff between expensive housing in central areas, or affordable locations with limited transportation access, oftentimes far from the city. Collaborated with HOST to create a shared community-centered solution: Understanding the needs, perspectives, and ideas of college students regarding housing affordability. Designed and distributed flyers and a survey with Universities in the Denver Metro, collecting data to support HOST's goals. Survey responses are currently being collected and will be used by HOST to inform decisions on how to support college students and to identify emerging risks regarding housing affordability. Our project has also strengthened connections between HOST and the universities in Denver for future collaboration!

INVESTIGATION OF CLATHRIN RECRUITMENT DURING MVE EXOCYTOSIS IN A549 CELLS

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Every cell is wrapped in a "skin" called a membrane that controls what enters and leaves to keep the cell healthy. To stay balanced, cells use a process called exocytosis to spit out tiny packages (vesicles). Our study used specialized high-resolution microscopy to watch these packages being released in real-time within human lung cells. We discovered that a specific protein called Clathrin gathers exactly where these packages are released, acting like a

crew that helps manage the cell's surface tension and overall stability. This project investigates whether Clathrin is present during the exocytosis of multivesicular endosomes (MVEs) to understand its role in regulating cell membrane balance. Determining this relationship is crucial for understanding how cells maintain equilibrium and regulate surface tension through vesicle release. Total Internal Reflection Fluorescence (TIRF) microscopy was used to record live A549 human lung cells, tracking the specific markers CD63 and Clathrin. Additionally, temperature modifications (optimizing for 37 degrees Celsius) were applied to manipulate membrane tension and encourage clathrin-mediated protein recruitment. The project revealed that clathrin-mediated pathways initiate directly at and adjacent to MVE fusion sites, suggesting that exocytic protein recruitment is a primary driver of membrane regulation. Although fusion frequency was low, these findings establish a foundation for hypothesizing how cells can dynamically manage their internal and external environments.

EXPLAINING VARIATION IN MEDICAL AID IN DYING POLICY ACROSS U.S. STATES

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Medical Aid in Dying (MAiD), a practice that allows terminally ill patients to choose the timing of their death, is legal in some U.S. states but banned in others. At first glance, you might expect this to follow a simple political pattern, with more liberal states allowing it and more conservative states opposing it. However, this project finds that the reality is much more complicated. Through a combination of nationwide data and in-depth case studies of Montana, Colorado, and West Virginia, this research explores why states with similar political environments can end up with very different policies. The findings show that where and how the issue is debated matters just as much as people's beliefs. Policies change differently depending on whether they are decided in courts, state legislatures, or through public votes. The project also highlights how the way the issue is described (for example: whether as "medical aid in dying" or "assisted suicide") can shape public opinion and political outcomes. In some states, strong disagreements within political groups prevent clear decisions, while in others, unified support leads to firm laws, either allowing or banning the practice. Overall, this project shows that decisions about deeply personal and moral issues are not just about political views, but about how institutions, messaging, and group dynamics shape the final outcome. These findings help explain not only MAiD policy, but also other debates about personal autonomy and medical ethics in the United States. This project asks why Medical Aid in Dying (MAiD) laws vary so widely across U.S. states, rather than following a clear political pattern. Understanding this matters because it reveals how decisions about deeply personal issues, like end-of-life care or other bodily autonomy policies, are shaped not just by beliefs, but by political systems and processes. This project combines a nationwide dataset of MAiD policies across all 50 states with in-depth case studies of Montana, Colorado, and West Virginia. By comparing how laws were adopted or prohibited in different institutional settings, it analyzes how political processes, messaging, and group dynamics shape policy outcomes. The results show that differences in how MAiD policies are decided, through courts, legislatures, or ballot initiatives, play a major role in whether the practice is legalized, restricted, or left unclear. This highlights that outcomes in morally personal policy areas are shaped not just by political beliefs, but by the systems and processes through which decisions are made.

UNDERSTANDING FACTORS ASSOCIATED WITH EARLY CHILD SOCIAL COMMUNICATION IN FAMILIES EXPERIENCING SOCIOECONOMIC ADVERSITY

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This project explores how parent-child interactions are associated with children's social communication skills in families experiencing significant socioeconomic adversity. We found a significant association between higher parental sensitivity, defined as parents responding accurately and consistently to their child's cues, and children's initiating behavior requests.

ISOLATION AND ANALYSIS OF ASTROCYTE-AND MICROGLIA-DERIVED EXOSOMES FROM 3XTGAD MOUSE BRAIN TISSUE

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In this project, we isolated exosomes, vesicles released by cells carrying cell-type specific cargo, from astrocytes and microglia, two brain cells shown to play an important role in neuroinflammation. To isolate exosomes from these cell types, we used an immunoaffinity magnetic bead-based technique. We validated this technique using transmission electron microscopy and nanoparticle tracking to confirm the size, concentration, and morphology of the exosome samples. We then isolated astrocyte and microglia-derived exosomes from four mouse groups, old and young triple transgenic Alzheimer's disease mice and old and young wild-type mice. We then conducted immunoassays with these samples to compare the concentrations of proteins associated with neuroinflammation in each group. We found that proteins associated with inflammation were higher among astrocyte-derived exosomes from the old Alzheimer's disease group than other mouse groups. In this project we validated a novel protocol for the isolation of astrocyte- and microglial-derived exosomes from mouse brain tissue. We then assessed proteins associated with neuroinflammation present in exosomes isolated from 3xTgAD and wild-type mouse models. We used an immunoaffinity magnetic bead-based isolation method to isolate exosomes from the mouse brain tissue, and then used transmission electron microscopy, nanoparticle tracking, and western blots to validate the protocol. We then used immunoassays to assess proteins present in the samples. The validation of this protocol confirmed that the size, morphology, and concentration of our samples was consistent with exosomes. Immunoassay data showed a trend that proteins associated with neuroinflammation were at a higher concentration in astrocyte-derived exosomes from the old Transgenic Alzheimer's disease mouse group.

THE ORBITAL ANGULAR MOMENTUM OF LIGHT

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The orbital angular momentum (OAM) of light has uses in optical communication and The orbital angular momentum (OAM) of light has uses in optical communication and microscopy, but is manifest in light's phase and can't be directly measured with a camera. We propose that OAM can be measured using diffraction from a grating, and demonstrate quantitatively-accurate OAM measurements of a variety of modes.

POLARIZATION IN TYPE IC SUPERNOVAE

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We use the amount of light coming from supernovas at different wavelengths to determine what elements are present in the supernova and how fast they are moving. We also use the polarization of the light (how much of the light is oscillating in the same direction) to determine the shape of these elements in the supernova. What is the relationship between wavelengths and the polarization of light in a type 1c supernovae over its lifetime? We are aiming to use polarimetry data from three supernova (in this case Sn 2014 L, 2012 FH and 2014 AD) to gain a greater understanding of the behavior of type 1c supernovae as they evolve over their lifetime I used python to create graphic representations of the data sets, specifically flux and polarization versus wavelength and Stokes q-u plots. From these graphs I was able to identify some polarization signatures that correspond to elemental absorption and emission spectra in the flux spectrum. By analyzing these supernovae, I was able to conclude that all three have a non spherical structure and distinct behaviors of different elements. I was able to compare the elements present in the three supernovas between their photospheric and nebular phases.

MOVEMENT REVOLUTION: HOW DOES LOCOMOTORY BEHAVIOR OF TELEGRYLLUS OCEANICUS DIFFER BETWEEN SEX AND GENETIC POPULATION?

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Pacific field crickets (*Teleogryllus oceanicus*) use acoustic communication to facilitate reproductive opportunities. Male crickets produce loud, long-distance calling songs by scraping their wings together to attract females for mating. Yet, in Hawaii, these crickets have developed silent and novel songs as an adaptive response to parasitism from lethal acoustically-oriented flies (*Ormia ochracea*). The parasitoid fly follows the loud, calling songs to locate

potential hosts to lay their larvae in; resulting in host death after the larvae reach maturity. The silent and novel songs prevent parasitism, but make it difficult for female Pacific field crickets to acoustically locate males for mating. As male cricket songs become less effective in attracting mates, locomotory behavior may increase in importance for males and females since it aids in the successful location of mates when their primary sexual signal is lost. This leads us to ask if locomotory behaviour differs between Hawaiian *T. oceanicus* populations and ancestral populations; and if increased locomotory behavior differs between females and males. How does locomotory behavior of Pacific field crickets differ between sex and genetic population? Has locomotory behavior changed as an adaptive response to mating search challenges and sexual selection of novel songs? We isolated 20 males and females from six different genetic populations based on their geographic location (Manoa, Kapa'a, Mo'orea, Tahiti, Cairns, and Daintree) for exploratory trials. We measured locomotory behavior by observing the number of lines they crossed and the time to start moving within a grided circular arena, to conduct a one-way ANOVA analysis. The research is ongoing, and the data is being collected for analysis. Yet, it is expected that ancestral populations will display less locomotory behavior and that females will be the more locomotory sex; which will help us better understand animal locomotory behavior and intermediary behaviors that result in speciation.

IF/THEN:PROCESS-BASED MUSIC AND CASSETTE TAPES

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If/Then is a music production project exploring music composition, recording, and mixing with the use of the ostensibly obsolete technology of cassette tapes in tandem with modern digital audio workstation software. This project generated a wide variety of novel production techniques, and the music produced, a full-length experimental electronic album titled "If/Then", expresses these techniques and their emergent musical elements. How does the technology of cassette tapes, and more generally, storing musical information physically, influence, limit, and expand creative music production? I used a 3-head cassette deck, a four-track cassette recorder, and a wide variety of cassettes to replace standard mixing processes, such as EQ or saturation, to manipulate music physically by interacting with the tape before and during playback, and to introduce "concrete" elements into otherwise standard compositions. In retrospect, the album of music I produced through this project communicates nostalgia through its sonic palette, which while unintentional, was an emergent process brought out through the imposed limitations of the project. I believe the work to be of very high quality and novelty, and the process of creation was challenging, informative, and inspiring in the ways I was hoping it would be.

WELCOME HERE:EXPANDING ACCESS TO LEGAL RESOURCES AND REPRESENTATION FOR OUR IMMIGRANT NEIGHBORS

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³Community Collaborator, Board Chair and Co-Founder of Colorado Immigrant Justice Fund

As part of the Pioneer Leadership Program's second-year Community Change Initiative, we endeavored to support our immigrant neighbors. This project seeks to increase access to legal resources and services for immigrants, as well as help make the immigration system more approachable. Through multilingual, information-rich booklets, Welcome Here helps save the time of wading through resources to seek the necessary support for immigrant communities from a variety of backgrounds. Additionally, it is part of a larger course of action to expand access to legal resources and knowledge in a variety of languages in order to allow for multiple communities to receive concise and accurate information about the resources available to them and their families. How do we make the immigration system as approachable and accessible as possible? In our research and conversations with organizations across the community, we have found that there are significant barriers to accessing legal services and understanding how the American immigration system works. We want to know how to support and empower as many immigrants in our community as possible with knowledge and tools to navigate the immigration system, seek legal counsel, and stay safe in the face of heightened aggression and national tension. We interviewed more than 30 community members to determine what the highest needs in our community were when it came to supporting immigrants. Developing relationships with our community allowed us to determine where we would be most impactful. This project led to the production of booklets explaining the legal processes associated with immigration, and the compilation of a directory of local resources to support those processes. These booklets are

multilingual, free, and widely available, and will additionally be distributed at a fundraising event to support the Colorado Immigrant Justice Fund.

HOW DATA CAN IMPROVE AI COACHING FOR YOUNG PROFESSIONALS

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My project was about helping an education technology company improve an AI coaching tool for young professionals. The company is called The Experience Accelerator, and their tool, Avatar Coach Kate, is meant to help users build leadership skills, confidence, and resilience as they start their careers. My role was to use data to help the team make better decisions. I built a system to compare possible partner organizations, created a dashboard to track where users were dropping off during the sign-up process, and researched risks related to generative AI, especially privacy, explainability, and responsible use. This project matters because more people are starting to use AI tools for learning and career growth, but those tools need to be designed carefully to actually help people. My work helped the company better understand user behavior, improve reporting, and set clearer guidelines for how the product should grow. My project asked: how can data be used to help an AI coaching platform for young professionals make better decisions about partnerships, user engagement, and responsible growth? This question matters because AI tools can only really help people if they are designed carefully, based on real user patterns, and supported by clear privacy and policy guardrails. I answered this question by building a normalized dataset and weighted scorecard to compare partner programs across more than 15 criteria and identify the strongest options and biggest policy risks. I also mapped the user acquisition funnel, built a weekly KPI dashboard to track drop-off points, and reviewed Generative AI issues like privacy, explainability, and RAG to create a risk brief that could guide product decisions. My project gave the team a clearer way to make decisions. The scorecard helped prioritize partners and flag risks, the KPI dashboard showed where users were dropping off in the acquisition funnel, and the AI risk brief helped set policy guardrails around privacy, explainability, and responsible product growth.

WHAT IS "WEAVING"?:FOSTERING COMMUNITY ENGAGEMENT IN DENVER NEIGHBORHOODS

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We are working to bolster Denver Inter-Neighborhood Cooperation (INC)'s social media presence, specifically on Instagram, to further community engagement. We have interviewed numerous members of Denver INC, DU, the Aspen Institute, and the Denver community in order to learn their stories and highlight their successes. We edited these videos and combined them with graphics we created on Canva. We are also working to create more content for the Instagram about Denver INC events, the importance of neighborhood engagement, and new ideas for videos. How can social media be used to increase awareness and participation in actions that benefit Denver neighborhoods—"weaving"? To answer our research question, we used a variety of methods, including social media graphic posts; recorded interviews with "weavers;" and videos, clips, and photos of Denver INC events. Our project met our goals through increasing Denver INC's social media presence to 2-3 posts a week, gaining several followers and likes that represent increased engagement. These posts have improved the community's knowledge of Denver INC and what "weaving" actually is, preparing Denver INC Instagram followers well for when weaving awards will be distributed to the community.

HOW DOES JOINING A CLUB IMPACT THE FATE OF THE UNITED STATES?

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Rooted in Robert Putnam's research on how American communities impact democracy, this project aims to apply this research into an impactful actionable plan to encourage stronger community connections and engagement amongst the DU community to promote a stronger community, civic engagement, and a healthier democracy. By connecting the Korbel School of Global and Public Affairs, the Center for Community Engagement to Advance

Scholarship and Learning (CCESL), Denver Inter-Neighborhood Cooperation (DenverINC), and the Scrivner Institute of Public Policy, we created an event built around Putnam's research in hopes to encourage DU students to engage in their communities in more meaningful and impactful ways. The event featured a screening of the documentary, *Join or Die* (a documentary on Putnam's research), a panel of DU faculty who are dedicated to community scholarly work, and Snarf's Sandwiches catering. By understanding how the lack of club engagement and participation is impacting the American loneliness epidemic and democracy, this project aims to understand ways the community can support the American youth while also understanding ways the American youth can better support their communities to promote stronger civic engagement and community connections. Analyzing documentary, event planning, multi-organization coordination and collaboration. We met our goals by putting together a collaboration event for a *Join or Die* screening alongside CCESL, DenverINC, Korbel, and the Scrivner Institute of Policy for April 17. Since this date has not passed yet, specific details and numbers are hard to provide.

EVALUATING PURPLEAIR FLEX AND SD SENSOR PERFORMANCE FOR PARTICULATE MATTER MONITORING AT THE KENNEDY MOUNTAIN CAMPUS

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Air pollution is an increasing global health concern, yet regulatory monitoring tools remain limited due to high cost and inaccessibility. Low-cost devices, such as PurpleAir sensors, offer a feasible solution to supplement more expensive monitoring tools, despite their technical limitations. As a part of an undergraduate thesis project, this research is investigating particulate matter (PM) concentrations using PurpleAir sensors while also investigating differences between two models; the II-SD and Flex. Six PurpleAir PM sensors are co-located in pairs (II-SD and Flex) at three sites at the University of Denver's Kennedy Mountain Campus (KMC) NW of Fort Collins, Colorado near Red Feather Lakes and have been deployed for continuous measurements since April 2024. Measurements of PM_{1.0}, PM_{2.5}, and PM₁₀ are recorded over 10-minute intervals, along with humidity, temperature, and atmospheric pressure. The poster will present an overview of PM trends at the site as well as an intercomparison between the two PurpleAir models. This work aims to further introduce the KMC as a nascent atmospheric monitoring site easily accessible to the Front Range research community by highlighting nearly two years of PM data in the low mountain region. This project investigates low-cost PurpleAir sensor performance in a rural, high-elevation forest environment by evaluating differences between two PurpleAir models (the II-SD and Flex) to further understand their viability as accessible supplements to traditional air quality monitoring networks. Six PurpleAir sensors were installed at the University of Denver's Kennedy Mountain Campus (KMC) on February 25th, 2024 where they were connected to WiFi for continuous operation. Data is continuously downloaded on a bi-weekly period using PurpleAir's downloading software which captures measurements of PM_{1.0}, PM_{2.5}, and PM₁₀ alongside temperature, humidity, and atmospheric pressure at 10-minute intervals using their integrated ATM conversion. Collected data was then consolidated and analyzed using IGOR Pro to identify particulate matter trends and evaluate performance differences between the two sensor models. The results of the study advanced our understanding of particulate matter trends in a rural, forested, high-elevation location by building a continuous dataset spanning over two years. These findings contribute to a growing investigation evaluating the reliability of low-cost air quality sensors, offering insight into whether devices like PurpleAir can serve as reliable alternatives to traditional monitoring equipment and how they can be used to better understand atmospheric conditions and air quality.

TURNING BARRIERS INTO OPPORTUNITIES:HOW ENTREPRENEURS NAVIGATE INSTITUTIONAL VOIDS

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Entrepreneurship is often portrayed as a process driven by innovation, passion, and access to resources. However, in many parts of the world, entrepreneurs operate in environments where key systems such as infrastructure, financing, and formal institutions are unreliable or absent. This project explores how entrepreneurs navigate these "institutional voids" through a study of business leaders in Guatemala. Using in-depth interviews with entrepreneurs, investors, and ecosystem actors, the study finds that success depends less on following established models and more on adapting to systemic constraints. Many entrepreneurs distinguish between necessity-driven

ventures and passion-based entrepreneurship, showing how limited opportunity shapes motivation. Government inefficiencies, corruption, and infrastructure gaps often become drivers of innovation, pushing entrepreneurs to create their own solutions, develop alternative financing approaches, and rely on trusted networks. The findings also highlight the importance of exposure to success stories and experiences outside the local ecosystem, which expand what entrepreneurs believe is possible. Overall, this research shows that entrepreneurship in resource-constrained environments is defined not by the absence of opportunity, but by the ability to navigate and reshape the systems in which businesses operate. This project examines how entrepreneurs succeed in environments where key systems—such as access to funding, infrastructure, and institutional support—are limited or unreliable. Understanding this is important because many regions around the world face these conditions, yet most entrepreneurship education is designed for more stable environments. We conducted in-depth interviews with entrepreneurs, investors, and ecosystem actors in Guatemala to understand their experiences. These interviews were coded and analyzed to identify common challenges, strategies, and learning processes. We found that entrepreneurs develop creative strategies to overcome systemic gaps, including combining different funding sources, building their own solutions, and relying heavily on networks and mentorship. These findings suggest that entrepreneurship education—and the way we talk about entrepreneurship more broadly—should be reframed to better reflect the realities of operating in less-developed ecosystems, rather than assuming the conditions found in more developed contexts.

SUSTAINABILITY ON STAGE: A CASE STUDY IN CARBON-NEUTRAL THEATRICAL PRODUCTION

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³Community Collaborator

This hybrid portfolio-thesis attempts to address two questions: How does environmental sustainability intersect with live theatre? And how do we emphasize the importance of environmental sustainability in the theatre department here at DU? To answer these questions, I created Project Objectives and Guiding Principles for my Senior Capstone Production team to follow in sourcing their necessary materials (scenery pieces, costume items, lighting needs, etc.) I also worked with the Tech and Costume Shops here at DU to sustainably source materials we construct in-house, while discussing the life cycle of every item used in the production. The result of this project is a completely sustainably-sourced senior capstone show, something that has never been done before in the Theatre Department at DU. By sourcing all our materials from second-hand avenues, we have significantly reduced the carbon footprint of the department this quarter while also reducing spending costs. Analyzing the final budget and spending patterns has shown that producing a fully sustainable play with second-hand or sustainably sourced materials is actually more cost-effective to the department and student designers than it would be to purchase new; this data highlights the importance of thoughtful spending and environmental awareness in the design process.

EFFECTS OF MECHANICAL PROPERTIES ON CO RELEASE RATES FROM HYDROGELS

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Carbon monoxide (CO) is usually thought of as a harmful gas, but scientists have recently found that very small, carefully controlled amounts of it may actually help the body. In particular, CO can reduce inflammation and protect cells from damage. One challenge is getting CO to the right place in the body safely. To do this, researchers use special compounds called carbon monoxide-releasing molecules, or CORMs, which store CO and release it when triggered. The Worrell lab is studying a new type of CORM made from a chemical called diphenylcyclopropanone (DPCP). This compound releases CO when exposed to violet light. The researchers can attach DPCP to soft, water-rich materials called hydrogels, which are often used in medicine to deliver drugs. These hydrogels are made from PEG, a material that is safe for the body and can be adjusted to be softer or stiffer. My role in the project is to study whether the stiffness of the hydrogel changes how quickly it releases CO. To do this, I change how much solid material is in the hydrogel, which changes its stiffness, and then measure how fast the CO is released. Although the lab has already shown that these hydrogels can release CO, we still do not know how fast the release happens or how the hydrogel's stiffness affects it. The question asked is how the modulus of Hydrogels would effect the CO release rate. The importance of understanding this release rate is to control and optimize how

much CO is delivered and how quickly it is released. Hydrogels with different stiffnesses will be made by changing the amount of PEGDMA and DEGDMA in the mixture and adding a light-sensitive carbon monoxide-releasing compound. The stiffness of each hydrogel will be measured, then the hydrogels will be exposed to different amounts of ultra violet light to trigger CO release, allowing the relationship between hydrogel stiffness and CO release rate to be analyzed. It was found that decreasing the solid wt% produced substantially faster and higher apparent CO release, with 10 wt% hydrogels consistently exhibiting the most rapid CO accumulation in solution. Vice versa was also observed, higher-solid-content hydrogels (40 wt%) showed slower CO release kinetics.

CATHETER DESIGN FOR LASER ABLATION OF REDO-TAVR PROCEDURES

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Transcatheter Aortic Valve Replacement (TAVR) is a minimally invasive procedure used to treat severe narrowing of the heart's aortic valve and is an alternative to open-heart surgical valve replacement. TAVR is increasingly performed in younger patients, so many patients will outlive their first valve and need a second valve replacement called redo-TAVR. In redo-TAVR, a second valve is deployed inside the existing valve, displacing the existing leaflets and potentially blocking blood flow to the coronary arteries. The objective of this project was to design a catheter for laser ablation of the existing leaflets in redo-TAVR. An outer delivery catheter and inner steerable catheter were developed. The catheters were designed to have outer diameters of 20.88 Fr and 11.4 Fr, to accommodate optical fiber on the inside while remaining compatible with arteries. Both catheter designs layered an inner PTFE liner to allow smooth device and guidewire movement, stainless steel braided reinforcement, and Pebax outer tubing to balance flexibility, pushability, and kink resistance. The outer catheter was designed to follow a guidewire into the heart's aorta and provide stability during ablation. The inner catheter design incorporated a pull wire mechanism for the controlled deflection of the catheter tip. The outer catheter was fabricated and evaluated, using 3D printed models of three patient's aorta and left ventricle. The testing focused on the catheter's mechanical performance and its ability to navigate the aorta. The catheter demonstrated strong pushability, successfully navigating through the aortic arch and down into the aortic valve. However, localized kinking was observed in the arch, indicating the need for increased reinforcement. These results support future research by demonstrating successful fabrication methods and informing continued optimization of catheter design for redo-TAVR.

ZINC CAN INTERACT WITH MICROTUBULES TO REGULATE MICROTUBULE STABILITY AND PROTECT MICROTUBULES FROM DAMAGE

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This project uses live cell imaging techniques to explore how microtubule-associated proteins (MAPs) and zinc (Zn) can affect the stability of microtubules. Previously, different proteins have been associated with microtubules. Additionally, previous work in the Qin lab has shown that Zn can interact with microtubules. However, the exact mechanism involved and physiological effect remains unexplored. This research supports the idea that Zn and certain MAPs play a stabilizing role to help protect microtubules from different types of damage. How do zinc and microtubule-associate proteins affect microtubule stability, and how are these processes important for normal physiological conditions? This project used live-cell fluorescence microscopy with COS7 cells to see real-time effects of certain drug treatments. Results from this project supported the idea that Zn and MAPs can protect microtubules from certain types of damage and are important for future research on the impact of zinc-related disorders on cell stability and overall health.

PHOSPHOLIPASE D FACILITATES EXOSOME SECRETION THAT MAY HELP TRANSPORT NEURODEGENERATIVE PROTEINS

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Cells release small packages called exosomes to transport materials to other cells or dispose of waste. Two enzymes, PLD1 and PLD2, help cells release exosomes by producing a molecule called phosphatidic acid, which

stabilizes the curved membranes required for exosome release. TDP-43 is a protein that normally stays in the nucleus of a cell, where it helps process genetic information. However, when TDP-43 ends up outside the nucleus, it clumps together and can contribute to neurodegenerative diseases like amyotrophic lateral sclerosis (ALS). This project investigates whether exosomes can transport TDP-43 between cells. If so, this could explain how harmful proteins spread through the brain and contribute to disease progression. What is the role of PLD1 and PLD2 in exosome secretion? Are exosomes able to transport neurodegenerative proteins (like TDP-43) between cells? For PLD1/2, confocal microscopy with immunofluorescence techniques were used to determine colocalization of CD63 and PLD1/2. For neurodegenerative proteins, confocal microscopy was also used to examine colocalization, but rather than immunofluorescence, cells were manipulated to produce biological markers on proteins of interest (TDP-43 and CD63). PLD1 and PLD2 are colocalized with CD63, which supports their role in facilitating exosome secretion. TDP-43 and CD63 show moderate correlation, but at a significantly lower level than PLD1/2 and CD63. This suggests that TDP-43 is associated with exosomes, and that TDP-43 may be carried between cells in exosomes.

BREAKING BARRIERS:EMPOWERING WOMEN THROUGH SPORTS BY PROMOTING EQUITY AND VISIBILITY

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This project is about recognizing the challenges women in sports still face and working to change them. It focuses on increasing visibility for women athletes, building stronger support systems, and creating more inclusive spaces where they feel valued and respected. By using digital platforms to highlight achievements and amplify voices, we helped women show up with confidence, be seen for their talent, and have the same opportunities to grow, compete, and lead. Despite major strides towards equality, women in sports still struggle against barriers that prevent them from receiving the same respect, resources, and strong community connections. We used interviews and research to understand key challenges, then used social media outreach, sponsorship efforts, and personal connections to expand visibility and support. We also engaged directly with the community through tabling to build awareness and strengthen relationships. While the project is still in its early stages, it has already begun building awareness and generating interest through outreach, social media engagement, and community connections. Early responses show increased visibility and growing support for women's sports, helping establish a strong foundation for future partnerships, participation, and measurable impact.

BIOLOGICAL RHYTHMS IN CRICKET IMMUNE ACTIVITY

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Biological rhythms coordinate behaviors and physiology with the environment. Immune function is one such biological rhythm, and given that it is energetically costly to operate, it may be beneficial to coincide peak immunity with times-of-day that infection risk is highest. Male *Teleogryllus oceanicus* crickets sing at dusk to attract female crickets to mate; however, their song also attracts the deadly, acoustically-orienting parasitoid fly *Ormia ochracea*. In this study, we examined whether immune function peaks at times-of-day when the fly is most actively host-seeking, and thus likely to infect singing male crickets. We tested whether immunity varies across time-of-day and between parasitized (Hawaiian) and unparasitized (Australian) cricket populations. Specifically, we wanted to observe if peak activity coincides with "risky" times-of-day, and/or varies across populations. We evaluated two measures of immune function (melanization of a foreign body (n=90) and immune cell count (n=115)) over a 24-hour period in a parasitized (Hawaiian) and unparasitized (Australian) population. Although we did not detect a significant difference between the timing of peak immune function in the Australian (unparasitized) and Hawaiian (parasitized) populations, we discovered that for both populations, immunity peaked when the light began to transition to dark phase (i.e., dusk). Our findings bolster that male crickets have evolutionarily primed their immune function at the start of the dark phase (i.e., the onset of their active period), which coincides with the time-of-day they are most likely to encounter pathogens and/or parasites.

CARDIOMYOCYTE-ENDOTHELIAL CONTACTS DURING HEART REGENERATION

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Heart disease is the leading cause of death worldwide. Unlike humans, zebrafish can regenerate their hearts after injury. My thesis focuses on understanding heart regeneration in zebrafish, a model organism capable of scar-free cardiac repair. Previously, proximity labeling proteomics (BioID2) was used to investigate the β -catenin interactome during heart regeneration. β -catenin is a dual-function protein involved in Wnt signaling and cell adhesion. While the role of Wnt signaling in heart regeneration has been studied, it remains unclear. Unexpectedly, the BioID2 screen revealed a strong interaction between β -catenin and Cadherin-5 (Cdh5), an endothelial adhesion molecule, with no change in interactions with Wnt signaling proteins. My work used immunofluorescence to examine Cdh5 and β -catenin localization in uninjured and regenerating hearts and found that Cdh5 accumulates around blood vessels after injury, implicating cardiomyocyte–endothelial adhesion as a key mechanism in heart regeneration. Despite the well-established role of β -catenin in cardiac biology, the molecular interactions through which it contributes to heart regeneration remain unknown. Identifying these interactions in the zebrafish model is critical to uncovering the cellular mechanisms that enable scar-free cardiac repair, knowledge that could eventually treat heart disease in humans. Proximity labeling proteomics (BioID2) was used to map the β -catenin interactome in uninjured and regenerating zebrafish hearts, identifying Cadherin-5 (Cdh5) as a strong candidate interaction. Immunofluorescence was then used to examine the localization of β -catenin and Cdh5 in cardiac tissue across uninjured and regenerating conditions. Immunofluorescence revealed that Cdh5 and β -catenin change localization in the regenerating heart, with Cdh5 levels decreasing and β -catenin levels increasing in blood vessels following injury. Both proteins, were found to localize to cardiomyocyte-endothelial cell contacts, suggesting that remodeling of adhesion complexes at these junctions may be a key feature of cardiac repair.

DOES MOOD IMPACT HOW WE BOUNCE BACK AFTER MAKING A MISTAKE?

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The eyes are a window to the mind, allowing us to understand what's happening in the brain through changes in pupil size. The PEAR project studies how people recover from mistakes during a challenging cognitive task, completed under differing reward contexts, and what changes in a person's pupil diameter during the task can tell us about that recovery process. A large part of performance in this task is how participants recover after making a mistake — if they got something wrong, would they be able to get the next one right? And what do their pupils do in this process? We call this recovery from error. To examine how these questions may vary depending on mood, participants completed a mood survey after the task. In this poster, we explore what a participant's mood might tell us about how they recover. We compared task performance and simultaneously collected pupil activity in people who reported positive vs. negative mood to see how they might differ in their recovery from error. This can tell us more about how mood influences everyday performance; for example, does feeling more positive help us bounce back faster after making a mistake? How does emotional state, specifically positive and negative mood, influence how we recover from errors during a cognitive task? Understanding how mood shapes recovery can provide valuable insights for psychological researchers, with long-term implications for applied (e.g., clinical, educational) domains. Participants completed a modified cognitive control (Flanker) task followed by a survey measuring their current or recent emotional state using the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). By examining the relationship between reported positive or negative mood and error recovery, we sought to better understand the influence of emotional state on cognitive task performance. We hypothesize that participants reporting a more positive mood will show better recovery after making an error. We are currently analyzing data from 30 young adult participants to determine whether positive or negative mood predicts error recovery and pupil response. Findings from this work can provide insight into how mood shapes performance, and this can be useful to applications in contexts like academic testing, workplace performance, or high-pressure decision-making.

FIRST RECORD OF EGG GUARDING IN MOTHS:THE EFFECT OF FEMALE POSITION AND SCALES ON EGG CLUSTER SURVIVAL IN GENERALIST MOTH

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Egg guarding in insects results in higher rates of offspring survival by decreasing predation and parasitism rates of the eggs. Female fall webworm moths (*Hyphantria cunea*, hereafter FW) are frequently observed atop their egg clusters after they die, but it was unknown if this behavior is a form of egg guarding. Female FW also deposit some of their tuft scales onto their eggs as they lay them. Whether these scales also help protect the eggs (e.g. from parasitoids) is also unknown. To test if female FW egg guard and if scales help protect their eggs, we conducted a field experiment in which we pinned egg clusters to host plants in one of four FW egg cluster treatments: 1) an egg cluster uncovered with no scales, 2) an egg cluster uncovered with scales and no moth, 3) an egg cluster with scales and a pinned moth covering half the egg cluster, and 4) an egg cluster with scales and a pinned moth completely covering the egg cluster. After five days in the field, we retrieved the remaining egg clusters and examined them in the lab for evidence of predation. We continue to rear larvae to determine parasitism rates, but our preliminary results for field predation show that the presence of FW moths atop their eggs decreased rates of predation. We also found that the presence of scales may decrease predation compared to egg masses without scales. Together, our results suggest that FW may deposit tuft scales and rest atop their eggs when they die to guard them from natural enemies. Do female FW moths use egg guarding as a means of increasing the survival of their offspring? 17 replicates of 4 treatments of FW egg clusters: 1. no scales, no moth, 2. scales, no moth, 3. scales, half moth, 4. scales, moth were pinned to chokecherry (*Prunus virginiana*) host plants for 5 days at a Boulder Canyon field site. Egg clusters were then retrieved, examined for predation, and reared in the lab to assess for parasitism. From this research, we can conclude that female FW likely guard their eggs from natural enemies by resting atop them after death, but scales did not affect predation. While egg clusters with scales did not deter predation, they may affect parasitism, which we are continuing to monitor.

ASSOCIATIONS BETWEEN DEPRESSIVE SYMPTOMS AND SIBLING RELATIONSHIPS ACROSS CHILDHOOD AND ADOLESCENCE:A MULTI-METHOD STUDY

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This study examined whether depressive symptoms are related to sibling relationship quality in children (9–11) and adolescents (15–17). We used both self-report questionnaires from participants and their siblings, as well as behavioral observations from a structured interaction task. Results showed that higher depressive symptoms were linked to lower warmth and higher conflict, but only in participants' own reports, not in sibling reports. Depressive symptoms were also related to differences between siblings' reports, especially for conflict, where disagreement was greater. In the interaction task, depressive symptoms were not strongly related to specific observed behaviors like emotional expression or help-seeking, but were linked to lower overall agreement between siblings. Overall, depressive symptoms were more related to how youth perceive their sibling relationships than to observable interaction behaviors. The study explored how depressive symptoms are associated with sibling self-reported and observed relationship quality in childhood and adolescence. Relationship quality was measured during a recorded 5-minute task where participants worked with their sibling to prepare a short speech for researchers. The recordings were then coded using a lab-based system to rate behaviors like closeness, emotional support, and help-seeking. Higher depressive symptoms were linked to lower warmth and higher conflict in sibling relationships based on participants' own reports, but not their siblings' reports. Depressive symptoms were also related to more disagreement between siblings about their relationship, while observed behaviors during the interaction task were not strongly related to depressive symptoms.

FLAVORS OF HOME, VOICES OF STRENGTH:A PLACE WHERE FOOD, STORYTELLING, AND IMMIGRANT EMPOWERMENT MEET

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Cocina Libre is a Denver-based community outreach initiative that uses food and storytelling as a bridge between cultures and a tool for immigrant empowerment. Through cookbooks, community events, and collaborative engagement with immigrant chefs, the project highlights the connection between personal narratives and culinary traditions, fostering empathy, cultural understanding, and social connection. In what ways does food contribute to creating more inclusive communities and to resisting the marginalization of immigrants? The project engages immigrant chefs through community-based workshops, shared meals, and storytelling-centered activities in Denver. These interactions include collaborative cooking sessions, narrative sharing, and public engagement events that center immigrant voices. The workshops focus on food preparation, storytelling, and dialogue to amplify immigrant experiences and cultural knowledge, while creating spaces for sharing narratives and demonstrating how food can serve as a powerful tool for identity, connection, and empowerment. The project contributes to creating inclusive community spaces where immigrant stories are shared and valued, demonstrating how food can serve as a powerful tool for cultural identity, connection, and empowerment. By pairing recipes with personal narratives and facilitating shared experiences, Cocina Libre promotes empathy, challenges dominant narratives about immigrants, and strengthens community ties while supporting the visibility and economic empowerment of immigrant chefs.

LACTATE IS PROTECTIVE IN ACUTE LUNG INJURY VIA HISTONE LACTYLATION & SUBSEQUENT ACTIVATING TRANSCRIPTION FACTOR 4 ACTIVATION

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When the lungs are severely injured, the body naturally produces lactate as a signal substrate to help mediate excessive inflammation of the lung tissues. Our research found that lactate acts as a molecular switch that modifies how DNA is packaged, a process called histone lactylation. This modification shows increases activation of a protein called ATF4, which instructs immune cells to stop releasing harmful inflammatory markers and to shift towards healing. By investigating this Lactate-ATF4 pathway, we have identified a potential molecular mechanism involved in inflammation of acute lung injury (ALI).

COMMUNITY OUTREACH OF PLANETARY GEOLOGY

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This project focuses on making planetary science accessible to all ages. Mars used to have water and it made patterns into the surface. Because they were formed by water flow on the surface the patterns themselves serve as a record of that water flow. We can use this fact to extract climate information about the ancient climate. To explore this we use the physics of network growth and this occurs in everyday situations. We also explore the erosion of rivers through a small scale stream table. We seek to educate the public on planetary geology using hands on demonstrations. We used a stream table to show rover dynamics and for sand and glue and plastic to show network growth. Younger kids got to interact with a concept not on Earth in a hands on way.

RING OPENING METATHESIS POLYMERIZATION TO INDUCE FROSTER RESONANCE ENERGY TRANSFER FOR THE DETECTION OF ETHYLENE

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This project aims to develop a new method of ethylene detection. Ethylene is one of the simplest organic molecules, yet it has a wide range of applications ranging from industrial manufacturing and plastics to serving as a hormone that governs ripening in climacteric fruit. Currently many methods to quantify ethylene are restricted to laboratory settings, requiring instrumentation and trained personnel. This project aims to begin the development of a more robust system that could be used beyond laboratory settings. To accomplish this a bespoke catalyst-resin system polymerizes upon exposure to ethylene, this polymerization yields a readily observed optical response which allows for the detection of ethylene. How can ethylene triggered ring opening metathesis polymerization

be used to create a system capable of ethylene detection with an easy to read response? To complete this work novel molecules were synthesized, characterized and tested. In this work I was able to show that I could achieve polymerization and characterize the response. I have now begun working on optimizing this process and testing the effects of ethylene on the system.

HOW IS ACCESSIBILITY COMMUNICATED IN UNDERGRADUATE COMPUTER SCIENCE SYLLABI

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Computing enrollments have surged in the United States, with bachelor's degrees in computer and information sciences more than doubling over the past decade. Despite this, many computing courses remain difficult to access for diverse learners. Course syllabi shape students' first impressions by outlining expectations, resources, and support, but little research explores how accessibility and accommodations are communicated within these documents. Further, recent computing education research shows that accessibility content is often confined to HCI (Human-Computer Interaction) courses, indicating HCI teachers may have more content knowledge of accessibility than other computing educators, and perhaps be more likely to discuss accessibility in their syllabi. Toward this end, we are exploring the research question "how are accessibility policies communicated the undergraduate CS and HCI syllabi?", evaluating syllabi for three core undergraduate computing courses across eleven U.S. universities to identify patterns in the tone and information about accessibility communicated to students across different computing courses. This project provides insights into making computing and HCI education more accessible to all learners. Our main RQ is: How is accessibility offered in syllabi for Intro to Computer Science, Human Computer Interaction, and Data Structures and Algorithms courses for undergraduates across eleven U.S. colleges and universities? We analyzed HCI (Human-computer interaction), CS1 (Intro to Computer Science), and data structures syllabi from eleven well-known CS programs representing offerings from R1, public, private, not-for-profit, and liberal arts institutions. We restricted our dataset to undergraduate courses offered during the 2024 to 2025 academic year, excluding special topics, independent studies, and HCI courses offered outside of CS departments (e.g., in Psychology or Design) to ensure that our sample was reflective of computing departments' cultures and norms. Only syllabi publicly available through official institutional websites were included. We conducted an inductive qualitative content analysis using affinity diagramming, memoing, and inductive coding to develop an initial codebook reflecting the ways that accessibility policies are communicated to students in these courses. The codebook categories include whether accessibility is mentioned, where it appears in the syllabus, the specificity of details to request accommodations, tone of the language, references to disability services, and whether accessibility is framed as proactive pedagogy or primarily as formal accommodations. Our analysis identified gaps in course syllabi, such as limited attention to protecting the privacy of students seeking accommodations, unclear or vague instructions for obtaining disability support, and a lack of consideration for evolving or changing conditions that may alter accommodation needs. Based on these findings, our project proposes a set of clear, actionable guidelines to help faculty create more inclusive and effective syllabi.

THE LONELY LITTLE LADYBUG: UNDERSTANDING ANXIETY

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Through the power of storytelling my project, a children's book entitled, *The Lonely Little Ladybug*, encourages kids to explore and understand the complex worries of anxiety. It offers tips and tricks to combat their fears, and a protagonist that they can relate to. Additionally, it provides parents a method to help their children label and normalize their feelings. My project aimed to address how to adequately explain separation anxiety disorder and treatment to young children in approachable terms. I began by conducting research on the most effective treatment for separation anxiety, through children's hospital websites, the DSM-5, and published studies. I then wrote and illustrated a children's book explaining symptoms and treatment in age-appropriate terms. Given that there is an ongoing need for mental health education my book explores proven coping mechanisms for helping kids with anxiety. By providing a fun vehicle for learning an important and complex topic, it helps children feel understood.

A SYMBOLIC MODEL OF PROOF ACQUISITION IN ACT-R

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Learning to construct mathematical proofs—formal arguments demonstrating the truth of a mathematical statement using logical deductions and previously established facts—is one of the most challenging skills in STEM education. This research aims to build the foundations for a symbolic cognitive model, using the ACT-R cognitive architecture and implementing in Python with the pyactr package, to explore how different proof strategies can be thought through with only symbols and rules. The model observes simple proofs, and its abilities are assessed based on its generalization capabilities, efficiency, and error patterns. By developing and analyzing such a model, this research provides insights into how symbolic reasoning skills are acquired, offering a detailed case study of proof acquisition within a cognitive architecture. Given the foundational role of proof in advanced mathematics and computer science, it is important to consider the learner’s perspective in acquiring proof skills. This research asks: How can proof acquisition be modeled within a cognitive architecture—a framework designed to model human cognition—, so as to gain insight into both the mind of the student and the optimal strategy of the instructor? I designed and implemented a preliminary cognitive model, under the ACT-R cognitive architecture framework and in Python with the pyactr package, to observe training proofs. I evaluated the model using a three-pillar approach, which I propose for the evaluation of future, more complex models. The current, primitive model demonstrates that ACT-R can be configured to execute complete mathematical proofs across multiple proof genres, clarifies the cognitive operations and representational commitments required to symbolically step through formal arguments, and shows how proof states can be treated as dynamically evolving cognitive configurations within the mind of the learner. Although preliminary, this work establishes the foundations needed to study proof acquisition at a level of cognitive realism, opening a pathway toward models that can autonomously improve their strategies and further illuminate the psychological mechanisms that underlie formal mathematical reasoning.

VOTERS UNITED: ENGAGING YOUNG STUDENTS FOR THE 2026 MIDTERM ELECTIONS

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General trends suggest that younger and first-time voters are much less likely to participate in elections outside the national level in comparison to older voters. Midterm elections present a particular challenge for engaging voters because they have less visibility and perceived impact. The question our project seeks to answer is: how can nonpartisan, community-based initiatives effectively increase civic participation among young and first-time voters in the Denver Metro Area for the upcoming midterm elections? Through our partnership with the Denver chapter of the League of Women Voters, we distributed informational materials for voters including important deadlines, resources for absentee and mail-in voting, and descriptions of ballot issues for Colorado to various 2 and 4-year educational institutions in the Denver Metro area. We also expanded our outreach to social media, allowing us to track our engagement more effectively. Voting in midterm elections at all levels is just as important of a civic duty as voting in presidential election, but they frequently see significantly lower levels of turnout at all age levels, but especially for young voters. As a group of young voters who are invested in the democratic process, our project seeks to answer: how can nonpartisan, community-based initiatives effectively increase civic participation among young and first-time voters in the Denver Metro area for the upcoming midterm elections? Through a dozen stakeholder interviews with professors at the University of Denver and representatives from local non-profit and volunteer organizations, we learned that young voters need to be met where they are at and they need to be engaged in issues that they care about to energize them to vote. To address this need, we created informational materials that are pertinent to young voters’ needs to be distributed at 2 and 4-year educational institutions in the Denver Metro area and on social media channels. Our project is still in the beginning stages of implementation, but by the night of the showcase, we will have been able to assess the success of our informational flyer distribution (possibly through a survey) and the level of engagement in our social media campaign.

INTERPERSONAL EMOTION REGULATION FACTORS AND AI

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Interpersonal emotion regulation (IER) is a subtype of emotion regulation (ER) occurring between two people (receiver and provider) which is known to be effective in changing affect as well as promoting positive long-term outcomes. Successful IER (i.e. IER that a receiver is receptive to) is adaptive and healthy, but little is known about the contextual factors that influence whether a receiver is receptive to an IER offer. There is reason to believe that the nature of the receiver's relationship with the provider is relevant. This online study assessed receiver receptivity to a hypothetical IER offer from a romantic partner, friend, or AI chatbot in two combined samples (N = 211) of Prolific users and university students. We hypothesized that receivers would be most receptive to offers from romantic partners and more receptive to offers from friends than from AI. An ANOVA comparing receiver ratings on the offer's influence, helpfulness, validation, manipulation, and shame revealed a main effect of relationship type in that receivers were significantly more receptive to human IER offers, regardless of their relationship, than AI offers. This foundational study establishes a basis for understanding the contextual factors that contribute to IER success in common social interactions.

HETEROGENOUS NITRATION AND OLIGOMERIZATION REACTION OF BDA PROTEIN WITH URBAN AIR

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Proteins are found in the aerosol phase primarily as a component of biological particles such as pollen or spores. While proteins can promote allergenic or other effects directly, they can also undergo heterogeneous reactions to promote post-translational modification of the proteins. A heterogeneous reaction mechanism driven by gas-phase ozone (O₃) and nitrogen dioxide (NO₂) has been shown to promote both nitration and oligomerization of exposed tyrosine residues within analyzed proteins. This protein nitration modification can produce an increased IgE response in rat models, thus suggesting that proteins embedded in pollen could become more allergenic when exposed to urban air pollution. BSA (bovine serum albumin) was used as a standard protein analyte and loaded onto syringe filters, then exposed to a constant flow of ambient air through Teflon tubing. Samples were placed at the Rocky Flats North and La Casa air monitoring sites operated by the Colorado Department of Public Health and the Environment (CDPHE) in the Denver metro area of Colorado. After 2-5 weeks of exposure for each sample, the BSA protein was extracted off the filters using a PBS buffer flush and analyzed via high performance liquid chromatography (HPLC). The degree of nitration was then determined by comparing peaks produced at wavelengths of 280 nm, for unmodified protein detection, and 357 nm, for nitrated protein detection, utilizing reverse-phase chromatography. A separate analysis using size exclusion chromatography (SEC) was performed to measure the relative degree of oligomerization, however there were column complications. Previous preliminary work from the Huffman group showed the relative ratio of oligomerization to nitration increased when exposure time increased, however only a small number of samples were available for that initial set of observations. This work continues that project to observe nitration and oligomerization degrees over a wider range of exposure conditions. Nitration patterns are expressed here. How do the nitration degree and oligomerization degree of BSA proteins change with the amount of ozone and NO_x exposure? Protein samples were exposed at a CDPHE air-quality monitoring site for 2 to 6 weeks. After exposure, the samples were analyzed using HPLC (high-performance liquid chromatography) analysis to determine the nitration degree. I am currently in the process of completing HPLC and data analysis utilizing Igor.

MOLECULES FOR NEURODEGENERATIVE DISEASES

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I am a pre-med chemistry major here at DU working toward discovering organic molecules that will act as cures for Parkinson's disease. These molecules work by preventing the aggregation of large, insoluble proteins called alpha-synucleins in the brains of patients with Parkinson's disease, essentially helping to keep their brains clean and able to perform their normal functions. This will therefore slow down their neurodegeneration amongst these patients, allowing for healthier aging and better lifestyles. I am conducting my research in the Kumar Lab under Sunil Kumar, a research professor here at DU who works toward discovering cures for neurodegenerative

diseases. Working in this lab has helped me learn many principles of organic chemistry that I am able to apply to my classes. It has also helped me gain plentiful knowledge surrounding neurodegeneration and what it means to be a well-functioning brain in a chemical sense. Overall, this research will help me in my career as an undergrad in chemistry, and even later when I enter medical school. When searching for a therapy for neurodegenerative diseases, one question to be answered is what if there was a way to prevent or at least slow down further aggregation of certain problematic proteins for the sake of preserving brain function. Therefore, we are working with scaffolds with particular secondary structure that can act as foldamer/peptidomimetic inhibitors to interact with aggregation-prone regions to slow or prevent fibril formation, hopefully reducing the aggregate burden in cells in those with neurodegenerative diseases, allowing for healthier aging. I designed a 30-member library varying charge distribution, hydrophobic patterning, and H-bonding capacity to execute the synthesis, purification, and analytical confirmation, delivering well-characterized materials to the screening team on a roll-in basis. For each molecule I synthesized, I verified the data using both ¹H-NMR spectroscopy, verifying that I had the desired product by analyzing peaks representative of the molecular components of the sample, and Mass spectroscopy, to gain further data as to whether the correct molecule was synthesized by observing the peaks representative of the molecular weight of the sample. This is an ongoing project that I will continue to work on throughout spring quarter, but so far, I have achieved multiple purified NMR spectroscopies, verifying that I have synthesized a few of my desired products. For the rest of my synthetic molecules, they have been run to completion and are in the process of being worked up, optimized, and verified for further testing of their properties and whether or not they can be used as therapies.

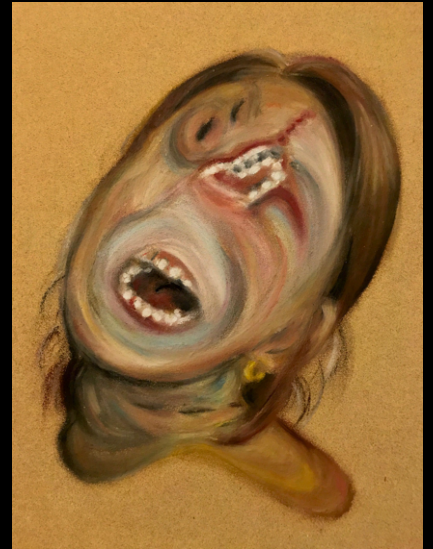
Additional Student Artwork



Untitled by Robin Bell



The Art Block by Lauren Siegfried



Uncomfortable by Lauren Siegfried



Paper Cardiology by Lauren Siegfried



Untitled by Alexandra Mele



Untitled by Alexandra Mele



Untitled by Alexandra Mele



Sisters by Aliyah Goldberg

