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AN INTRODUCTION - RANGE: UNDERGRADUATE RESEARCH JOURNAL

Annie Isabel Fukushima, Editor in Chief

Undergraduate Research Matters

Undergraduate research opportunities support retention towards completion, foster belonging, furthers decisions about careers, and supports societal impact.

At the University of Utah, we know that our students who participate in undergraduate research are being retained and graduating within 4 years at higher rates when compared to general trends of students at the U. Undergraduate research engagement is a high-impact practice with significant success in student retention and graduation rates. According to Hernandez (2018), students who have completed at least two semesters of research with a faculty mentor graduate within four years at a significantly higher rate than those who have not.

It certainly is true for many of our undergraduate researchers at the U.

Research experiences are critical to retaining underrepresented students and creating a sense of belonging for those who may not felt like they belonged in higher education (Aikens et al., 2017; Barlow & Villarejo, 2004; Espinosa, 2011; Hurtado et al., 2011; Jones et al., 2010). "Belonging" is defined as feeling connection and identification or isolation and alienation within a campus community (Hausmann et al., 2007; Johnson, 2012; Johnson, 2013). Imagine, yourself in a sea of people with over 30,000 students and thousands of professors – how do you find community, create connection? Many of our students have found a sense of belonging by participating in the research enterprise, connecting with mentors and research teams.

And we know that training students for the workforce matters. At the U, students participating in research are preparing themselves for careers, solving complex problems, and for many, have experience working in teams. Further, participation in undergraduate research clarifies interest in careers and expectations of obtaining a doctoral degree (Russell et al., 2007).

But through it all, consider the societal impact of undergraduate research. One need only peruse the publications in this issue to see the dynamic types of research reflected across the disciplines. Simply look through the fall issue, consider the wide range of research topics, methodologies, and questions that undergraduate students are addressing. This issue reflects contributions of summer programs from 2023, where over 200 students

from 79 different universities participated in research at the University of Utah.

Special appreciation to the OUR team Cindy Greaves, Angie Leiva, Shelly Parker, Jude Ruelas, Jennifer Santiago (staff editor of the journal), Doi Ahn, Anna Gilstrap, Ali Nopper, Sonia Osuna, Ava Peitz, and Kishan Thambu (student editor of the journal).

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References

Aikens, M.L., Robertson, M.M., Sadselia, S., Watkins, K., Evans, M., Runyon, C.R., Ebay, L.T., and Dolan, E.L. (2017). Race and Gender Differences in Undergraduate Research Mentoring Structures and Research Outcomes. CBE-Life Sciences Education 16, 1-12.

Barlow A.E.L., Villarejo M (2004). Making a difference for minorities: evaluation of an educational enrichment program.

Espinosa, L.L. (2011). Pipelines and pathways: women of color in undergraduate STEM majors and the college experiences that contribute to persistence. Harvard Educ Rev 81, 209–240.

Hausmann, L.R.M., Schofield, J.W. & Woods, R.L. Sense of Belonging as a Predictor of Intentions to Persist Among African American and White First-Year College Students. Res High Educ 48, 803–839 (2007). https://doi.org/10.1007/s11162-007-9052-9

Hernandez, P.R., Woodcock, A., Estrada, M. and Schultz, W. (2018). Undergraduate Research Experiences Broaden

Diversity in the Scientific Workforce, BioScience 68, 3, 204–211, https://doi.org/10.1093/biosci/bix163

Hurtado, S., Eagan, M.K., Tran, M.C., Newman, C.B., Chang, M.J., and Velasco, P. (2011). We do science here": underrepresented students' interactions with faculty in different college contexts. J Soc Issues 67, 553–579.

Jones, M.T., Barlow, A.E.L., and Villarejo, M. (2010). Importance of Undergraduate Research for Minority Persistence and Achievement in Biology. The Journal of Higher Education 81, 82 – 115.

Johnson, D.R. (2012). Campus Racial Climate Perceptions and Overall Sense of Belonging Among Racially Diverse Women in STEM Majors. Journal of College Student Development 53(2), 336-346. Johnson, D. R. (2011). Examining sense of belonging and campus racial diversity experiences among women of color in STEM living–learning programs. Journal of Women and Minorities in Science and Engineering, 17, 209223.

Russell, S.H., Hancock, M.P., and McCullough, J. (2007). Benefits of Undergraduate Research Experiences. Education Forum 316.

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SECTION I

SCHOOL FOR CULTURAL AND SOCIAL TRANSFORMATION

1.

ECOLOGICAL JUSTICE

Aaliyah Henderson

Faculty Mentor: Andrea Baldwin (Ethnic Studies and Gender Studies, University of Utah)

Ecocriticism is a movement aimed to bring awareness to environmental concerns. This movement started in the 1990s but soon displayed a need for more diversity regarding how they approached sustainable environments. Research published during this time was very Westernized and catered to white intellectual men. This lack of diversity soon started impacting vulnerable communities in ways they could process environmental situations that go beyond them. Such as many families not having much knowledge about how the environment is impacting their health. Or some families not having the resources to leave the community that they reside in that

is at risk due to the environment. Implementing research is critical in situations where vulnerable communities are at risk. It is important because we have a right to have as much help and research with environmental issues as white communities do. The lack of diversity in research is something that should not be dismissed and need to be brought to light. Therefore in this research, we use open-ended interview questions to gather data about how vulnerable communities broadly defined are impacted by the environment in which they reside. This research is specifically interested in understanding vulnerable communities in Utah and as well as gathering information about how these communities are working toward just environment futures. In this research, we hope to bring light and discover how ecocriticism movements impact vulnerable communities here within Utah, and how many vulnerable communities are affected by the current state of Utah's environment. We hope to use this data to show how many of the vulnerable communities are not aware of environmental risks that are occurring in their backyard. This should help bring to light why it's important to include all communities even black and brown in research tailored to environmental concerns.

About the Author

Aaliyah Henderson

2.

RESEARCH REFLECTION BY AALIYAH HENDERSON

Aaliyah Henderson

Faculty Mentor: Andrea Baldwin (Ethnic Studies and Gender Studies, University of Utah)

Undergrad research has helped me develop my communication and networking skills significantly. I have gained a lot of experience in how to conduct research as well as applying research skills to my career. This is my second time conducting research, and it seems like the more I do research the more I can see myself going into a career that is research based. This will diffidently not be my last time doing research, and I can't wait to start another project!

About the Author

Aaliyah Henderson

SECTION II

SCHOOL OF DENTISTRY

3.

UNRAVELING THE IMPACT OF COVID-19 ON SJOGREN'S DISEASE: A RETROSPECTIVE COHORT ANALYSIS

Eliza Diggins; Melodie Weller; and Swetha Shankar

Faculty Mentor: Melodie Weller (Dentistry, University of Utah)

Objective

Autoimmune syndromes impact approximately 1 in 5 Americans; however, their characterization, both phenotypically and etiologically, is severely lacking.

Sjogren's Disease (SjD) is a chronic autoimmune disease characterized by decreased tear and/or saliva production, chronic salivary gland inflammation, autoantibody development and other extraglandular manifestations. There has been growing evidence of potential role of viral pathogens in development of autoimmune diseases such as SjD, most notably SARS-COV-2.

Methods

A retrospective cohort study was conducted utilizing data from TriNetX, LLC, that consists of >128,000 patients diagnosed with SjD (2015 to 2023). The SjD cohort was composed of all patients who had 2 or more M35.0 (M35.01-M35.09) ICD-10 codes with a separation of at least 6 months. Two additional control cohorts were composed of a comprehensive set of patients who displayed Sjogren's associated symptomology (R68.2 Dry Mouth, H04.12 Dry Eye Syndrome) but did not meet the criteria for SjD diagnosis. Demographic and phenotypic changes observed in the Sjogren's cohort before and after the COVID-19 pandemic were characterized.

Results:

The study highlighted notable changes in the SjD demographic profiles before and after the COVID-19 pandemic. There was a significant increase in the age of SjD patients at diagnosis during the pandemic relative to pre-pandemic (57.14+/-7.14 years pre-pandemic to 58.61+/- 9.10 years pandemic, $p<0.0001$). Additionally, there was a significant increase in the percent of males being diagnosed with SjD during the pandemic, raising from 12.86% to 15.12%. Racial and ethnic composition revealed a significant increase in SjD diagnoses among Black or African American and Hispanic populations, with

a decline among Asian populations. Regionally, the southern U.S. witnessed a rise in SjD diagnoses, while all other U.S. regions experienced a decrease.

Conclusion

The COVID-19 pandemic has significantly influenced the demographic profile of SjD patients. These findings emphasize the potential interplay between viral pathogens and autoimmune disease prevalence and characteristics.

About the Authors

Eliza Diggins

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4.

RESEARCH REFLECTION BY ELIZA DIGGINS

Eliza Diggins

Faculty Mentor: Melodie Weller (Dentistry, University of Utah)

As an undergraduate student, I have had to opportunity to participate in research both in the School of Dentistry doing mathematical epidemiology and in the Department of Physics and Astronomy studying extragalactic dynamics. These experiences have helped prepare me for graduate school and have opened many doors professionally.

About the Author

Eliza Diggins

5.

EXPLORING THE IMPACT OF HDV ON SJOGREN'S DISEASE DEVELOPMENT: A MURINE MODEL STUDY

Alexander Romano

Faculty Mentor: Melodie Weller (Dentistry, University of Utah)

Abstract

Sjogren's Disease (SjD) is a chronic autoimmune disease affecting approximately 0.1% of the United States population. Clinical classification of SjD includes reduced tear and saliva excretion, accumulation of lymphocyte foci in the salivary gland tissue, and the detection of

antibodies against Ro (SSA), La (SSB), and nuclear proteins. The cause of SjD is unknown, though it is hypothesized that pathogens, including viruses and bacteria, may play a role. Previous studies have detected Hepatitis Delta Virus (HDV) in the minor salivary gland of patients with SjD (1,2); without the typical presence of a Hepatitis B virus coinfection. In this study, murine models were transduced with Adeno-associated virus containing expression cassettes for Luciferase (control), small, large, or a combination of both small and large HDV antigens to evaluate the impact of HDV antigen expression on salivary gland function and SjD autoimmune disease development. After a ten- or four-month period, the models were analyzed for disease phenotype development and changes in the gene expression profiles within the salivary gland tissue. Findings included a significant increase of inflammation in mice expressing both small and large HDV antigens, a significant increase of anti-SSA(Ro) antibodies in samples expressing the short HDV antigen, and a correlation between increased overall inflammation and decreased overall saliva flow. HDV transcripts within submandibular glands were quantified by qPCR and matched with transcriptomic sequencing. Analyses identified an increase in glycolysis and beta oxidation metabolism in models with detectible HDV antigen expression. The models showed significantly increased IgM expression in the HDV murine models, without significant change of other antibodies.

Future plans include an ELISA diagnostic assay to verify the antibody levels and further sequencing analyses. With this information we can build a better picture of the direct mechanisms of HDV-mediated changes in salivary gland

dysfunction and determine the extent that HDV is inducing systemic SjD symptoms.

References

1. Hesterman M.C, Furrer S.V., Fallon B.S., Weller M.L. Clinical and In Situ Characterization of Hepatitis Delta Virus in Sjörgen's Syndrome.bioRxiv 2022doi: https://doi.org/10.1101/2022.12.03.518993

2. Weller M.L., Gardener M.R., Bogus Z.C., Smith M.A., Astorri E., Michael D.G., Michael D.A.,Zheng C., Burbelo P.D., Lai Z., Wilson P.A., Swaim W., Handelman B., Afione S.A., Bombardieri M., Chiorini J.A. Hepatitis Delta Virus Detected in Salivary Glands of Sjogren's Syndrome Patients and Recapitulates a Sjogren's Syndrome-Like Phenotype in Vivo. Pathog Immun. 2016 doi:10.20411/pai.v1i1.72.

About the Author

Alexander Romano

6.

RESEARCH REFLECTION BY ALEXANDER ROMANO

Alexander Romano

Faculty Mentor: Melodie Weller (Dentistry, University of Utah)

Working in the Weller lab has helped me grow in so many ways, but most of all, I have found myself given the opportunity to explore my interests and take charge of my future development. I hope to go to graduate school, something I never before thought was accessible to me. I have taken classes I never thought to consider before and I have found so many subjects that I truly interested in, whether it is genetics or biochemistry. I want to see what else I can do in the microbiological space, and to go on to

succeed in my future graduate program, all thanks to the opportunities this research experience has given me.

About the Author

Alexander Romano

SECTION III

COLLEGE OF EDUCATION

7.

EXPLORING THE RELATIONSHIP OF INSTRUCTOR-LED SCAFFOLDING, SCIENTIFIC OBSERVATION, AND SOCIAL GROUP DYNAMICS IN GEOSCIENCE FIELD SETTINGS

Jordan Giron; Lauren Barth-Cohen; Adrian Adams; and Lynne Zummo

Faculty Mentor: Lauren Barth-Cohen (Educational Psychology, University of Utah)

Abstract

The goal of the present study was to examine the relationship between different levels of instructor-led scaffolding, social dynamics, and scientific observations learners made in a geology field course, factors which are often minimized in existing geoscience fieldwork literature, and which combination of these factors are related with an effective learning environment (ELE). In the context of this study, an ELE in geoscience fieldwork supports a collaborative discussion between a group of learners that results in synthesis of relevant geologic concepts.

To analyze this relationship, we used audio and video data from 20 secondary science teachers on a summer field trip spanning over six days in Capitol Reef National Park (CRNP). Specifically, we did a multiple case study analysis of one group of four teachers throughout one day of the field course, examining three distinct cases exhibiting a high, medium, and low level of scaffolding. During our analysis we reviewed student self-reflection forms to find cases of interest, then we created transcripts of the relevant video/audio data, and finally we used these transcripts to write narrative summaries of the cases.

Our analysis found that high-level scaffolding was related with low group collaboration and scientific observation but also a synthesis of relevant geological concepts. In contrast, low-level scaffolding was related with greater group collaboration and observation but did not exhibit synthesis of relevant concepts. We found that

mid-level scaffolding bridges this gap, as learners engaged in group collaboration and the sharing of observations, while also being guided towards a synthesis of relevant geologic concepts. An ELE was most closely related to the mid-level scaffolding case. These results highlight the importance of scaffolding within a field learning environment and how different levels of scaffolding may potentially relate to the nature of group collaboration, scientific observation, and eventually an ELE. Implications of this work suggest future attention to the role of scaffolding in fieldwork.

Bibliography

Atchison, C. L., Marshall, A. M., & Collins, T. D. (2019). A multiple case study of inclusive learning communities enabling active participation in geoscience field courses for students with physical disabilities. Journal of Geoscience Education, 67(4), 472-486.

Barth-Cohen, L. A., & Braden, S. K. (2022). Unpacking the complexity in learning to observe in field geology. Cognition and Instruction, 40(2), 233-265.

Boyle, A., Maguire, S., Martin, A., Milsom, C., Nash, R., Rawlinson, S., … & Conchie, S. (2007). Fieldwork is good: The student perception and the affective domain. Journal of Geography in Higher Education, 31(2), 299-317.

Mooney, S. J. (2006). A simple group work approach for effective field work: A soil sciences case study. Journal of Geoscience Education, 54(1), 74-79.

Petcovic, H. L., McNeal, P. M., Nyarko, S. C., & Doorlag, M. H. (2020). “How did you learn to map?” A model for describing influential learning experiences in geologic mapping. Journal of Geoscience Education, 68(3), 220-236.

Schwartz, D. L., Tsang, J. M., & Blair, K. P. (2016). The ABCs of how we learn: 26
scientifically proven approaches, how they work, and when to use them. WW Norton & Company.

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8.

RESEARCH REFLECTION BY JORDAN GIRON

Jordan Giron

Faculty Mentor: Lauren Barth-Cohen (Educational Psychology, University of Utah)

As someone who has lived in El Paso, Texas my entire life I was immediately struck by the beautiful greenery and cool, comfortable weather that I was greeted with, a far cry from the year-long summer we must endure back home. Granted, everyone assured me that this chill weather was unusual in Utah this time of year, but regardless I wasn't complaining.

Now, with regards to my research experience I can say it was hands-on from the get-go, as our data-collection period was at the beginning of June during which we were

out in the field in Capital Reef National Park. My role during this was to manage the Go Pros we were using to collect audio and video data, so I was always on the lookout for dead cameras wailing out to me so I could replace their batteries. I enjoyed this, as it always kept me on my toes, and the scenery in the park was beautiful as well.

I am a psychology major, however up until this point I was unsure of what research area to pursue besides my interest in cognitive functions, which does not narrow things down really. However, after my research this summer I am quite confident I want to continue research on learning and cognition, as my project was a part of the educational psychology department. In fact, I enjoyed education research and my experience here so much that I am more than willing to return to the University of Utah for graduate school. This was a great experience for me, as not only did I make great connections, but I was also able to narrow down my career path as well.

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Jordan Giron

9.

SUPPORTING ELEMENTARY TEACHERS' ENACTMENT OF EQUITABLE MATHEMATICS AND SCIENCE INSTRUCTION

Abigail McWhirter; Lauren Barth-Cohen; and Lynne Zummo

Faculty Mentor: Lauren Barth-Cohen (Educational Psychology, University of Utah)

Background and Theoretical Framework

Promoting *equity-oriented teaching practices* (EOTP), or teaching that appreciates student diversity and acknowledges their lived experiences, is a necessary undertaking within science and mathematics teacher education. The disciplines of science and mathematics are often assumed to be "objective" and, therefore, disconnected from *equity*, or tensions related to access for historically underrepresented and underserved populations. However, teacher education that utilizes EOTP has resulted in greater learning outcomes within these fields. There is a growing need to develop these teacher education practices to encourage pre-service teachers' (PSTs), or teachers in training, to address issues of equity when they appear in PK-12 classrooms. To do so, we utilized a framework known as *culturally grounded pedagogy* (CGP). CGP refers to teaching practices that 1) leverage students' multiple strengths and competencies, 2) explicitly value students' diverse lived experiences and ways of knowing or participating, including language and cultural practices, 3) attend to classroom power and status dynamics to create equitable learning opportunities, and 4) aim to diversify curriculum and challenge dominant perspectives (Aguirre et al., 2013; Banks, 2019; Gay, 2002; Ladson-Billings, 1995; 2014; Paris, 2012). These practices are known as the *features of CGP* and are often present in classrooms that utilize EOTP.

There are roadblocks to discussing and implementing the features of CGP with PSTs. For instance, merely discussing CGP and equity in the classroom leaves PSTs' understanding as highly theoretical and difficult to practically carry out. It is beneficial to utilize teaching *cases*, or hypothetical scenarios, that are developed

through collaboration with in-service teachers (ISTs) (Shulman, 1992). This empowers ISTs to reflect upon their experiences of classroom equity and construct cases that present PSTs with realistic and tangible scenarios. PSTs are asked to engage with these cases in the methods courses that outline teaching practices in math and science. This project aimed to analyze the extent to which one such case succeeded in eliciting PST classroom conversation of the features of CGP discussed during its development.

Methods

To design the case, three two-hour long IST workshops were hosted over a period of three weeks. The 6 IST participants were recruited from local school districts and given an introduction to CGP and example cases. They were then asked to collaborate in pairs and design a case.

This case was later implemented into the recorded PST methods class. The 11 PSTs were asked to review the case and draft their own responses before discussing the prompts, first in small groups and then with the class as a whole.

A thematic coding scheme was used to analyze the audio, video, and written data from the IST workshops and PST classroom discussions. The process involved highlighting and summarizing relevant comments before extracting common themes to be turned into a codebook. The codes were then applied to the data and analyzed.

Results

The findings were mixed, revealing the emergence of a continuum for the features of CGP related to their discussion. Features 1 (leveraging student strengths) and 3 (dismantling classroom hierarchies) were of most

relevance to the case, both in its IST workshop development and PST classroom discussion. Many of the comments made by ISTs and PSTs alike were located on one end of the continuum where *early versions* of the feature held significant room for development. Other comments were on the opposite end, where discussion was a *target version* that more aligned with the instructional goals of the class. Less frequent were *emerging versions* that still held room for improvement but were moving more in the direction of the target than their early version counterparts. Where the PST classroom comments fell on the curriculum mirrored that of the IST workshop discussions during the case's development.

Discussion and Implications

We considered a number of theories for why the data from the IST workshops and PST classroom data presented in the ways it did. For instance, much of the discussion of the cases centered around the issue of student grouping. We suggested that this might be due to the nature of the case, which explicitly mentioned student grouping. It might also have been a significant focus because it is a particularly intriguing issue for teaching populations for whom student grouping is the source of classroom conflict. Additionally, there was much attention paid to student differences that do not forefront equity, such as student personality, rather than differences rooted in structural inequity, such as race and gender. We considered that this

might be due to feelings of discomfort surrounding such topics. Indeed, the literature suggests that practices such as race-evasion and silencing can be found in classroom settings (Castagno, 2014; Chang-Bacon, 2021). Furthermore, the transcripts revealed a heavy presence of hedging, or linguistic cues of uncertainty, within the IST workshop conversations, suggesting some hesitancy to discuss inequities based on race and gender.

Conclusion

Our findings suggest that there is still room for improvement in the development and implementation of cases that aim to foster the use of CGP in teaching populations. Further research will aim to continue promoting EOTP and CGP in PK-12 math and science education.

Bibliography

Aguirre, J., Mayfield-Ingram, K., & Martin, D. (2013). The impact of identity in K-8 mathematics: Rethinking equity-based practices. The National Council of Teachers of Mathematics.

Banks, J. A. (2019). An introduction to multicultural education (Sixth edition). Pearson.

Castagno, A. E. (2014). Educated in whiteness: Good intentions and diversity in schools. University of Minnesota Press.

Chang-Bacon, C. K. (2021). “we sort of dance around the race thing”: Race-evasiveness in teacher education. Journal of Teacher Education, 73(1), 8–22.

Gay, G. (2002). Preparing for culturally responsive teaching. Journal of Teacher Education, 53(2), 106-116.

Ladson-Billings, G. (2014). Culturally Relevant Pedagogy 2.0: A.k.a. the Remix. Harvard Educational Review, 84(1), 74–84. https://doi.org/10.17763/haer.84.1.p2rj131485484751

Paris, D. (2012). Culturally Sustaining Pedagogy: A Needed Change in Stance, Terminology, and Practice. Educational Researcher, 41(3), 93–97. https://doi.org/10.3102/0013189X12441244

Shulman, L. S. (1992). Toward a pedagogy of cases. In J. L. Shulman (Ed.), Case method in teacher education (pp.1-32). New York: Teacher College Press.

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SECTION IV

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10.

MEDICAL IMAGING USING NEAR-INFRARED WAVES

Luis Lorenzo Delos Reyes

Faculty Mentor: Rajesh Menon (Electrical and Computer Engineering, University of Utah)

Abstract

With the growing demand for more non-invasive based treatments in the medical field paired with the rise of COVID-19 which came with it the widespread adoption of more contactless technologies, the emergence of infrared technologies and therapy might prove beneficial as it not only provides a contactless, non-invasive way of measuring many health biometric information, but it also has the potential of being utilized as a way of providing valuable imaging through its unique properties and

wavelength which makes it optimal for some applications. Infrared light is usually utilized in PPG or Photoplethysmogram which can be seen in most hospitals and clinics wherein its main use is to measure blood attributes and blood changes in volume by shining infrared light into a patient's finger and then observing the changes in the amount of light being detected at the other side of the finger with a light sensor. Infrared waves also find extensive use in Thermal Imaging Cameras which use lenses to focus infrared energy into the sensor and, more recently, in vein finding devices which can help image vein networks to ease the administering of shots and blood extraction proving the great potential that this technology has. The proposed project aims to explore various ways in which infrared use can be expanded into more applications such as utilizing infrared and near-infrared wave imaging on specific vital points to help in diagnosing blood clots and blood clot related viruses and diseases. One of the many diseases wherein the symptoms consist of blood clots in the blood network going to the brain is COVID-19.

Index Terms— Near-Infrared Waves, Raspberry Pi, Image Segmentation, Signal Processing, Vein-Finding, Hemoglobin

I. Introduction

While compared to the other forms of imaging such as ultrasound and X-Rays, infrared might not provide as much detail, or propagate as freely within the body, one area where this technology really stands out is in its accessibility and convenience on top of its potential to image blood flow in veins and arteries. In recent years, there has also been a surge of interest in NIR with some

applications even going as far as providing cerebral oxygen saturation data and other cerebral applications [7] but most of these are still relatively new and very costly. Most NIR (Near Infrared) vein finders typically image veins and blood patters for about 10 to 15mm of depth.[2] One of the reasons why NIR proves promising when it comes to its blood related applications comes down to the properties of blood, to be specific, the properties of hemoglobin makes it so that when NIR is directed towards its blood flow, the NIR light is absorbed by the flow of blood, while the tissue surrounding the vein reflects the light back into a sensor wherein some signal processing takes place in order to map out and project where veins are located.[3]

Recent research and developments may have increased the capabilities of NIR light and driven down the costs associated with utilizing this technology, but more can be done with the improvement of NIR as well. The ability to use lenses and non-imaging optics may prove useful in trying to maximize the NIR when it comes to concentrating and transferring light into the desired imaging location.[6] Before doing these manipulations however, the right infrared light must be chosen, and from a study by Garcia and Horche, it was identified that a wavelength between 585nm-670nm would be optimal for vein visualization.[4] After the reflected light has been collected, there is also a potential to improve the signal received through post processing similar to that seen in ultrasound signal conditioning in order to improve the accuracy and resolution of the image.

Having an improved NIR imaging system could also bring a whole new level of benefits for infrared

technology. Expanding its capabilities could help in diagnosing more and more blood related diseases especially those relating to blood and blood clots such as potentially COVID-19 which can be identified through blood clots present in the arteries surrounding the brain.[1] One of these arteries near the brain is the Basilar and facial arteries which are vital arteries which could lead to various disorders within the body and the nervous system should they have any abnormalities.[5] This was pointed out because their location within the face makes it so that NIR has the potential to propagate through and actually analyze areas where these arteries reside which is the area surrounding the nose which is perfect because this is also an opening where bone does not serve as an obstruction.

II. Technical Introduction

A. Near-Infrared Waves

Near-Infrared wave is a segment of the electromagnetic spectrum, lying just beyond the visible spectrum of light. These waves, with wavelengths ranging from approximately 700 nanometers (nm) to 1,400 nm, possess unique properties and find diverse applications in various fields such as astronomy, medicine, agriculture, and more. In this project, we will explore the characteristics, uses, and significance of nearinfrared waves.[8]

Near-infrared waves, often abbreviated as NIR, have wavelengths that are slightly longer than those of visible light. This means they are not visible to the human eye, but they share some common properties with both visible light and longer-wavelength infrared radiation. NIR waves are characterized by their ability to penetrate

certain materials and interact with the molecular vibrations of substances.

One of the key properties of NIR waves is their ability to interact with the chemical composition of objects. When NIR radiation interacts with a substance, it causes the molecules within that substance to vibrate at specific frequencies. These vibrations produce a unique absorption spectrum that can be measured and analyzed. This property forms the basis for many applications of NIR waves.[9]

NIR spectroscopy also plays a crucial role in the pharmaceutical industry. It is used for quality control and the identification of chemical compounds in drugs. The technique is rapid, non-destructive, and highly accurate, making it an essential tool for ensuring the safety and efficacy of pharmaceutical products.

In the field of medicine, NIR waves find application in non-invasive imaging techniques like near-infrared spectroscopy (NIRS). NIRS is used to measure oxygen levels in tissues and detect anomalies such as tumors. It has become an indispensable tool for diagnosing medical conditions and monitoring the health of patients. Scholkmann et al. (2014) discuss these applications in their article "A Review on Continuous Wave Functional Near-Infrared Spectroscopy and Imaging Instrumentation and Methodology."[10]

B. Raspberry Pi

A small, affordable, and versatile single-board computer that has captured the imagination of hobbyists, educators, and innovators around the world. Introduced in 2012 by the Raspberry Pi Foundation, this credit-card-sized computer has had a profound impact on various

fields, from education to DIY electronics and even professional applications. In this section, we will explore the history, features, applications, and significance of the Raspberry Pi. The Raspberry Pi's appeal lies in its simplicity and affordability. Despite its diminutive size, it packs impressive features:

1. Processing Power: Raspberry Pi models come with various processors, with the latest versions offering significant computing power. The Raspberry Pi 4, for instance, boasts a quad-core ARM Cortex-A72 CPU, making it capable of handling a wide range of tasks.
2. Connectivity: Raspberry Pi boards offer multiple USB ports, HDMI outputs, audio jacks, and network connectivity options like Ethernet and Wi-Fi. This connectivity allows users to connect various peripherals and use the Raspberry Pi as a versatile computing platform.
3. GPIO Pins: The Raspberry Pi includes a set of General-Purpose Input/Output (GPIO) pins, which enable users to interface with external hardware and electronics, making it a favorite for DIY electronics projects.
4. Operating Systems: Raspberry Pi supports various operating systems, including the Raspberry Pi OS (formerly Raspbian), Linux distributions, and even Windows 10 IoT Core, providing flexibility for different applications.
5. Community and Accessories: An active and passionate community has formed around the Raspberry Pi, creating a wealth of resources,

tutorials, and accessories. From camera modules to touchscreen displays, users can expand the capabilities of their Raspberry Pi to suit their needs.

Applications of the Raspberry Pi: The Raspberry Pi has found applications in a multitude of domains:

1. Education: Its original purpose remains a core focus. Raspberry Pi computers are used in schools and educational programs worldwide to teach programming, electronics, and computer science.
2. DIY Electronics: Hobbyists and makers use Raspberry Pi for projects ranging from home automation and robotics to retro gaming consoles and media centers.
3. Professional Prototyping: It serves as a cost-effective tool for prototyping and proof-of-concept development in the professional world. Engineers and researchers use it to create innovative solutions quickly and inexpensively.
4. Server and Network Applications: Raspberry Pi is employed as a low-power server for various purposes, including web hosting, file storage, and even as a network-attached storage (NAS) device.
5. IoT (Internet of Things): Its small form factor, GPIO pins, and connectivity options make it an ideal choice for IoT projects. It can be used to build smart home devices and sensors.

The Raspberry Pi's significance lies in its democratization of computing and innovation. It has made computing accessible to a wider audience, breaking down barriers to entry into technology and fostering creativity. Students can learn programming and electronics without the need for expensive hardware, and professionals can rapidly prototype ideas without large budgets. [11]

As technology continues to evolve, the Raspberry Pi is likely to play a significant role in shaping the future of computing and innovation. Its community-driven development and continuous improvements in hardware and software ensure that it remains a relevant and powerful tool for years to come.

C. Image Segmentation and Signal Processing

Image segmentation is a fundamental technique in computer vision and image processing that plays a pivotal role in identifying and extracting meaningful regions or objects within an image. This process involves partitioning an image into multiple distinct segments, each representing a specific region of interest. In this section, we will delve into the principles, methods, applications, and significance of image segmentation. At its core, image segmentation aims to group pixels or regions in an image based on their visual characteristics. This involves distinguishing objects from the background, identifying boundaries between objects, and dividing the image into homogeneous regions. The primary principles guiding image segmentation include

color, intensity, texture, and spatial proximity. A variety of techniques and algorithms are employed for image segmentation, each suited to different scenarios and challenges:

1. Thresholding: This straightforward method involves selecting a threshold value and categorizing pixels as foreground or background based on their intensity or color values. It is simple yet effective for binary segmentation tasks.
2. Region-based Segmentation: This approach groups pixels into regions by examining their similarity in terms of color, texture, or other features. Region growing and region splitting/merging are common techniques in this category.
3. Edge Detection: Edge-based segmentation detects edges and contours in an image, using techniques like the Canny edge detector or the Sobel operator. Edges often correspond to object boundaries.
4. Clustering Algorithms: K-means clustering, and hierarchical clustering are utilized for segmenting images based on pixel similarity. These methods are versatile and can handle various types of data.
5. Machine Learning: Deep learning methods, particularly convolutional neural networks (CNNs), have revolutionized image segmentation. U-Net, Mask R-CNN, and FCN (Fully Convolutional Networks) are popular

architectures for semantic and instance segmentation.[12]

Image segmentation finds applications across a wide range of fields:

1. Medical Imaging: It is vital for detecting and analyzing anatomical structures and abnormalities in medical images, including MRI, CT scans, and X-rays.
2. Autonomous Vehicles: In self-driving cars, image segmentation is crucial for identifying pedestrians, other vehicles, and road signs.
3. Object Recognition and Tracking: In robotics and surveillance, image segmentation helps in identifying and tracking objects of interest.
4. Satellite and Remote Sensing: Image segmentation assists in land cover classification, crop monitoring, and environmental analysis.
5. Biomedical Imaging: It is used in cell and tissue analysis for tasks such as counting cells, identifying nuclei, and tracking cell movement.
6. Natural Language Processing: In document processing, image segmentation is used to isolate text regions for optical character recognition (OCR).

Image segmentation is integral to understanding and extracting information from images in the era of big data and artificial intelligence. Its significance lies in its ability to simplify complex visual data,

making it more manageable and interpretable. With the advent of deep learning techniques, image segmentation has seen significant advancements in accuracy and efficiency [13].

The future of image segmentation holds promise as it continues to evolve with advancements in computer vision and machine learning. Enhanced algorithms, real-time processing capabilities, and improved accuracy will expand its applications and make it even more integral in fields ranging from healthcare to autonomous systems.

III. Methodology

Now that a background has been established for the related information and technologies for the Near-Infrared vein finder, the development of the vein finder system consists of three main sections: the Near-Infrared array/sensor, the Image Segmentation and processing software, and the Pico projector to project the image to the desired area all of which working hand in hand in conjunction with the Raspberry Pi which acts as the main microprocessor for the device. In the case of this study, a Raspberry Pi 2 was used along with a Near-Infrared led array and the NoIR sensor (Figure 1.a). This sensor was used because of its ability to block unwanted light waves which are not in the Near-Infrared spectrum. A 36800mAh battery was also used as a means of powering the device to ensure its portability and ease of use, all of which are housed inside of a 3D printed enclosure to protect the entire system (Figure 1.b). A black material was also placed around the NIR array and the sensor in order to reduce the reflected unwanted light which could compromise the image.[14]

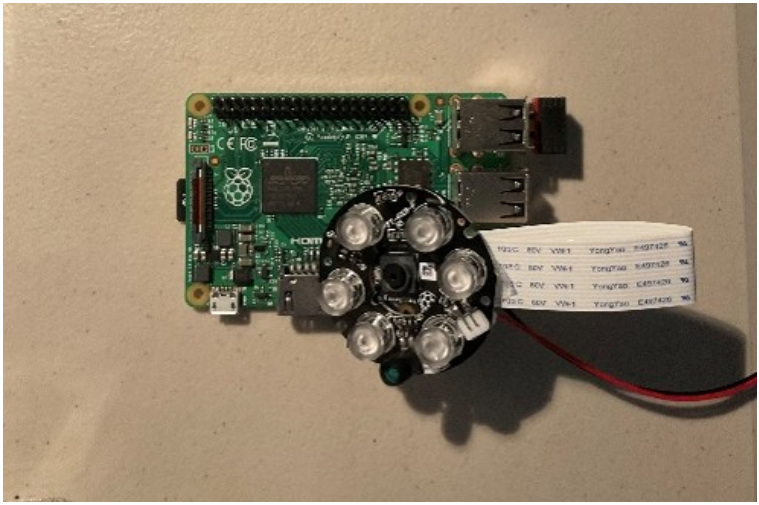


Figure 1.a. Raspberry Pi Microcontroller with NoIR sensor attachment.

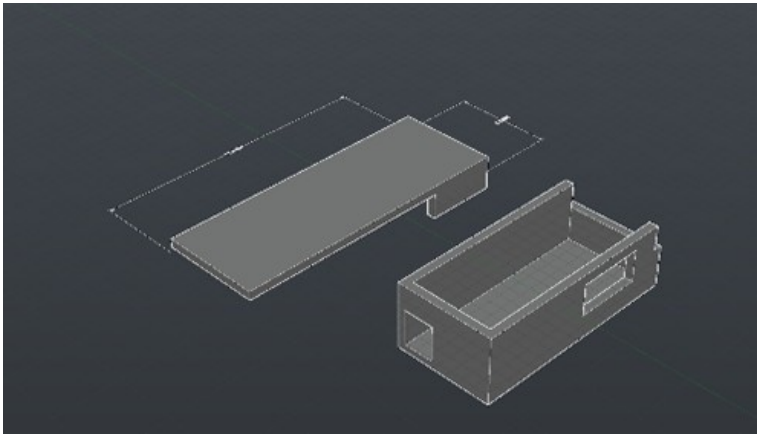


Figure 1.b. 3D model of the Vein Finder Enclosure on AutoCAD.

The first thing to consider was to make sure that the camera doing what it was intended to do, which in this case was to read and sense the Near-Infrared waves coming from the Near-Infrared LED array, which in this

case utilizes an 850nm wavelength, being reflected by the hemoglobin flowing inside the veins. Originally, it was intended to use just a regular camera or sensor to do this task and to just modify that sensor by essentially removing the infrared filter from the sensor which would open the range of wavelengths being seen by the sensor to include those wavelengths on the Infrared spectrum. Initially, the OV2640 sensor was chosen for its affordability running at just around $10.00, although after removing its infrared filter and testing it out for the first time the image quality turned out to be less than sufficient for accurate vein imaging. It was then decided that the best option would be to use an actual sensor that is specifically manufactured for sensing infrared wavelengths to begin with, this is why the NoIR camera by Adafruit was chosen to be the main sensor. The result for this sensor shows vast improvements from the initial sensor clearly showing the location of veins in the wrist. Pictured below are the results from both sensors.

Figure 2.a. Image from the initial sensor used, the OV2640 with the infrared filter removed.

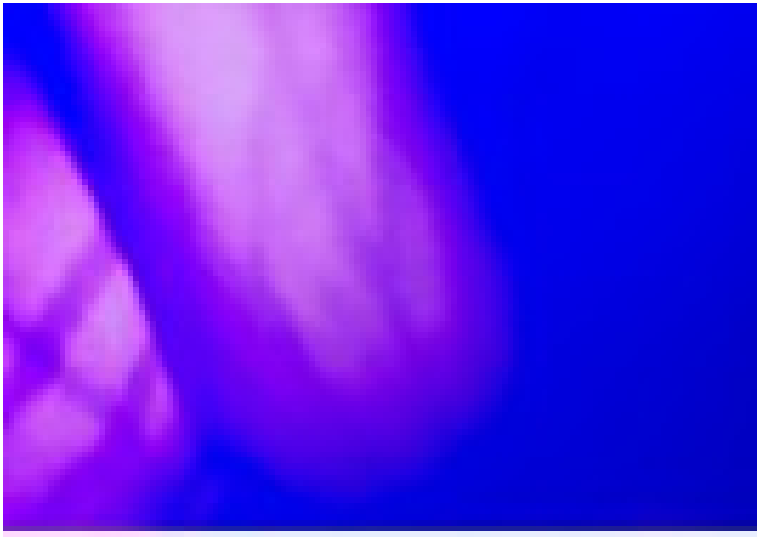


Figure 2.b. Image from the NoIR camera sensor

Now that a sensor has been confirmed to be working with Raspberry Pi that also has NIR sensing capabilities, the next logical step would be to try and improve the image seen and make the veins more prominent. There are many different image segmentation techniques which can be beneficial to achieving this goal. For the purposes of this research study, the image segmentation software was developed in Python because of its ease of accessibility and its extensive support. The first method used made use of color detection to essentially filter out all the pixels in the image apart from the ones which have a specific color value which corresponds to that of the veins. (figure 3.a) After that, thresholding was also done which essentially converts the image into a specific color space wherein an area of interest can be chosen while the rest of the image is ignored. (figure 3.b) Tone curves were also explored in this research study, tone curves allow for ease of manipulation of an image's exposure, amount of light and tone of the image. This can be very useful in making the specific adjustments in making the veins in an image more prominent, and giving the image the ability to show more detail which would not have originally been seen without the implementation of tone mapping by removing unwanted intensities. Edge detection was also implemented by looking for sudden changes in pixel intensity throughout the image which greatly improves delineating different sections of the image such as where the veins start and stop differentiating them from the arms. Implementing all of these functions results in a much more improved version of the original image that allows the user to locate the

veins much more accurately, but there's still more that can be done to improve this device's capabilities.

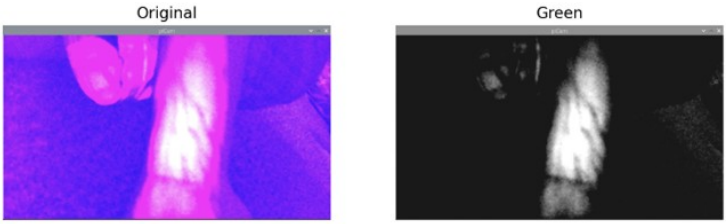


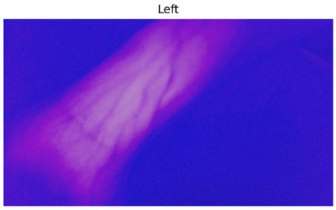
Figure 3. Resulting image after image was converted to the green color space.

The next aspect of image segmentation used in this project was the use of image annotations as well as implementing a machine learning algorithm to the code. First, for the image annotations, a contour analysis must be done to correctly determine bounding boxes around the masks which were done during thresholding. Morphing is also done to the image to improve its ability to learn and delineate which structure counts towards having an annotation assigned to it. Once the annotations have been implemented, filtering out unwanted boxes around areas which don't correspond to vein areas were also done. Finally, once all of that had been accomplished, all that was left was to make sure that the image segmentation code that was put together could work flawlessly with the Pico projector so that the image can be projected into the desired area instead of just having the live feed on a screen. After making a few adjustments to the Raspberry Pi, mainly adding the file path of the image segmentation code to rtc.local, the Vein Finding program starts immediately after starting up when plugging in the Raspberry Pi to the Pico Projector.

A few adjustments were also made to the code to make sure that when the live video feed was being projected, it would do so in full screen and without any title bars or any other obstruction.

IV. Results

The results of Near-Infrared Vein Finder System prove to be very effective at helping in locating where the veins are located at a specific area. With the NIR sensor at a range of about 305mm away from the arm or the desired area, the effective surface depicting an accurate representation of where the veins are is obtained to be about 533mm2 . From the specified range, a depth of about 2.5mm is penetrated by the NIR light which is enough to reflect the NIR light to the sensor. From the results pictured below, this set up can image the essential veins such as the median cubical and the radial artery which is the preferred vein that phlebotomists use to draw blood. When it comes to machine learning and drawing annotations on the image, the system can accurately place annotations on most of the veins visually seen from the image segmentation being done on the image. In the case of this Vein Finder when compared to other similar devices in the market, the results show a similar result in terms of functionality and which veins are accurately delineated for a fraction of the price as well.



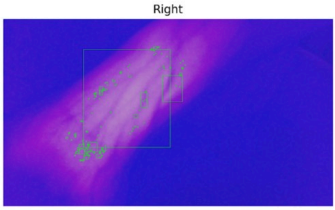


Figure 4.a. Image with all the image segmentation techniques applied compared to the same image but with the annotations.

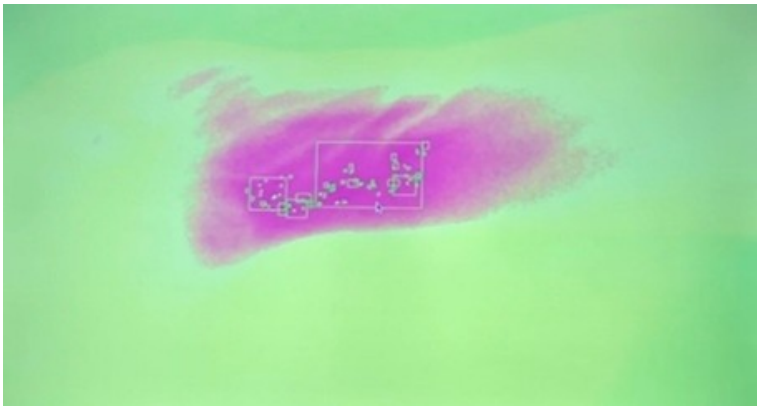


Figure 4.b. Live Image being Projected.

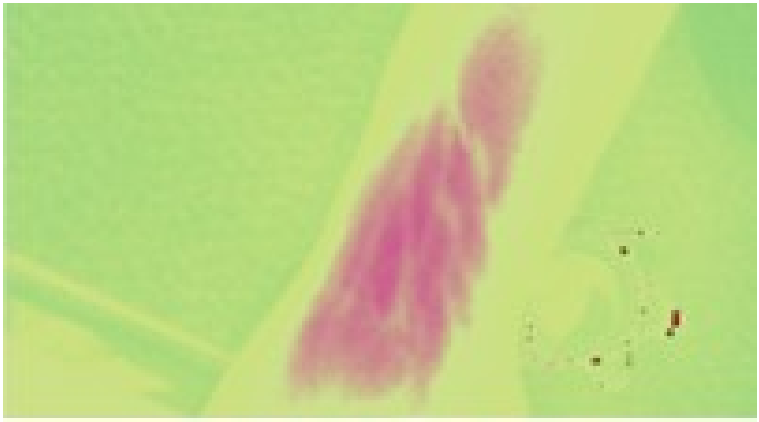


Figure 4.c. Image with the tone mapping applied.

V. Discussion and Conclusion

The results of this research through image segmentation show very promising results for NIR as a means of accurately locating veins which will only

improve as more machine learning aspects are improved and integrated into this system. Although the results may be promising, there is much to be said about the significance of this research and its implications.

A. A New Way of Imaging

When looking into this research, the most noteworthy implication that this hold is that it will advance the use of NIR in the medical field and that this research will hopefully lead to more research to be done in this specific area. This project has opened the gates in terms of what's possible and what can be achieved with NIR when used in conjunction with various image segmentation techniques and machine learning. In the case of this project, it was determined that even with a limited budget one can achieve results like that of vein finders which cost ten times more than the Vein Finder system used through NIR and image segmentation.

Through the pairing of NIR technology and software based image processing and segmentation, it is possible to unlock a whole new plethora of applications for this type of technology such as imaging on different levels such as potentially with areas such as the cerebral arteries which can affect the brains day to day function especially with monitoring oxygen levels in those areas, observing abnormal tissues within a specified areas, or at a more intricate level such as with facial veins which will really benefit dermatologists with their procedures. It's also worth mentioning that the use of NIR imaging, particularly in functional brain imaging, raises ethical questions about consent, data security, and potential risks associated with prolonged exposure to NIR radiation. It is also worth mentioning that these

applications are not just limited to the medical field but have a lot of potential in other fields as well. In agriculture, NIR imaging has revolutionized farming practices. By analyzing the reflectance of near-infrared light from crops, it is possible to assess plant health, nutrient content, and moisture levels. This information aids farmers in optimizing crop management, reducing waste, and increasing overall agricultural productivity. The implications for global food security and sustainable agriculture are substantial. NIR imaging also plays a vital role in environmental monitoring and remote sensing. Satellites equipped with NIR sensors can track changes in vegetation cover, analyze soil moisture levels, and assess the impact of climate change. By providing a bird's-eye view of the Earth's surface in the NIR spectrum, this technology aids in disaster management, biodiversity conservation, and land-use planning. Astronomy is another field where NIR imaging has proven invaluable. Since near-infrared light can penetrate cosmic dust clouds, it allows astronomers to observe celestial objects that are obscured in visible light. This capability has led to the discovery of distant galaxies, the study of exoplanets, and the characterization of stellar atmospheres. NIR imaging telescopes have broadened our understanding of the universe and the existence of potentially habitable planets. In the realm of security and surveillance, NIR imaging has significant implications. Law enforcement and military agencies use this technology for night vision and surveillance purposes. It enables enhanced situational awareness in low-light conditions, contributing to public safety and national security.

In conclusion, near-infrared imaging is a transformative technology with far-reaching implications in diverse fields. It enhances medical diagnostics, revolutionizes agriculture, advances our understanding of the universe, and contributes to environmental monitoring. However, its adoption also necessitates careful consideration of ethical, privacy, and safety concerns. As NIR imaging continues to evolve, its impact on society and the various sectors it touches will only become more profound, necessitating ongoing ethical and regulatory discussions to ensure its responsible and beneficial use.

B. Overlooked Complications and Future Work

There is also some room for improvements and things which could've been changed in this project. One of these improvements is to alter the live image feed coming from the Pico projector. The reason why this still needs to be altered is because since the projector is located about 2 inches away from the sensor, this distance may seem insignificant, but since the system projects the live feed directly to where the veins are trying to be located, i.e., what the NIR sensor is picking up, this minor 2-inch space means that the image is not being projected exactly at the desired area. This can easily be mitigated through altering the design of the system to make sure that the projector and the sensor are located as close as possible to each other or by altering the projector software to make up for the small distance by altering the image to compensate for the gap. One more improvement which could be made lies in the annotations being made on the image. From the results we see that at some of the veins, the annotations are consistent and yet at the other ones,

its more sporadic and even nonexistent at the more obscure veins, this could potentially be improved through altering the morphing section of the image segmentation code. Finally, being able to gather a large dataset for the system to work on will streamline machine learning algorithms in the future, especially when making use of clustering which is a type of algorithm which would greatly benefit this project in terms of an improved machine learning capability.

Bibliography

1. P. Galiatsatos and R. Brodsky, "What Does COVID Do to Your Blood?," Hopkins Medicine, 03-Mar-2022. [Online]. Available: https://www.hopkinsmedicine.org/health/conditions-and-diseases/coronavirus/what-does-covid-do-to-your-blood. [Accessed: 02-Feb-2023].

2. "Veinviewer is clinically proven to – carestream america," VEINVIEWER FREQUENTLY ASKED QUESTIONS, 2013. [Online]. Available: https://www.carestreamamerica.com/wp-content/uploads/2019/12/Christie_VeinViewer_Vision2_Flyer.pdf. [Accessed: 02-Feb-2023].

3. "How does vein finder work?," BLZ Tech, 2015. [Online]. Available: http://www.veinsight.com/en/how-does-vein-finder-work.html. [Accessed: 02-Feb2023].

4. M. Garcia and P. R. Horche, "Light source optimizing in a biphotonic vein finder device: Experimental and theoretical analysisM," Results in Physics, 03-Nov2018. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2211379718318874. [Accessed: 02-Feb-2023].

5. L. Welsh, J. Welsh, and B. Lewin, "Basilar artery and Vertigo," SAGE Journals, 2016. [Online]. Available:

https://journals.sagepub.com/doi/10.1177/000348940010900701. [Accessed: 02-Feb-2023].

6. W. Jia, R. Menon, and B. Sensale-Rodriguez, “Visible and near-infrared programmable multi-level diffractive lenses with phase change material Sb2S3,” Optica Publishing Group, 2022. [Online]. Available: https://opg.optica.org/oe/fulltext.cfm?uri=oe-30-5-6808&id=469497. [Accessed: 02-Feb-2023].

7. G. S. Umamaherwara and S. Bansal, “Neurological critical care,” Essentials of Neuroanesthesia, 31-Mar-2017. [Online]. Available: https://www.sciencedirect.com/science/article/pii/B9780128052990000348. [Accessed: 02-Feb-2023].

8. L. Sun, “The difference between light therapy and near Infrared therapy,” Sunlighten, https://www.sunlighten.com/blog/difference-light-therapy-near-infraredtherapy/#:~:text=Near%20infrared%20light%2C%20with%20wavelengths,tissue%20repair%2C%20and%20reduce%20inflammation. (accessed Oct. 26, 2023).

9. R. Osibanjo, R. Curtis, and Z. Lai, “Infrared Spectroscopy,” Chemistry LibreTexts, https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectrosc opy/Vibrational_Spectroscopy/Infrared_Spectroscopy/Infrared_Spectroscopy (accessed Oct. 26, 2023).

10. F. Scholkmann F;Kleiser S;Metz AJ;Zimmermann R;Mata Pavia J;Wolf U;Wolf M;, “A review on continuous wave functional near-infrared spectroscopy and Imaging

Instrumentation and methodology," NeuroImage, https://pubmed.ncbi.nlm.nih.gov/23684868/ (accessed Jun. 26, 2023).

11. "About Us," Raspberry Pi, https://www.raspberrypi.com/about/ (accessed Oct. 26, 2023).

12. "Image segmentation detailed overview [updated 2023]," SuperAnnotate, https://www.superannotate.com/blog/image-segmentation-for-machine-learning (accessed Oct. 26, 2023).

About the Author

Luis Lorenzo Delos Reyes

11.

RESEARCH REFLECTION BY LUIS LORENZO DELOS REYES

Luis Lorenzo Delos Reyes

Faculty Mentor: Rajesh Menon (Electrical and Computer Engineering, University of Utah)

Overall, I would say that my undergraduate research experience has really helped in making me a more well-rounded student. I really appreciate the fact that I was able to focus more on an area of study that I found interesting, and got to work with some amazing people to accomplish my goals. Learning more about the research process and the various tools that we have at our disposal is also another reason why I loved my experience being

an undergraduate researcher. I think that my research experience has also given me a greater appreciation of the research process in general which is why I am planning on pursuing postgraduate studies after my time as an undergraduate.

About the Author

Luis Lorenzo Delos Reyes

12.

PRELIMINARY MECHANICAL STUDY OF PRETERM MIDDLE CEREBRAL ARTERIES

Kerrigan Denham and Ken Monson

Faculty Mentor: Ken Monson (Mechanical Engineering, University of Utah)

Introduction

In 2020, 13.4 million infants were born premature [1]. Of infants born before 32 weeks and weighing less than 1.5 kg, 32% will experience interventricular hemorrhage (IVH), which is bleeding in the ventricle region of the brain. Of these cases, 75% will experience long term

neurological disabilities. It is suspected that structural deficiencies in developing cerebral vasculature plays a significant role in the occurrence of IVH [2]. The goal of this preliminary study was to compare the development of mechanical damage in middle cerebral arteries (MCAs) of different gestational age groups.

Methods

Tissue Collection and Preparation: Preterm lamb MCAs were collected from the Albertine Lab in the Department of Pediatric Medicine at the University of Utah's School of Medicine. All samples were classified as moderately preterm cases (80 to 92.5% gestation), as seen in Table 1. MCA branches were then ligated and cut into test segments around 6 mm in length.

Table 1: Preterm lambs used in study.

Gestational Age	Age Euthanized	Sex	Number of Mechanical Tests
128 days (~87%)	7 days	Female	1
128 days (~87%)	7 days	Male	2
120 days (~82%)	~72 hours	Female	2
119 days (~81%)	~72 hours	Male	2
118 days (~80%)	~72 hours	Female	1

*A full term lamb is born at 147 days

Mechanical Testing: After the tissue was prepared, the test segments went through the mechanical testing procedure previously reported by the Monson Lab [3]. In brief, MCA test segments were mounted to cannula and preconditioned by cycling the pressure from 6.7 to 20 kPa. The in vivo length was determined using the load and pressure values found during preconditioning. Before the vessel was subjected to damage via a quasi-static axial overstretch of 1.3 times the in vivo length, sample properties were determined through a baseline stretch of 1.1 the in vivo length. After overstretch, the vessel was re-characterized using the same baseline procedure.

Results/Discussion

Figure 1 depicts the stress-stretch response for every sample in the study before and after overstretch. Samples from lower gestational ages (118 and 119 days) tended to have larger initial stress values when brought to a baseline stretch of 1.1 relative to the in vivo length. This could be an indication that the elastin and collagen fibers in these vessels are still developing significantly in lower gestational ages. Comparison of the stress-stretch response before and after overstretch shows that there is a significant reduction in vessel stiffness, indicating that the vessel microstructure has experienced damage, likely due to collagen and elastin fiber failure.

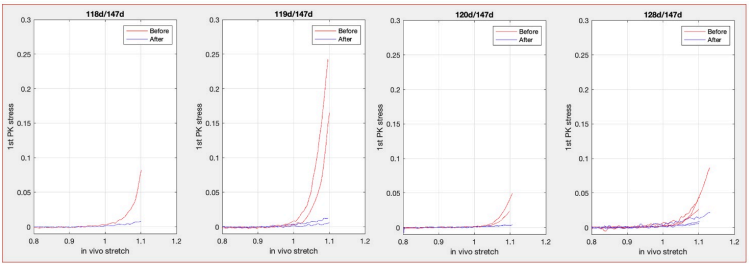


Figure 1: Large-deformation, quasi-static, axial stress-stretch responses for vessels from sheep born at 128 days, 120 days, 119 days, and 118 days. Baseline data from before overstretch is indicated in red, and baseline after overstretch is indicated with blue.

Conclusions

This preliminary research shows that are significant differences in mechanical responses for varying gestational ages. However, this study only included a range of samples from moderately preterm cases. Further research will be done to include other preterm classifications, including extremely preterm (less than 70% gestation) and very preterm (70 to 80% gestation). Further research will also be done to link mechanical

damage to IVH, specifically how vessel microstructural damage causes leakage.

Bibliography

[1] 'Preterm birth', *World Health Organization* (2023)
[2] Nye, *American Journal of Perinatology* (2014)
[3] Nye, *Annals of Biomedical Engineering* (2016)

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13.

BIOFEEDBACK FOR REHABILITATION: DEVELOPMENT OF MUSCLE ACTIVATION FEEDBACK APP TO RETRAIN MUSCLES AFTER STROKE

Manya Murali; Jacob George; Fredi Mino; and Danielle Lopez

Faculty Mentor: Jacob George (Electrical and Computer Engineering, University of Utah)

The long-term goal of this research is to rehabilitate healthy muscle activation patterns in stroke patients through a portable muscle biofeedback system. Approximately 795,000 people experience a stroke each year, and 80% of survivors struggle with upper-limb hemiparesis. Hemiparesis is associated with delayed muscle activation and delayed muscle relaxation that makes it difficult to perform activities of daily living. To address this challenge, we developed a software application to provide real-time biofeedback of muscle activity that patients can use to practice faster muscle activations and relaxations at home. The app automatically detects and logs muscle activations by thresholding electromyography (EMG) data sampled at 1 kHz from the forearm. Time constants are used to quantify the speed of muscle activation and relaxation and are displayed in real-time with dynamic color changes indicating improvement relative to a running average over the past three activations. Preliminary data from one stroke patient hinted at delayed muscle relaxation during hand extension on the paretic side relative to the non-paretic side (0.411 s vs

0.223 s; $p = 0.074$, Wilcoxon signed rank test). The time constant of muscle relaxation during hand extension trended towards improving after 10 minutes of biofeedback (from 0.411 s to 0.154 s; $p = 0.097$, Wilcoxon signed rank test). The participant also expressed interest in using the app for at-home rehabilitation. At-home use of this app may further improve muscle activation through real-time biofeedback, muscle strengthening, and high-repetition training. This accessible rehabilitation platform could also be used to rehabilitate muscle function after other neurological conditions (e.g., spinal cord injury or traumatic brain injury).

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14.

UNDERSTANDING REAL-WORLD PRIVACY CHOICES BY SCRAPING PERMISSION AND NOTIFICATION SETTINGS ON MOBILE PHONES

Siddharth Dhumal and Sameer Patil

Faculty Mentor: Sameer Patil (School of Computing, University of Utah)

In today's technology-driven world, cybersecurity has emerged as a complex and pressing challenge. With

technology deeply integrated into every aspect of our lives, safeguarding digital assets and preserving user privacy has become of utmost importance. However, the ever-evolving technological landscape and the constant threat of cyberattacks make it increasingly difficult for individuals to navigate the digital realm securely. As these threats persist, there is a growing demand for innovative and usercentric solutions that prioritize digital safety.

To address this critical issue, I have developed a cybersecurity app tailored to gather essential data on real-world settings from users' Android devices. The primary focus of the app is to empower researchers in understanding user preferences and practices concerning cybersecurity matters. The app efficiently scrapes the list of installed applications along with the corresponding privacy permissions and notification settings. By aggregating this data in a secure database, the app can enable researchers to derive insights into user behavior, potential privacy risks, and prevailing trends. By gaining insights into app permissions and notifications, researchers could identify potential privacy and security issues and develop strategies that can help users manage their security and privacy more effectively.

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15.

RESEARCH REFLECTION BY SIDDHARTH DHUMAL

Siddharth Dhumal

Faculty Mentor: Sameer Patil (School of Computing, University of Utah)

During my undergraduate years as a Computer Science freshman, I had the opportunity to be part of a remarkable research experience, Summer Program for Undergraduate Research, that significantly impacted my education and future goals. I collaborated on the development of a privacy app, which aimed at helping researchers identify potential privacy and security issues and develop strategies that can help users manage their security and privacy more effectively. Being involved in this project allowed me to apply theoretical knowledge from my

coursework to real-world challenges, giving me hands-on experience in mobile app development.

The research experience exposed me to cutting-edge technologies and methodologies in the field of privacy and data protection, enhancing my understanding of the complexities involved in safeguarding user information. Working in a team with an experienced mentor provided invaluable guidance and mentorship, fostering my growth as a young aspiring computer scientist.

Moreover, the project's focus on privacy and cybersecurity ignited my passion for these critical areas of technology. It fueled my desire to pursue further studies and research opportunities in cybersecurity and privacy protection. As I move forward in my academic journey, I am inspired to contribute to the development of innovative solutions that prioritize user privacy and security in the digital landscape.

Overall, my undergraduate research experience in the cybersecurity app project has been transformative, shaping my academic and career aspirations. It has instilled in me a sense of responsibility to leverage technology for the greater good, with a focus on protecting user data and promoting digital trust. I am excited about the possibilities that lie ahead and am eager to continue exploring and making meaningful contributions in the realm of cybersecurity and privacy.

About the Author

Siddharth Dhumal

16.

MODELING AND SIMULATION OF TURBULENT PREMIXED HYDROGEN FLAMES

Alex Gilsoul

Faculty Mentor: Alex Novoselov (Mechanical Engineering, University of Utah)

With global warming becoming an ever-present danger, it is important that we work to lower our carbon emissions. As such, hydrogen has been proposed as a green alternative to natural gas for energy conversion in gas turbines, as it is carbon neutral.

Because of its low molecular weight and high reactivity,

hydrogen gas expresses some unique properties during combustion, such as unstable flame fronts [1]. These instabilities strongly modify global properties of the flame, such as flame speed, that are relevant to modeling systems like gas turbines.

Good models to predict the effects of these instabilities do not exist. Simulations of hydrogen flames at small scales are possible with Direct Numerical Simulations (DNS) which solve the Navier-Stokes Equations, however for full combustor scales this type of modeling is computationally intractable.

We simulated 3D laminar and turbulent hydrogen flames on a small-scale. The thermochemical quantities of these flames were analyzed and compared to 1D flame solutions modeled with Cantera using the Pele Suite of flow simulation codes and C++ and Python codes we wrote. Our codes use GPU parallelization to generate a large number of flame paths simultaneously by following progress variable gradients through the flame front [2]. Then, we used trilinear interpolation to determine the properties of points along these paths such as temperature, mixture fraction, and curvature. Plotting this data, we found that our 1D Cantera flames will not give us enough information. However, we did discover that curvature seems to have a large impact on whether a given flame path will reach adiabatic flame temperature (AFT), stay below AFT, or go higher than AFT. These results imply that curvature will be an important piece of an effective model, and so we will pursue it further.

References

[1] Berger, L., Attili, A., Pitsch, H. (2022). Intrinsic instabilities in premixed hydrogen flames: Parametric

variation of pressure, equivalence ratio, and temperature. Part 1 – Dispersion relations in the linear regime. DOI: https://doi.org/10.1016/j.combustflame.2021.111935

[2] Chan, W. L., Kolla, H., Chen, J.H., Ihme, M. (2014, April 13). Assessment of model assumptions and budget terms of the unsteady flamelet equations for a turbulent reacting jet-in-cross-flow. DOI: http://dx.doi.org/10.1016/j.combustflame.2014.04.007

About the Author

Alex Gilsoul

17.

HOSPITAL ROOM DESIGN FOR FALL PREVENTION EXPERIMENTS IN ELDERLY PATIENTS

Zachary Olson and Haohan Zhang

Faculty Mentor: Haohan Zhang (Mechanical Engineering, University of Utah)

Background

Falls are common in elderly residents, which can lead to disabling consequences. This SPUR project is part of a bigger study where we aim to determine and optimal configuration of hospital rooms that can reduce risks of falls through biomechanical observations. In an earlier

study, the research team has identified multiple design factors, including the door type of the bathroom (i.e., swing vs slide) and its orientation relative to the bed.

Objective

To accommodate this study, in this project, our objective is to design an easy-to-configure mock bathroom to carry out the experimental trials with minimal
downtime. The design must also fit within the physical space of the laboratory. This room must allow visibility for the motion capture cameras.

Methods

Using SOLIDWORKS we designed this mock bathroom to be able to accurately accommodate the multiple bathroom, and room configurations with minimal downtime between setups. Our design allowed us to change which doors are in operation and which way the swing door opens to cover a wider array of hospital room layouts. We designed the room using inexpensive, off-the-shelf components. The frame of the design is mounted on casters which allows for easy reconfiguration when unlocked while providing a stable structure when locked.

Results and Deliverables

A physical mock bathroom with modular doors is built within the laboratory space for the planned experiments. A step-by-step instruction
manual for building the room and how to change its configurations is provided.

Acknowledgements: We acknowledge that this work was partially funded by AHRQ (award no. 5R18HS025606-05, PI: Bob Wong). We thank for the great insights obtained from discussions with the research team

(Bob Wong, Ellen Taylor, K. Bo Foreman, Alan Kuntz, Edoardo Battaglia, Peter Fino, and Nooshin Seddighi)

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18.

RESEARCH REFLECTION BY ZACHARY OLSON

Zachary Olson

Faculty Mentor: Haohan Zhang (Mechanical Engineering, University of Utah)

The research done for this project helped me to understand better how to work with a team. I discovered how slow processes can be when needing approval from a large group helping me to not procrastinate and take initiative when possible. This project has helped me understand how to perform research which will be helpful as I enter into graduate school in this following year. The tools I've learned during this SPUR of being proactive and in navigating a research process was greatly beneficial to my future as a graduate student.

About the Author

Zachary Olson

19.

ENGINEERING MEETS PHOTOGRAPHY THROUGH VITAMIN C AND SILVER

Abigail Stringfellow

Faculty Mentor: Roseanne Warren (Mechanical Engineering, University of Utah)

Background

Recently, Professor Joe Marotta from the Department of Art & Art History pressed a lily onto a piece of photopaper, then developed it, without light exposure through the process. When a permanent image remained, he and Professor Roseanne Warren from the Department of Mechanical Engineering determined that it occurred due to the chemical reaction between the silver in the

photopaper and the L-ascorbic acid (vitamin C) in the flower. Though ascorbic acid has been used as a developing agent for light-exposed silver-based paper before, Professor Marotta and Professor Warren's findings are the first to show this result in the absence of light [1, 2]. L-ascorbic acid is widely used industrially and commercially. Among its uses are as an additive or preservative in food, a medical treatment, a measurement of quality in produce, and a crop spray in agriculture [3-6]. Due to the many applications of ascorbic acid, ascorbic acid detection methods are in demand in both consumer and industrial markets. Approaches to detection include, among others, titration [7], fluorescence [8], and electrochemical [4]. Out of the current options, none are low-cost, and most use specialized equipment, making them unsuitable for the average consumer. This project investigates the chemical reaction between ascorbic acid and silver halides with the aim to develop a low-cost ascorbic acid concentration sensor. In the past weeks, I have determined a preliminary grayscale to use in the sensor, which relates ascorbic acid concentration to image darkness. Type of photopaper, time between application and development, pH of solution, addition of copper ions, and ascorbic acid concentration were experimented with in this model.

Methods

Using the statistical analysis program JMP, I produced a Design of Experiment based on these five factors. In each test, 35 milliliters of pH buffer four, seven, or ten was added to 100 milliliters of deionized water. Between four and eight grams of ascorbic acid was stirred in. A ratio of between 0:1 to 1:1 of cupric sulfate to ascorbic acid was

included in each solution. Solution pH was recorded using a pH meter. Each solution was applied to one of three types of Ilford photopaper—Multigrade Resin Coated (RC), Multigrade Fiber Based (FB), and Ilfospeed Resin Coated (IS)—using a needleless syringe. After being left without light exposure, the tests were developed after two, four, or six hours. Following development, each test was scanned and evaluated using the program ImageJ, which gave a grayscale score 0 to 255, with 0 as black and 255 as white. Tests 11, 18, and 22 (Fig 1-3 respectively) are shown below to show typical outputs of the experimental runs. A range of gray values can be seen alongside the added calibration black and white strips, which were added in ImageJ post-scan to standardize the tests.

Figure 1

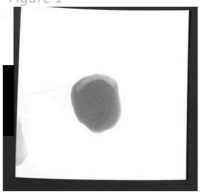


Figure 2

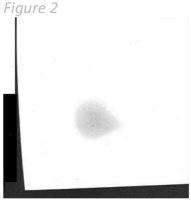
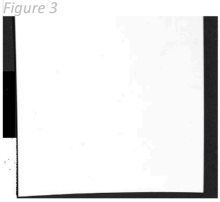


Figure 3



Results

Below, the data for all 25 tests is shown (Table 1). A regression line model "Experimental Darkness versus Predicted Darkness" was run in JMP, which is also shown below (Fig 4). The blue line is the mean of the data points, while the red line is the regression line. With a coefficient of determination of 0.89 and a p-value of 0.1035, this regression model explains 89% of the variation in experimental darkness from the predicted. There is a probability of 0.1035 that these results would have occurred at random. None of the data points are outliers,

as the studentized residual graph shows (Fig 5). Overall, the model fits the data fairly well, but with further testing, it could be strengthened.

Table 1

DOE Data							
Test	Paper	Ascorbic Acid	Metal Ions	Time	Buffer	Darkness	Measured pH
1	IS	8	1	6	4	240	2.5
2	FB	4	0.5	2	7	184	1.6
3	IS	4	0	4	4	255	2.4
4	RC	4	0	4	10	255	3.5
5	RC	8	0	4	4	255	2.5
6	RC	6	1	4	7	106	1.4
7	RC	4	1	6	4	174	1.8
8	FB	4	0	6	4	255	2.4
9	RC	6	0	2	7	236	2.5
10	RC	4	1	2	4	183	1.8
11	IS	8	1	2	7	115	1.2
12	IS	8	0	4	7	255	2.6
13	FB	8	1	2	4	239	2.5
14	FB	6	1	4	10	128	1.6
15	FB	4	1	6	10	171	1.7
16	FB	8	0	2	10	246	3
17	FB	8	0.5	6	7	188	1.5
18	IS	4	1	2	10	196	1.6
19	FB	6	1	4	7	192	1.4
20	IS	6	0	2	4	228	2.4
21	RC	8	1	2	10	111	1.5
22	IS	6.16	0	6	10	255	3.2
23	IS	4	1	6	7	131	1.6
24	RC	8	1	6	10	112	1.5
25	RC	6	0	6	7	255	2.5

Figure 4

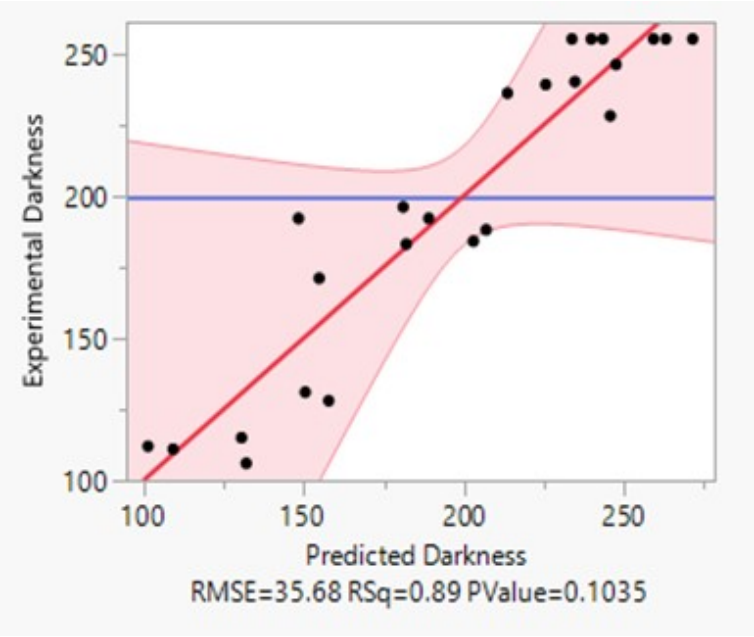
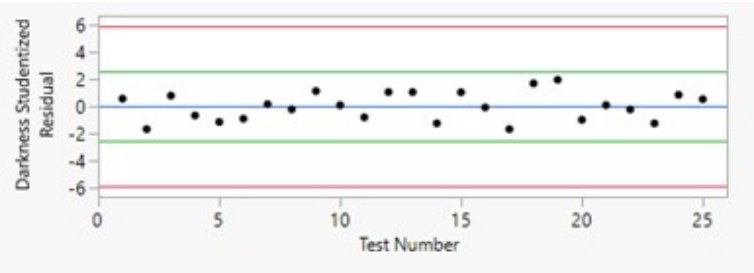


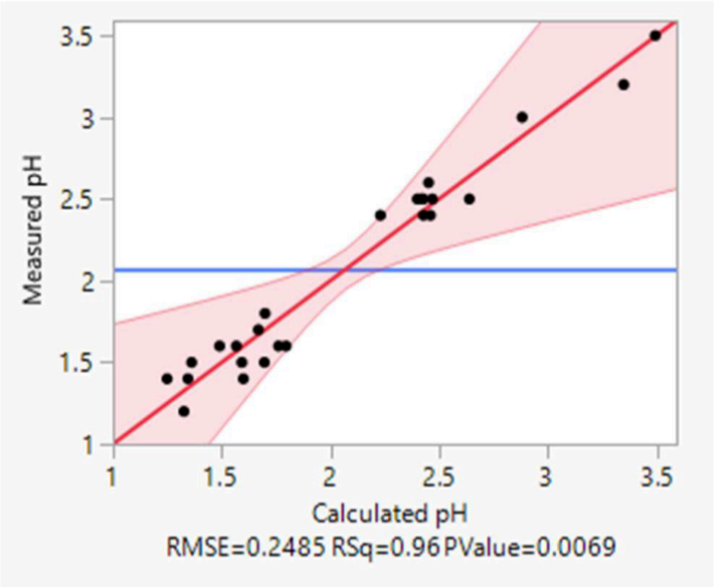
Figure 5



The model "Measured pH versus Calculated pH" is also given below (Fig 6). As can be seen in the data table, all measured pH values were between 1.2 and 3.5, despite the addition of pH buffers to change the pH of the solutions further. This graph, where the theoretical pH of each solution is graphed against the measured value, shows evidence that the pH buffers were not strong enough to effectively change the pH of the solutions to higher

values. Therefore, one of the next steps for the project is to calculate the necessary added amount of a stronger buffer that would be needed to effectively test solutions with higher pH, such as 7 or 10.

Figure 6



The graph below shows the modeled quadratic line of fit for "Darkness versus Measured pH" (Fig 7). This line of fit shows promising results for relating a solution's pH to its darkness, as the coefficient of determination shows that 81% of the variation in the darkness can be explained by the measured pH from this model. Additionally, the series of graphs of "Darkness versus Ascorbic Acid Concentration," split into three graphs based on time between application and development, show that leaving tests for four hours presents a quadratic model where ascorbic acid explains 84.6% of the variation in darkness

(Fig 8). The fact that the models for two and six hours have much less accountability (r2 = 0.193 and 0.339 respectively), however, brings up the question of why the four-hour range developed with more predictability. Running further tests in this time range would be recommended to investigate these results.

Figure 7

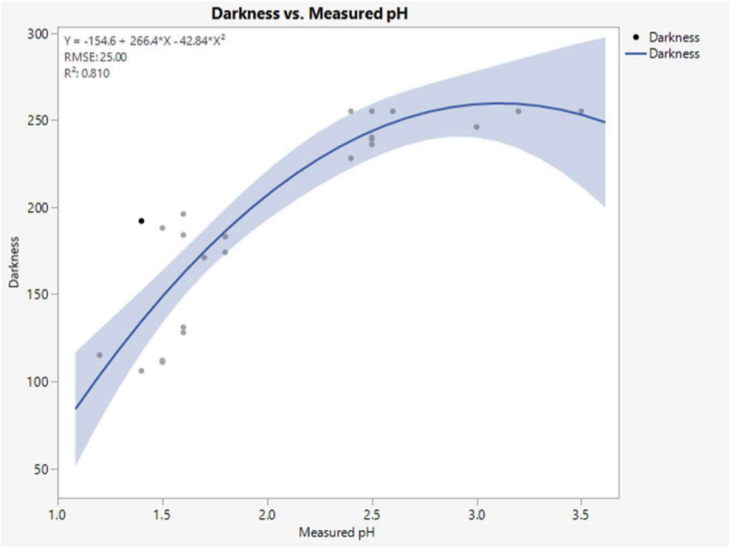
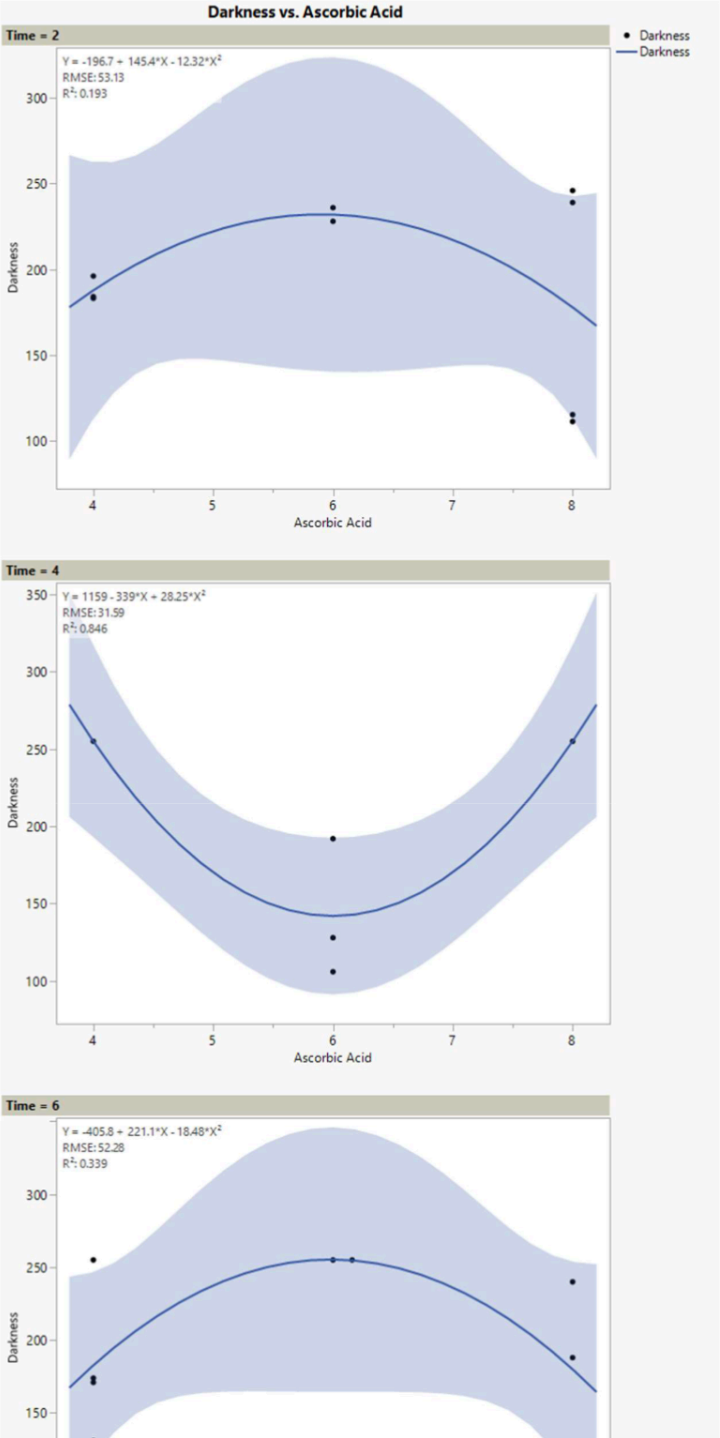


Figure 8


Darkness vs. Ascorbic Acid
Time = 2
Y = -196.7 + 145.4*X - 12.32*X²
RMSE: 53.13
R²: 0.193
Darkness
Darkness
Darkness
Ascorbic Acid
Time = 4
Y = 1159 - 339*X + 28.25*X²
RMSE: 31.59
R²: 0.846
Darkness
Ascorbic Acid
Time = 6
Y = -405.8 + 221.1*X - 18.48*X²
RMSE: 52.28
R²: 0.339
Darkness

Conclusion

In the coming months, a secondary experiment should be run to strengthen these results. This grayscale relates ascorbic acid solutions with different chemical pH buffers to the darkening of silver halides. Therefore, the next experiment should use liquids that would realistically be measured in the sensor, such as juices, beverages, crop sprays, or medicines. This next DOE should use a time of four hours based on the results of "Darkness versus Ascorbic Acid Concentration." Additionally, the Multigrade Fiber-Based (FB) photopaper should be excluded from further tests, as it curled, yellowed, and was generally harder to work with in the darkroom. As the regression lines for Darkness versus Ascorbic Acid Concentration and Darkness versus Measured pH are refined, they will be used for the sensor to determine ascorbic acid content from the darkness of the sample.

Acknowledgements

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Bibliography

[1] C. E. Bills, "Ascorbic acid (vitamin C) and photographic developing action," Science, vol. 81, no. 2097, pp. 257-258, Mar. 1935.

[2] T. H. James, "Ascorbic and iso-ascorbic acids as

photographic developing agents," J Am Chem Soc, vol. 66, no. 1, pp. 91-94, Jan. 1944.

[3] J.-A. López-Pastor, A. Martínez-Sánchez, J. Aznar-Poveda, A.-J. García-Sánchez, J. García-Haro, and E. Aguayo, "Quick and cost-effective estimation of vitamin C in multifruit juices using voltammetric methods," Sensors-Basel, vol. 20, no. 3, pp. 676-690, Jan. 2020.

[4] P. J. O'Connell, C. Gormally, M. Pravda, and G. G. Guilbault, "Development of an amperometric L-ascorbic acid (vitamin C) sensor based on electropolymerized aniline for pharmaceutical and food analysis," Anal Chim Acta, vol. 431, no. 2, p. 239-247, Mar. 2001.

[5] J. T. B. Collie, R. F. Greaves, O. A. H. Jones, G. Eastwood, and R. Bellomo, "Vitamin C measurement in critical illness: challenges, methodologies and quality improvements," Clin Chem Lab Med, vol. 58, no. 4, pp. 460-470, Apr. 2020.

[6] Allahveran, A. Farokhzad, M. Asghari, and A. Sarkhosh, "Foliar application of ascorbic and citric acids enhanced 'Red Spur' apple fruit quality, bioactive compounds, and antioxidant activity," Physiol Mol Biol Plants, vol. 24, no. 3, pp. 433-440, May 2018.

[7] L. Suntornsuk, W. Gritsanapun, S. Nilkamhank, and A. Paochom, "Quantitation of vitamin C content in herbal juice using direct titration," J. Pharm. Biomed. Anal., vol. 28, no. 5, pp. 8490855, Jun. 2002.

[8] X. Wu, Y. Diao, C. Sun, J. Yang, Y. Wang, S. Sun, "Fluorometric determination of ascorbic acid with o-phenylenediamine," Talanta, vol. 59, no. 1, pp. 95-99, Jan. 2003.

About the Author

Abigail Stringfellow

SECTION V

COLLEGE OF HUMANITIES

20.

RACE AND RUNAWAYS: PUBLIC PERCEPTION OF KAWAILOA TRAINING SCHOOL FOR GIRLS ESCAPES, 1938-39

Callie Avondet

Faculty Mentor: Maile Arvin (History, University of Utah)

From the mid-19th to mid-20th centuries, several states opened reformatories for "delinquent" children. White middle-class reformers believed that education on white middle-class norms and low-paying manual labor would transform "bad" children (people of color, English

language learners, poor, etc.) into "good" Americans. Though reformers viewed reformatories as distinct and better than prisons, judges sentenced children to the institutions and superintendents spent considerable effort preventing escapes. In 1929, Maunawili Training School for Girls (later renamed Kawailoa Training School for Girls) opened on Oʻahu, Hawaiʻi. Kawailoa Training School continued a legacy of forced industrial education for "deviant" (nonwhite, poor, usually sexually active or perceived to be) girls in Hawaiʻi. The superintendent and white public hoped that commitment to Kawailoa would turn "deviant" girls of color into "good" young women, ready for marriage and domestic life.

Using papers from the Hawaiʻi State Archives, census data, and newspapers, this research explores how varying perceptions of escape and escapees at Kawailoa Training School represented people of color as criminals. Though Miss Field, superintendent from 1938-39, challenged the perception of Kawailoa girls as a threat to society and therefore escape being the highest crime at the reformatory, her framework for Kawailoa gained little support. Public and governmental backlash led to her ouster in late 1939. In the tension between Field and the white public's perceptions of Kawailoa escapes is the assumption that Kawailoa girls were dangers to the public. Since few, if any, of these girls were committed for violent crimes, the white public concern over their escape is rooted in fear of sexual activity producing more "delinquent" children of color.

About the Author

Callie Avondet

21.

AN INVESTIGATION ON THE EFFECT OF LISTENER'S PERCEPT OF PERCEIVED SPEAKER GENDER ON VERACITY JUDGEMENTS

Samantha Barlow; Rachel Hayes-Harb; Emma Farnsworth; Sylvia Page; and Seung Kyung Kim

Faculty Mentor: Rachel Hayes-Harb (Linguistics, University of Utah)

Listeners make judgments about speech and speakers based on many factors,

including the speaker's racialized appearance (Kang & Rubin, 2009), accent (Ingvalson et al. 2017), and gender (Weibel, Wissmath & Groner 2008). We are interested in the finding that listeners' willingness to believe the content of speech is influenced by the speaker's self-identified binary gender (Brann & Himes, 2010). In the present study, we will examine the effect of *listener's beliefs about the speaker's gende*r on veracity judgments. We will investigate the relationship between listeners' assessment of masculine and feminine properties in a speech sample and their willingness to believe the speaker. We seek feedback from the SIPS community on study design and how to best operationalize the listener's percept of gender in this study. We hope that this research will contribute to a better understanding of how the genderized properties of speech and speakers impact veracity judgments of speech.

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22.

RESEARCH REFLECTION BY SAMANTHA BARLOW

Samantha Barlow

Faculty Mentor: Rachel Hayes-Harb (Linguistics, University of Utah)

I started late in my academic career with undergraduate research. I only first started to work on research in my last year as an undergraduate. However, in that small amount of time, I helped conduct a replication study that will be published in Studies in Second Language Acquisition, joined the Speech Acquisition Lab in the Linguistics department, and start working on a research project with a smaller group. Both studies I have worked on have been accepted to conferences and I have and will attend both conferences to present. I have learned how to think

critically, collaborate, and think about the effects of my work as a researcher. I have learned that I value the research process and am interested in continuing work in research. The knowledge and networking opportunities I have been able to develop have been extremely beneficial for my education and future plans.

About the Author

Samantha Barlow

23.

LINEAR B: A SNAPSHOT

Caleb Curtis

Faculty Mentor: Alexis Christensen (Humanities, University of Utah)

Linear B: A Snapshot of the Environment

In the existing literature surrounding the Myceneans (the culture that rose to prominence in the Aegean during the latter half of the Bronze Age c. 1400-1200 BCE) and the world they lived in, the study of the historical climate of the Eastern Mediterranean has become increasingly popular. In light of the crises arising from anthropogenic climate change, there is a desire to look back at the past, to people who endured periods of climate change in order to understand how they endured such changes. One period to which the modern scholar can look is the end of the Bronze Age. Much like today, the latter portion of

the bronze age c. 1400-1200 BCE was a time in which the cultures of western Asia and the eastern Mediterranean existed and participated in what can aptly be called a globalized economy, though it is important to note that *global* here is referring to this particular portion of the world. From the River Nile to the Euphrates, from the Baltic to the Indian Sea, trade was essential for the functioning of the complex societies of the region as well as a key component in the international politics of the time (Cline, 181-184). These ancient peoples both imported and exported goods. Exports included textiles, mainly consisting of linen and wool; metal objects; olives, both the fruit itself and oil; wine; leatherwork; ceramics; furniture; and jewelry (Pomeroy et al. 31, 32). Mycenean society was no different and the various polities governed from the palace complexes that dotted the rugged landscape of Greece participated in these trade networks (Kelder, 339-349).

Record keeping was essential for the successful functioning of the Mycenean centers, and it might well be the spark that ignited the art of writing. In letters and administrative records, the rulers, and bureaucrats of this region of the world recorded the economic exchanges essential to the functioning of these societies. During the late Bronze Age, the Myceneans inhabiting both the mainland and the islands of what is now roughly Greece, used a system now call Linear B. This is a syllabic system that consist of signs representing syllables and pure vowels1. In addition, there are both ideograms representing different ideas such as man, woman, cow, or flax and numerical signs. These symbols record an early form of Greek. Scribes would write in this early Greek

script on clay tablets that were often recycled. At Pylos, located in the Peloponnesian peninsula, the recycling of tablets was a normal part of the administrative year (Judson, 135). It is only by accident that tablets have survived to the modern day (Cline, 124). Unluckily for the Myceneans and luckily for us, the palace complexes of the Aegean were destroyed around 1200 BCE. Across most palatial sites there is a layer of debris indicating destruction, a destruction that was often violent. These layers roughly coincide with the end of the Bronze Age period. In these destructive events fires baked the tablets that would have otherwise been recycled allowing them to survive until the present day (Cline, 124).

These Linear B tablets are a valuable asset for any scholar wishing to understand the state of the environment of the Aegean in approximately the last century of the Bronze Age as many of them list agriculture products. Products that are often quite particular in terms of where they will grow. In my translation of the tablets from Pylos, aided by the DAMOS database and Chadwick and Ventris's book *300 Documents in Mycenean Greek*. Here I will be focusing primarily on my translation of the PY Na series, a collection of tablets that deals specifically with linen and/or flax used to produce the linen depending on how you translate the ideogram SA, which can be taken as either (Hooker, 39). For the sake of this discussion, I will refer to SA as linen, the finished textile product. Linen was often used by individuals or groups as a means of paying taxes to the palace, though it could also be used by the palace to pay individuals and communities for services rendered to the palace. The Na tablets more often record tax exemptions rather than actual taxes paid. In the Na

series tablets, two formulas indicate a tax exemption. The first consists of the ideogram SA modified by the adjective E-RE-U-TE-RA, which is related to the later Greek ἐλευθερία, which translates to "freedom". In this context, the adjective translates as something to the effect of "free from the burden of" indicating a tax exemption (Ventris et Chadwick, 299). An alternate formula that is used to indicate a tax exemption is OU-DI-DO-SI taking SA as the direct object. This verb, a compound of οὐ, a particle that negates the verb, much like not in English, and δίδωμι, translates as "they do not give".

Flax is an environmental taxing crop requires a substantial amount of water to grow properly (Valamoti, 556). The prevalence of flax in the Pylos tablets indicates that Messenia, the region where Pylos sits, had enough moisture to support large scale flax production. Even in the modern era, flax production is an industry important to Messenia. In the 1950's Messenia was responsible for half of Greece's flax production (Burke, 437). In the arid Aegean, the presence of flax production is notable as it indicates that there is a significant level of moisture in the region.

The tablets from Pylos provide us with a snapshot of the state of Messenia right before the palace itself was destroyed. This image is one of a Messenia that has enough water and good soil to support large scale flax cultivation. With this in mind, we can look forward intime to other texts that discuss the Messenian region to look for flax production. If there is evidence for flax production in the region from later periods in time, this may indicate that, although the climate might have fluctuated in antiquity, such as the period of aridity that seemed to

contribute to the collapse of the Palatial systems in the Aegea, Messenia returned to being a place capable of large-scale flax production, more particularly, the region retained enough moisture to support large-scale flax production.

Bibliography

Aurora, Federico. 2015. DAMOS (Database of Mycenaean at Oslo). Annotating a fragmentarily attested language. In: Pedro A. Fuertes-Olivera et al. (eds.), *Current Work in Corpus Linguistics: Working with Traditionally-conceived Corpora and Beyond. Selected Papers from the 7th International Conference on Corpus Linguistics (CILC2015)* (Procedia – Social and Behavioral Sciences, 198), 21-31, doi: 10.1016/j.sbspro.2015.07.415

Burke, Brenden "Textiles". in *The Oxford Handbook of the Bronze Age Aegean (ca. 3000-1000 BC)*. Oxford University Press ed. Eric H. Cline, 430-442. Oxford: New York: Oxford University Press, 2012.

Cline, Eric H. *1177 BC: the Year Civilization Collapsed*. Princeton: Princeton University Press, 2021.

Judson, Anna P. "LEARNING TO SPELL IN LINEAR B: ORTHOGRAPHY AND SCRIBAL TRAINING IN MYCENAEAN PYLOS." *The Cambridge Classical Journal* 68 (2022): 133–63. doi:10.1017/S1750270522000057.

Kelder, Jorrit M. "Royal Gift Exchange between Mycenae and Egypt: Olives as 'Greeting Gifts' in the Late Bronze Age Eastern Mediterranean." *American Journal of Archaeology* 113, no. 3 (2009): 339–52. http://www.jstor.org/stable/20627592.

Pomeroy, Sarah B., Stanley Mayer Burstein, Walter Donlan, Jennifer Tolbert Roberts, David W. Tandy, and Georgia Tsouvala. *Ancient Greece: A Political, Social, and*

Cultural History. New York, NY: Oxford University Press, 2018.

Valamoti, Soultana Maria. "Flax in Neolithic and Bronze Age Greece: Archaeobotanical Evidence." *Vegetation History and Archaeobotany* 20, no. 6 (2011): 549–60. http://www.jstor.org/stable/23885227.

About the Author

Caleb Curtis

24.

PERCEPTIONS OF GENETIC SUSCEPTIBILITY TESTING AS A CANCER PREVENTION TOOL FOR AFRICAN AMERICAN WOMEN

Christen Daniel; Crystal Lumpkins; and Adrienne Smith

Faculty Mentor: Crystal Lumpkins (Communications and the Huntsman Cancer Institute, University of Utah)

Introduction

Genetic Susceptibility Testing (GST) is an emerging technology used as a cancer prevention tool (Courtney, E., et al. 2018). Studies show that African American (AA)

women are disproportionately impacted by cancer outcomes but are less likely to take preventive measures due to a lack of trust in medical personnel and knowledge of healthcare resources. (Schölmerich, V. L. N. and I. Kawachi 2016). These factors often lead to GST counseling and testing barriers among AA women for cancer-risk gene discovery. The objective of this study was to explore how genetic counselors and AA leaders in Utah perceive GST as a preventive cancer measure among AA women.

Methods

Participants were recruited from the parent study (Lumpkins et al, 2020) and the Genetic Counseling Department of Huntsman Cancer Institute. Participants (N=4) included 2 genetic counselors and 2 community leaders of predominately AA organizations in Salt Lake City. Questions focused on their organization/work environment, communication about GST, and beliefs about GST among AA women in Salt Lake City. A Semi-structured in-depth interview guide was used to conduct the interviews, lasting between 45-65 minutes. Interview questions were derived from the parent study, literature review, and an informal conversation with a genetic counselor. In-depth interviews were held via Zoom, audio recorded, and transcribed for analysis where common preliminary themes were explored; data saturation was not reached.

Results

Preliminary Themes Included:

Limited Knowledge– Knowing that GST is a cost-effective resource can be used as important information in the communication of screening as a prevention measure.

Spirituality/Religion– Implementing spirituality or

religion into outreach and social support efforts concerning GST can bolster reach and relevance.

Social Support– Support efforts are already in place by each organization to begin outreach to African American women concerning GST.

Relationship– Physicians are important in increasing awareness about GST through existing physician-patient relationships. The patient's trust in the physician is important in communicating the benefits of GST.

Conclusion

We learned through preliminary data analysis that genetic counselors want to do more in Utah with African American women residents who may seek or not know about genetic counseling. AA leaders also recognize the importance of GST and that there is a need for health promotion. They are willing to become partners for future programming with African American women in the metropolitan area and throughout the state.

Bibliography

Courtney, E., et al. (2018). "Predictors of next-generation sequencing panel selection using a shared decision-making approach." npj Genomic Medicine 3(1): 11.

Schölmerich, V. L. N. and I. Kawachi (2016). "Translating the Socio-Ecological Perspective Into Multilevel Interventions: Gaps Between Theory and Practice." Health Education & Behavior 43(1): 17-20.

Lumpkins, C. Y., et al. (2020). "A road map for the future: An exploration of attitudes, perceptions, and beliefs among African Americans to tailor health promotion of cancer-related genetic counseling and testing." Journal of Genetic Counseling 29(4): 518-529.

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25.

THE LOST RIVERS OF LONDON

Mackenzie Fowles-Zimmerman

Faculty Mentor: Isabel Moreira (History, University of Utah)

The lost rivers of London have always been of great interest to scholars across many disciplines including history, archeology, and geography for the insight they can provide about times that have long since passed. For historians specifically, studying lost rivers and their surroundings can bridge gaps in our knowledge about topics such as urban development, infrastructure, trade, social culture, and effects of environmental factors on a city and its people. Until relatively recently, much of the early research regarding the locations of lost rivers and

their contributions to society has been primarily based on written sources. Over the last two decades, a team of geoarcheologists working with the Museum of London Archaeology (MOLA) have taken advantage of expansions being done across Westminster by implementing innovative geoarcheology techniques at construction sites, allowing them to expand on the existing research about lost rivers of London. As an act of "educational charity" MOLA has published their key findings using an ArcGIS StoryMap, walking us through the ancient Tyburn River valley.[1] The project is ongoing, but the findings they have made so far offer historians a window into the landscape of medieval London.

While construction for expansions and restoration around Westminster seems like nothing more than an inconvenience for Londoners, for geoarcheologists it offers an invaluable opportunity to examine what lies beneath the city's surface. In the course of searching for the lost Tyburn River, a tributary of the Thames River,[2] the team of specialists working with MOLA visited sites all over the city, most often construction sites, to collect earth samples from bore holes and trenches for analysis. Borehole samples are collected by drilling into the earth and extracting a section, keeping the layers intact for further analysis. The trenches however are more consistent with traditional archeology trenches, exposing a large section of earth beneath the surface, allowing for more in-depth analysis at the site. Once the samples have been collected the location of each one is logged on a map to ensure any data extracted can be geographically placed when creating maps following the analysis of ancient deposits within each sample. Once a sample is logged,

the layers of sand, clay, peat, silt, and mud are analyzed for ancient sediments that provide environmental and temporal information about the location from which it was collected. In addition to the sedentary information, MOLA specialists also look at known flora and fauna evidence confirmed in the area (such as pollen spores and inspect remains) compared to those in the samples for further information about environment factors of the area.

Based on the data gathered from over 4,000 samples contributing to the research of the Tyburn River,[3] the team of researchers input their findings into a computer modeling system that is able to construct a rendering of the Westminster area (found on the StoryMap), indicating which areas were likely to be low-lying wetlands versus those that were likely higher dry ground.[4] After constructing a model of the Tyburn River floodplains in London, researchers were then able to approximate where the river, and its theorized branches, once flowed. There is much scholarly debate surrounding the potential routes of the Tyburn River, however information collected from this research continues to shed light on those debates. According to collected data and the topographical rendering of the floodplains, the team of geoarcheologists was able to produce three potential routes of the Tyburn River. The first theorized route is that the Tyburn River flowed east across London into Westminster where it split into two branches forming what used to be Thorney Island. The second theory is that the river simply flowed south through the city into the River Thames. The third theory is that both of these proposed branches of the Tyburn River existed together. Remarkably these

suggested courses for the river are consistent with those of Nicholas Barton, a leading scholar in the study of London's lost rivers. In his book "*The Lost Rivers of London*" Barton examines in great detail, written sources from the eighth century onward, to construct his own image of what London's landscape once looked like before its rivers were lost. In Chapter 3 of Barton's book discussing the Tyburn River, he looks to charters, like those of Offa (c.785) and Edgar (c. 951), correspondences from Londoners that mention the river with other commonly known landmarks, earlier geological evidence, and early maps of the area like that of Norden (c. 1593).[5] Barton's work is considered one of the most influential treatises on the subject, however it is lacking corporeal evidence. The work of MOLA has offered an invaluable extension to the work of Barton, complementing his research rather than seeking to disprove it.

One of the city's development sites used by researchers for the MOLA project was Victoria Circle to the north of Victoria Underground Station, where the team collected samples from boreholes and trenches to expand their data and understanding of the Tyburn River floodplain. At this site, geoarcheologists designated five facies[6] based on macroscopic characteristics of the borehole samples and trenches. The fifth facies was used to denote anything post c. 1000 BCE. In Trench 5 there was charred matter which, after radiocarbon dating, appeared to be from the late thirteenth to fourteenth century. Along with the carbon dated material, experts conducted a pollen report[7] from the samples in Trench 5 that indicated a decrease in pollen from certain plants, thus indicating there was an increase of grain crops in the general area

after the early medieval period. Despite the pollen record indicating an increase of grain crops nearby, researchers were also able to conclude that this immediate area surrounding Trench 5 was likely a wetland during the Middle Ages, unviable for building houses or farming due to frequent flooding.[8]

The Tyburn River is not the only river of interest, there are dozens of other lost rivers across London that are of great interest to scholars from many disciplines. In Barton's book he takes great care to discuss many of the more well-known rivers such as the Walbrook River, the Fleet River, and the Lea River.[9] Through MOLA's efforts at another excavation site on High Street, in a patch of unused industrial land along the river,[10] geoarcheologists have been able to expand our knowledge about the uses of lost rivers, not just their locations. The Lea River in the Middle Ages was considered the boundary between two neighborhoods, one being Essex where the manor of Hamme (Ham) was situated. Within Ham there are records of eight mills that would have most likely been built along the Lea River or one of its channels, with one being the Saynes Mill. This was a tidal mill originally used for processing grains and was one of the furthest mills from the Thames River.[11] The first recorded mention of Saynes Mill, documenting the lease of the mill, is dated from the thirteenth century. Throughout the thirteenth and fourteenth centuries there are many similar sources documenting the lease and ownership of Saynes Mill. Use of Saynes Mill persisted throughout later centuries with the addition of another mill, a mill house, and a pump house in the sixteenth through eighteenth centuries. Despite much of the archeological evidence from this site

being post-medieval, examining the site provides an in-depth understanding of the city's geography as well as its infrastructure.

As discussed by Derek Keene, the Great Conduit, also uncovered by the MOLA team, was an important place for the social culture and economy of medieval London much like the Tyburn River. It was built sometime in the mid-thirteenth century as a source of water for those living in the area and was considered a monumental structure. There are many contemporary written sources mentioning the conduit, as early as the late thirteenth century, but until it was uncovered, only so many questions could be answered by them.[12] Through uncovering the conduit, researchers not only get a sense for the location of an important water source, but also the location of social gatherings and events such as pageants. Uncovering the Great Conduit also provides a lot of insight into the level of engineering and infrastructure that was used in the Middle Ages. There are written sources attesting to how it was built, but to physically examine the structure provides a far more intimate understanding of history. Much like the conduit, rivers have a wealth of insight to share with those who know how to find them. Rivers were, and still are, an important element when planning a city. They were at the core of the engineering and infrastructure, they provided the water for everyone whether it be directly or through diversion to a well, and they were a place of social importance whether it be for recreation or to witness a trial.

In a city like London that was, and still is, at the center of the world, there are centuries, even millenniums, of history that have been built over and are yet to be found.

Because the centuries of building and expanding never slowed, it is difficult and oftentimes impossible to know what lies beneath. Lost rivers are one of the many things that could provide invaluable insight into London's profound history, if only they were accessible. The work of MOLA, especially in taking advantage of construction sites, has allowed research to be shared with scholars across all disciplines, illuminating history before it vanishes. Finding lost rivers can tell us which areas of the city were fit for building, or not, making it more feasible to locate cities. Knowing where a city or even a small village once was is important for not only a deeper understanding of the medieval world, but also for knowing *where* to look for further archeological evidence.

Endnotes

1. Virgil Yendell. "London's Lost River: The Tyburn." Accessed April 12, 2023. https://www.arcgis.com/apps/Cascade/index.html?appid=6b00daa1acac4df7a2fcde06104bac1a.
2. A tributary is a river or stream that flows into a larger river or lake.
3. Virgil Yendell. "Liberating the Once Carefree Wanderer: The River Tyburn at the Curtis Green Building, Victoria Embankment, Westminster." *London Archaeologist*. 131.
4. Yendell, Virgil. "London's Lost River: The Tyburn."
5. Nicholas Barton. *The Lost Rivers of London*.

London: Historical Publications Ltd, 1992. 34-42.

6. A facies is the observable characteristics and changes of a body of rock such as its formation, composition, and fossil content that make it distinct from other areas which can be used for dating bodies of rock.
7. A pollen report is an analysis of pollen preserved in sediment or fossils that have been dated to provide information about past ecological systems.
8. Yendell and Scaife, "Invisible people next to a river that does not exist: geoarchaeology and the Tyburn River north of Victoria Station," 32.
9. Nicholas Barton. *The Lost Rivers of London*. London: Historical Publications Ltd, 1992
10. MOLA Team. "150 Strarford High Street," 2008. https://www.mola.org.uk/blog/150-stratford-high-street.
11. Wroe-Brown, Robin, Ian Betts, Lyn Blackmore, Damian Goodburn, Bob Spain, Geoff Egan, Jackie Keily, and Jacqui Pearce. "Saynes Mill: Excavation of a Tide Mill on the River Lea, London." *Post-Medieval Archaeology*. 357.
12. Derek Keene. "Issues of Water in Medieval London to c. 1300." *Urban History 28*, no. 2 (2001): 176.

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26.

STAYING OR LEAVING: A NARRATIVE ANALYSIS OF STORIES TOLD BY VICTIM/ SURVIVORS OF DOMESTIC VIOLENCE

Abril Vale-Luzardo and Jennifer Andrus

Faculty Mentor: Jenny Andrus (Writing & Rhetoric Studies, University of Utah)

Introduction

There is a methodological gap in the literature on intimate partner violence (IPV). While there is a lot of survey data and quantitative analysis, there is very little

narrative collection and qualitative analysis. The lack of detailed narratives and missed nuance in staying/leaving decision-making make it hard to better understand this topic and provide appropriate guidance. The present study focuses on increasing the understanding of robust decision-making that IPB victims engage in as they strategize leaving a violent relationship safely.

This study acknowledges the common reasons why IPV victims/survivors stay, such as financial or family reasons, but it goes one step further and uncovers other reasons that are unique to the individual that may impede leaving a dangerous relationship.

This study uses narrative analysis to analyze stories about IPV told in interviews with Dr. Jenny Andrus and public social media posts. The stories analyzed are considered "staying stories," which often reference social norms and stereotypes that incentivize staying. In particular, this study revealed two understudied reasons why IPV victims stay that are related to social stereotypes: first, some study participants didn't realize they were being abused because their abuse was emotional/verbal and didn't match the stereotypes of physical violence; second, some IPV victims didn't realize their abuse counted as IPV because they had no visible bruises.

Methods

This study made use of narrative analysis to provide careful and meaningful conclusions about the current situation surrounding IPV. The data for this study was collected through interviews. A total of 24 interviews were completed by Dr. Andrus. Each interview lasted between 30 and 60 minutes.

All of the interviews were transcribed and carefully

analyzed using an interactive coding scheme. Each interview was read and analyzed at least 3 times. The primary read was general, noticing common themes and topics. The secondary read identified keywords. The keywords were counted, to identify the topics and themes that emerged as the most important. Finally, the interviews were read to identify the narratives that corresponded to the keywords that were either the most referenced topic or the topic the least studied in the IPV literature. The topics that emerged as the most important were: financial abuse, emotional/verbal abuse, misunderstandings about abuse because of the lack of visible bruises and the lack of physical violence, and the impact of social discourses and IPV.

Once each interview was categorized under the different keywords, researchers decided that 7 interviews would be used in this study. These interviews possessed essential information about the current state of domestic violence. Then, the narrative types found in these interviews were compared to each other. After this, each interview was further analyzed and a coding system was developed. Within each interview, essential stories were shared by the participants, thus researchers looked for patterns in each passage.

Results

Most of the existing research is determined to examine the reasons victims/survivors of IPV stay in those violent relationships with the help of surveys or questionnaires. These methods do not produce detailed data, which could more directly assist victims/survivors to improve their well-being. Our qualitative, narrative-based research

provided much-needed detailed reasoning that went into staying/leaving decision-making.

During the interviews, many participants provided answers that align with the data found in the surveys and questionnaires conducted in the past. However, during the analysis of these interviews. a unique cluster of reasons emerged, which has not been thoroughly investigated. Referencing stereotypes about physical abuse, many participants articulated how they did not even realize that they were part of an abusive relationship until the relationship was in a late stage or even after it was over.

Through narrative analysis, we identified two important factors in staying/leaving decision-making. First, participants were not able to recognize emotional/verbal abuse as IPV. Second, they assumed that they were not victims of IPV because the abuse did not leave marks visible in public, such as a black eye. For both groups, unless abuse reached a particular level of severity, producing "proof" that would necessitate leaving, they did not see the abuse as IPV.

Conclusion

Through the examination of the interviews that were used in this study, it can be concluded that many of the participants were constantly being emotionally/verbally abused, however, they were not able to recognize it as abuse because they did not have the resources to see or have an example of what this abuse looks like.

Another group of participants did not recognize that they were being abused because the physical attacks did not leave a visible mark that could be seen or witnessed in public. Four of the seven women mentioned that they did not have any visible bruises or "evidence" of the physical

abuse they experienced, decreasing their likelihood that they would look for outside assistance or even consider themselves IPV victims.

It can be concluded that the narratives in US culture about what counts as domestic abuse are very limited, to the point where it has impacted the decisions of individuals in abusive relationships. This means that victims/survivors of IPV are not able to effectively recognize that emotional/verbal abuse is part of domestic abuse or that they do not need a visible bruise, and/or experience any type of extreme physical violence before they can think about leaving the relationship because it can be seen as irrational as it does not follow established cultural norms.

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SECTION VI

COLLEGE OF HEALTH

27.

BETTER TOGETHER? EXAMINING THE CONSOLIDATION OF MEMORIES SHARING A COMMON STRUCTURE

Owen Benzley; Geneviève Albouy; Ainsley Temudo; and Bradley R. King

Faculty Mentor: Geneviève Albouy (Health, Kinesiology, and Recreation, University of Utah)

Background

Previous research indicates that declarative and procedural memory processes are not separate but share

common networks and processes (Poldrack, 2004). Considering interactions between memory systems offers an interesting avenue to enhance memory consolidation (Mutanen, 2020), the process by which newly acquired memories are transformed into a more robust and long-lasting form (McGaugh, 2000). In this pilot study, we tested whether a common learning structure promoting higher-order associations between memories from different domains, can enhance the consolidation of newly created memories.

To do so, we developed a new serial reaction time task (SRTT) using pictures of objects to create visual cues to trigger motor responses, allowing us to investigate sequence learning in both the procedural and declarative memory domains. Notably, the task was designed such that there were – or not – associations between fingers and object categories. In the **associated** version of the task, each finger was associated to a specific object category, while there was no such finger-object association in the **unassociated** version of the task. This pilot study includes two groups of young, healthy adults that were assigned to either the associated (n=3) or unassociated (n=3) groups described above. All participants learned the motor and object sequences 4 hours apart on experimental day 1 and consolidation was assessed with an overnight retest on both tasks.

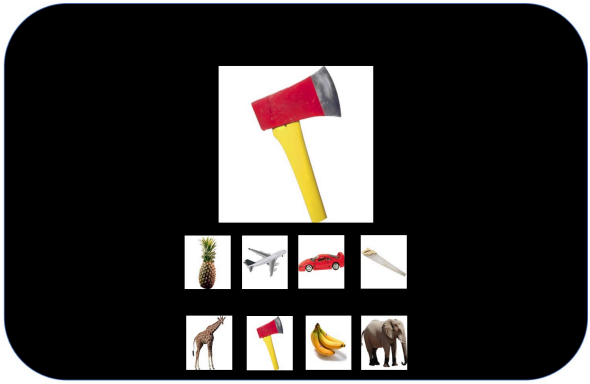
We hypothesized that participants in the associated group would show greater learning and consolidation (measured through performance speed and accuracy on the task), than participants in the unassociated group.

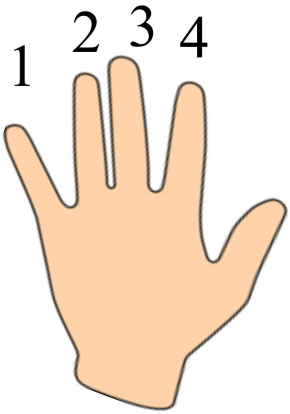
Methods

All six participants were healthy young adults aged

between 18 and 35 years with no formal musical training and were all right-handed. We designed a new serial reaction time task (SRTT) using pictures to create visual cues to trigger motor responses (Figure 1B). This task allowed us to probe both motor and object sequence learning (and to therefore examine procedural and declarative memory processes using the same task). The motor sequence was a pattern of 8 key presses using the fingers of the left hand (excluding the thumb), where each finger was used twice (i.e., 41324312). The object sequence was a pattern of 8 images split into four categories, vehicles, fruits, animals, and tools (Figure 2). To establish an association between memories from the different domains, a specific finger was associated to a specific object category (associated group, Figure 1C). No such association was present in the unassociated group. Participants were invited for three experimental sessions spread over two consecutive days (Figure 1A). They learned the motor and object sequence tasks on day 1 during two sessions separated by 4h (task order counterbalanced across participants). Consolidation was measured with an overnight retest (taking place approximately 24 h after session 2) of both object and motor tasks.

B





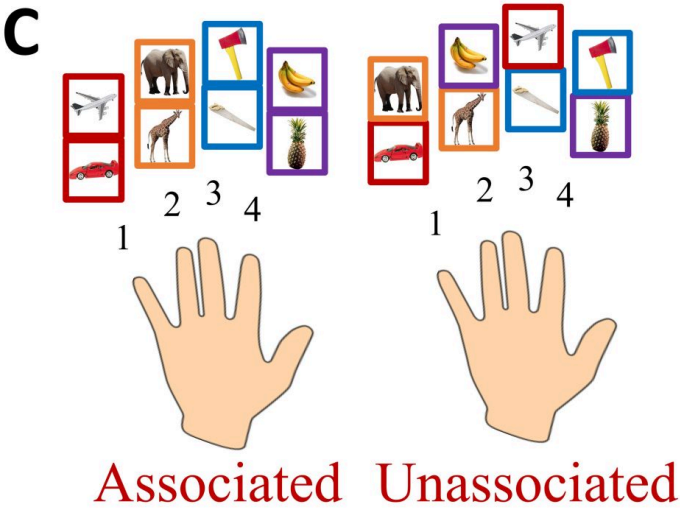
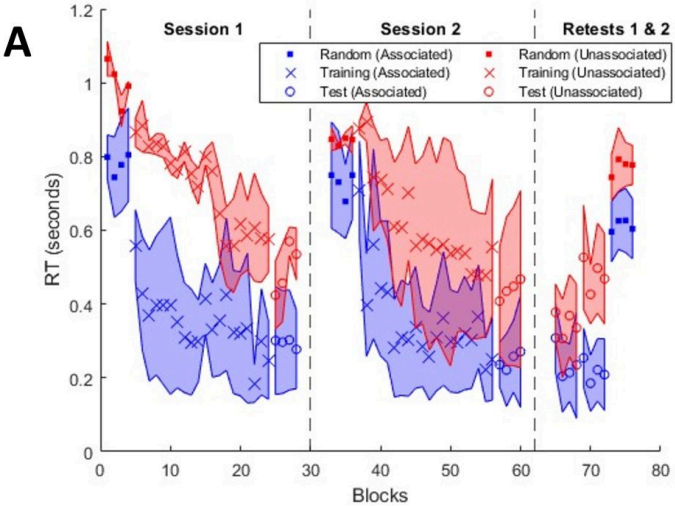
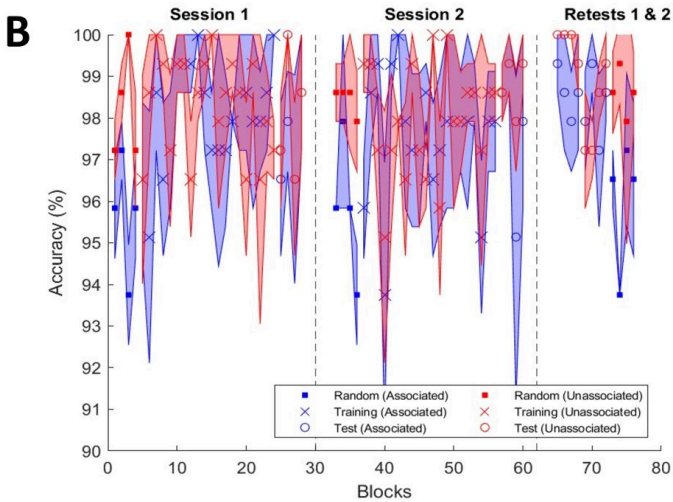


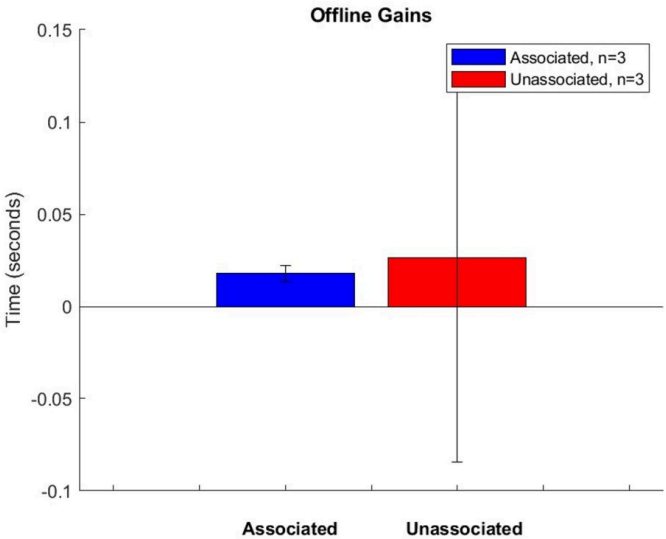
Figure 1: A. Visual representation of the experiment design. Participants learned the object and motor sequence learning tasks on day 1 (sessions 1 and 2) in a counterbalanced order. Consolidation was assessed with an overnight retest (session 3). Bl. = blocks. B. Diagram of the Serial Reaction Time Task (SRTT) with two objects mapped to each finger of the left hand (excluding thumb). C. Mapping of images to fingers in the associated and unassociated groups (left and right panel, respectively).

Group		Associated								Unassociated							
Ordinal Position		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Motor	M	4	1	3	2	4	3	1	2	4	1	3	2	4	3	1	2
	O	Randomized								Randomized							
Object	M	Randomized								Randomized							
	O																

Figure 2: Higher-order associations between the motor and the object sequences. In the associated group, each number (key/finger) occupies the same ordinal position as an object category (e.g., 4 is in the first and fifth ordinal positions, along with the vehicle category objects, car and airplane, in the same positions).




B
Session 1
Session 2
Retests 1 & 2
Accuracy (%)
Blocks
Random (Associated)
Training (Associated)
Test (Associated)
Random (Unassociated)
Training (Unassociated)
Test (Unassociated)


C
Offline Gains
Time (seconds)
Associated, n=3
Unassociated, n=3
Associated
Unassociated

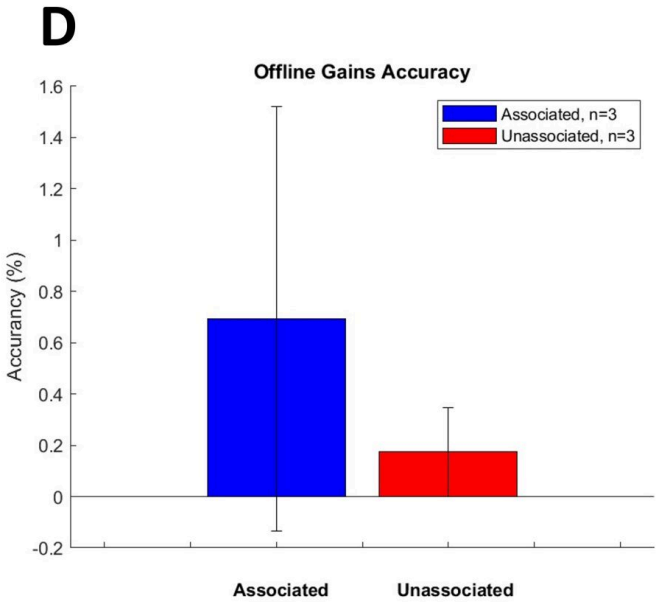


Figure 3: Averaged speed (A) and accuracy (B) data from 6 participants (3 associated, 3 unassociated) in all sessions irrespective of task order. The associated group shows an overall faster reaction time in all sessions compared to the unassociated group. Accuracy was similar between groups. Offline gains in performance speed (C) and accuracy (D) between the test in session 2 and the overnight retest in session 3. Results suggest that consolidation-related gains in speed were similar between groups whereas gains in accuracy were greater in the associated as compared to the unassociated group. In all panels, shaded regions and bars represent SEM.

Conclusion

These pilot data indicate that a higher-order association between memory domains did not improve learning as session 2 performance was not greater than session 1

performance in this preliminary sample. While associations between memory domains did not influence consolidation processes assessed with performance speed, offline gains in performance accuracy were greater in the associated, compared to the unassociated group. These pilot data therefore suggest that memories from different domains sharing a common learning structure show greater consolidation than unassociated memories. The results of this study will provide the foundation for future research that will examine the specific neural mechanisms underlying interactions between memory domains. This study also has the potential to unravel how shared processes across memory domains can be leveraged to enhance memory consolidation, which has important clinical implications.

Acknowledgements

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Bibliography

McGaugh JL. Memory–a century of consolidation. Science. 2000 Jan 14;287(5451):248-51. doi: 10.1126/science.287.5451.248. PMID: 10634773.

Mutanen, T. P., Bracco, M., Robertson E. M. (2020). A common task structure links together the fate of different types of memories. *Current Biology, 30(11),* 2139-2145.e5

Poldrack, R. A., & Rodriguez, P. (2004). How do memory systems interact? Evidence from human classification learning. *Neurobiology of learning and memory*, *82*(3), 324-332

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28.

RESEARCH REFLECTION BY OWEN BENZLEY

Owen Benzley

Faculty Mentor: Geneviève Albouy (Health, Kinesiology, and Recreation, University of Utah)

This research experience has helped me further my education and my love for neuroscience. It has given me a foundational stepping stone for my path to graduate school, and has provided me with quality learning experiences to help me grow. It has cemented my desire to continue in this field at the highest level possible.

About the Author

Owen Benzley

29.

EFFECTS OF INCREASING SLEEP DURATION ON C-REACTIVE PROTEIN, INSULIN SENSITIVITY, AND BLOOD PRESSURE IN ADULTS WITH HABITUAL SHORT SLEEP

Alisha Chong

Faculty Mentor: Christopher Depner (Health, University of Utah)

Abstract

Short sleep, cardiovascular disease, and type 2 diabetes are all highly prevalent health issues in modern society. Previous findings demonstrate that obtaining short sleep is linked to an increased risk of cardiometabolic diseases such as type 2 diabetes and heart disease. However, the mechanisms underlying how short sleep duration affects these health issues are not fully understood. C-reactive protein (CRP) is an inflammatory marker which has been linked to a greater risk of cardiovascular disease, but prior research has found conflicting information on whether short sleep significantly affects CRP levels. Thus, the current project aims to investigate the impact of short sleep on CRP levels as well as on insulin sensitivity and blood pressure to better understand the potential mechanisms by which short sleep duration is linked to adverse cardiovascular risk.

The project utilized data from the parent study, "Biomarkers and Altered Metabolic Pathways during Sleep Loss." The study recruited healthy individuals aged 18-35 who chronically received short sleep (<6.5h per night). After baseline assessments, participants completed a 4-week intervention aiming to increase their time in bed by 2 hours per night. Sleep duration and physical activity data were collected throughout the study. Insulin sensitivity, CRP, blood pressure, and fasting glucose and insulin levels were compared at baseline and sleep extension.

Of the 20 participants included in the current analysis, average sleep duration was 340 ± 83 (± SD) minutes per night at baseline and significantly increased ($p < 0.001$)

by 61 ± 11 (± SE) minutes during sleep extension. Insulin sensitivity after sleep extension was lower than baseline. Specifically, in a linear mixed-effects regression model adjusting for sex, body weight, and moderate-to-vigorous physical activity (MVPA), the Matsuda index significantly decreased ($P < 0.05$) by 1.2 ± 0.5 (SE) and HOMA-IR significantly increased ($P < 0.05$) by 0.4 ± 0.2 (SE) from baseline to extension. No significant differences between segments were observed for CRP, blood pressure, or fasting glucose and insulin levels. Systolic blood pressure was higher for men than for women at baseline, suggesting that among individuals habitually receiving short sleep, men may be at higher risk of hypertension. Our current findings highlight that otherwise healthy young adults with low overall risk of cardiometabolic disease do not show physiological benefit from a 4-week sleep extension intervention. The current intervention was feasible and increased sleep duration by ~1 hour per night. Longer term interventions in higher-risk populations such as older adults with obesity are needed to more comprehensively quantify the impact of sleep extension on risk of cardiometabolic disease.

Introduction

A vital aspect of maintaining overall good health is obtaining adequate sleep. Cardiovascular and metabolic health are no exception to this need. As such, the American Academy of Sleep Medicine and the Sleep Research Society recommend adults obtain seven or more hours of sleep each night for optimal health.[1] However, a large portion of adults are not meeting this recommendation. A report from the Centers for Disease Control and Prevention (CDC)'s *Preventing Chronic Disease*

journal shows in 2020, 33.2% of adults in the US reported receiving fewer than the recommended seven hours of sleep per night.[2] Prior studies demonstrate that obtaining short sleep duration increases risk of several diseases and health conditions, many of which are interconnected. For instance, poor quality sleep and short sleep are associated with an increased risk of type 2 diabetes,[3] and evidence shows short sleep duration leads to decreased insulin sensitivity.[4] Reduced insulin sensitivity may develop into prediabetes and eventually insulin resistance and type 2 diabetes, which increases risk of early mortality.

Few studies have explored whether increasing sleep duration is a viable and practical way to improve insulin sensitivity in people who obtain habitual short sleep durations. Broussard et al. conducted a study testing the effects of acute sleep deprivation followed by sleep recovery on insulin sensitivity in healthy young men, assigning them to complete, in random order, four nights of normal sleep and four nights with restricted sleep followed by two nights of recovery sleep under laboratory conditions.[5] Under this protocol, participants displayed impaired insulin sensitivity after sleep restriction and improvement in insulin sensitivity after recovery sleep,[5] suggesting that recovery sleep or sleep extension is a feasible method of improving insulin sensitivity after acute sleep deprivation. These intriguing laboratory-based findings warrant further investigation in people with habitual short sleep duration in the real-world setting. In adults with chronic sleep deprivation, another study by Leproult et al. found that six weeks of at-home sleep extension during weekdays improved a fasting

marker of insulin sensitivity.[6] Their results indicate that interventions to increase sleep duration in short sleepers may have potential to increase insulin sensitivity and reduce metabolic disease risk. Such interventions are a promising avenue for further investigation.

Short sleep duration is also linked to increased risk of cardiovascular diseases such as coronary heart disease and stroke.[7] However, the precise mechanisms by which this occurs are not fully understood. As mentioned previously, short sleep duration increases the risk of type 2 diabetes, which also increases the risk of heart disease as high blood sugar causes damage to blood vessels.[8] Furthermore, sleep deprivation is associated with high blood pressure.[9] High blood pressure is a common comorbidity of type 2 diabetes, and both may lead to cardiovascular disease through means such as development of atherosclerosis and inflammation.

The processes linking atherosclerosis and inflammation to cardiovascular disease involve immune cell leukocytes. Endothelial cells of the arteries experience inflammation when a plaque begins to form.[10] Though leukocytes do not typically bind to this endothelium, the inflamed endothelium expresses adhesion molecules which do bind to classes of leukocytes associated with arterial plaques.[10] The activity of these leukocytes has the potential to weaken the plaque's fibrous cap attachment, increasing the risk of plaque rupture.[10] This rupture can go on to cause heart diseases like heart attack or stroke. Thus, inflammation may both mediate and indicate risk of cardiovascular disease, especially heart attack and stroke.

As such, one potential measure of cardiovascular disease risk is the body's level of inflammatory markers

such as high-sensitivity C-reactive protein (hs-CRP).[11] CRP has been linked to higher stroke and heart attack risk.11 Evidence supports CRP playing a role in upregulation of adhesion molecule expression,[11] which may help mediate the aforementioned process involving inflammation, immune cell activation, atherosclerosis and thrombosis, and cardiovascular disease. Because short sleep duration might increase heart disease risk through increasing inflammation,[9] it is possible CRP levels may serve as an indicator of short sleep duration or as a clue towards a specific molecular mechanism through which short sleep increases heart disease risk.

However, there have been conflicting findings on how sleep duration impacts CRP levels. One study by Chiang in Taiwanese adults found that after adjusting for potential confounding factors, individuals with a self-reported sleep time of less than 5.5 hours per day, including naps, had over twice as high a risk of increased CRP levels than those sleeping longer.[12] Another study by Grandner et al. investigating self-reported extreme nighttime sleep durations and CRP levels across different racial and ethnic groups found that CRP levels tend to be elevated in people with long sleep duration but not significantly in people with short sleep duration.[13] These results varied by group, and contradictory to Chiang's study, Grandner et al.'s results found that in Asian participants, short sleep duration appears to protect against elevated CRP levels. The Asian group in Grandner et al.'s study, however, included a larger variation in ethnicities (labelled Asian/Other). For non-Hispanic White participants, CRP levels were elevated in individuals with long sleep duration. Hispanic/Latino participants did not display significantly

elevated CRP levels at any sleep duration after adjustments, and for Black/African American participants, CRP levels were elevated in individuals sleeping fewer than five hours and in individuals sleeping eight hours.[13] A different study in nurses of various racial and ethnic groups from two Texas hospitals found no differences in CRP levels by actigraphy nor diary-reported total sleep time in White, Black, and Asian participants but did find elevated CRP with higher diary-reported total sleep time in Hispanic participants.[14] Other studies have found increases in CRP after acute total and partial sleep restriction,[15,16] and one found an association in middle-aged to older adults between daytime napping and elevated CRP and between longer time spent in bed and elevated CRP but found no association with sleep duration.[17]

These conflicting results regarding the impact of sleep duration on CRP, the incomplete understanding of the molecular mechanisms linking short sleep to increased heart disease risk and diabetes risk, and the need for further investigation regarding increasing sleep duration to improve insulin sensitivity and metabolic disease risk in people with habitually short sleep all represent gaps in knowledge. These gaps limit the development of sleep-based countermeasures that could help reduce the risk of cardiometabolic disease in people with short sleep duration. This poses an issue given the current high prevalence of short sleep in adults as well as the high incidence of damaging diseases like heart disease and type 2 diabetes in the US. More research will help advance our understanding of the associations between sleep duration and cardiometabolic disease risk. Although the current

project does not study enough participants from different racial and ethnic groups to conduct a stratified analysis, it does aim to gather more data on the effects of sleep duration on CRP levels as well as on factors impacting heart disease risk such as insulin sensitivity and blood pressure.

The current project analyzed healthy individuals aged 18-35 chronically receiving short sleep. Various measures such as fasting glucose and insulin levels, CRP, insulin sensitivity, and vital signs of participants were compared at baseline and after a four-week intervention aiming to increase time in bed by 2 hours per night to determine whether significant differences existed before and after the sleep intervention. The project's hypothesis was that increasing sleep duration of people chronically receiving <6.5h of sleep per night would lower plasma CRP levels, decrease blood pressure, and increase insulin sensitivity.

Methods

Data for this project were collected in the parent study "Biomarkers and Altered Metabolic Pathways during Sleep Loss" conducted by the Sleep and Circadian Physiology Lab run by Dr. Christopher Depner in the University of Utah Department of Health and Kinesiology. All study procedures were approved by the University of Utah Institutional Review Board, and all participants

provided written informed consent prior to initiating any study procedures. The study recruited healthy individuals aged 18-35 who reported habitually obtaining fewer than 6.5 hours of sleep per night. Participants had a Body Mass Index (BMI) within the 18.5-24.9 range and reported fewer than 150 minutes of moderate-to-vigorous physical activity (MVPA) per week. Participants also lived

at or above the altitude of Salt Lake City for at least three months prior to beginning the study and stayed within the same time zone for at least three weeks prior to beginning the study. Individuals who reported night shift work within a year prior to beginning the study and individuals diagnosed with or displaying symptoms of clinically significant sleep disorders were excluded. Initial screening of applicants to the study was completed using an online REDCap survey with questions on applicants' medical history and conditions, habitual sleep and waketimes, and typical sleep onset latency. Prior to visit 1, potential participants also received additional REDCap surveys to further evaluate sleep history.

Data collection for each participant in the sleep study occurred over the course of nine visits. Visits 3 through 6 occurred during the baseline phase, where participants would maintain their regular sleep habits and schedule for two weeks at home. Visits 7 through 9 occurred during the sleep extension intervention phase, where participants would aim to increase their time in bed by 2 hours per night for four weeks. Participants were asked to refrain from napping or remaining awake for an entire night at any point during baseline and sleep extension. At visit 1, lab staff explained study procedures and obtained informed consent and additional medical and psychological health history as well as current drug and medication use. Additional medical screening was conducted at visit 2, and an overnight polysomnography sleep assessment was performed at visit 4 at the University of Utah Health Sleep-Wake Center. In the case that participants were unable to be evaluated at the Sleep-

Wake Center, they were given an Apnea Link device to conduct an at-home sleep assessment.

Sleep duration was measured throughout the study by wrist actigraphy using the Actiwatch Spectrum by Philips Respironics. Sleep and waketimes were recorded throughout the study in paper and electronic sleep diaries. An activPALTM monitor by PAL Technologies was worn on the thigh to determine physical activity throughout the two-week baseline period and during the last two weeks of sleep extension. The Actiwatch, sleep diary, and activPALTM device were given at visit 3, and participants would begin baseline monitoring that night. Participants received a Dreem headband (by Beacon Biosignals, Inc.) at visit 5 to track their brain activity at home while sleeping for the last week of baseline.

Visit 6 was an overnight visit held at the University of Utah Hospital to conduct physiological baseline measurements. Participants arrived approximately three hours prior to their habitual bedtime as determined by their electronic sleep log entries. Their sleep was again assessed by polysomnography. Scheduled waketime was also determined using electronic sleep log entries. Vital signs and body measurements, including systolic and diastolic blood pressure and body weight, were measured during this visit. CRP levels were measured from fasting plasma samples. Oral Glucose Tolerance Testing (OGTT) administered one hour after waketime provided the fasting, 30-, 60-, 90-, and 120-minute plasma glucose (PG) and insulin levels for use in calculating measures of insulin sensitivity.

After visit 6, participants were instructed to increase their time in bed by 2 hours per night for the next four

weeks. To facilitate the sleep extension, the study team worked with participants to set individualized sleep and waketime targets. To help participants increase their sleep duration, staff also provided handouts containing advice from the National Sleep Foundation. Examples of advice included keeping the bedroom temperature cool, maintaining consistent bed and waketimes, avoiding caffeine intake during the afternoon, and taking a hot shower as well as avoiding food and alcohol, exercise, and blue light exposure in the one to two hours before bed. Participants continued to use the Actiwatch and sleep diaries to track sleep duration and sleep and waketimes. At visit 7, the

activPALTM device was once again provided to them to track their physical activity for the last two weeks of sleep extension. Visit 7 also served as a check-in visit to ensure the participants were maintaining their target sleep and waketimes and to provide any guidance necessary to maintaining or reaching these goals. The Dreem headband was given again at visit 8 to track brain activity while sleeping at home for the last week of sleep extension. Finally, visit 9 was conducted under the same procedures as visit 6, with scheduled arrival, bed, and waketimes determined by the extension period entries of the electronic sleep log.

For the current project, Dreem data were used to calculate total sleep times. To determine participant insulin sensitivity, OGTT glucose and insulin data from visits 6 for baseline and 9 for extension were used to calculate Matsuda index and Homeostatic Model Assessment for Insulin Resistance (HOMA-IR). Linear mixed-effects regression models were created in R to test

for statistically significant differences between baseline and extension measurements of Matsuda index, HOMA-IR, CRP (mg/L), systolic blood pressure (mmHg), diastolic blood pressure (mmHg), fasting glucose (mg/dl), fasting insulin (microU/ml), and total sleep time (min). The primary model (model 1) adjusted for sex and body weight only. A second model (model 2) adjusted for sex, body weight, and moderate-to-vigorous physical activity. Statistical significance was set at an a of 0.05.

Results

After exclusions due to missing or outlier data, baseline and extension data from 20 participants (totaling to 36 observations for glucose, insulin, and insulin sensitivity indices and 38 observations for blood pressure and CRP in R data frame) were included in our current analysis. Ten participants were female, and ten were male. Total sleep time per night was 340 ± 83 (± standard deviation) minutes on average at baseline. After adjusting for sex in a linear mixed-effects regression model, the total sleep time significantly increased by 61 ± 11 minutes (± standard error, $p < 0.001$) during sleep extension. The average nightly total sleep time during sleep extension was 398 ± 84 (± SD) minutes, a 17% increase from baseline (Figure 1).

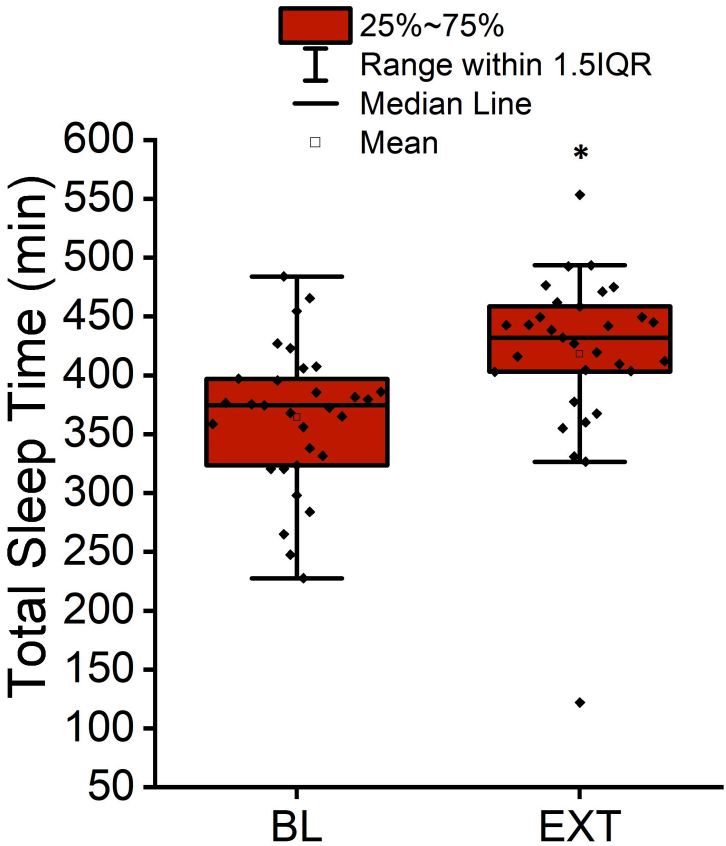

Figure 1. Mean, median, interquartile range, and 1.5 interquartile range of the total sleep time per night at baseline and after sleep extension. *p < 0.001 versus baseline (BL).

The Matsuda index average was 6.7 ± 2.7 (± SD) at baseline and decreased by 22% by the end of extension (p < 0.01; Figure 2 and Table 1). The HOMA-IR average was 1.3 ± 0.5 (± SD) at baseline and increased by 26% by the end of extension (p < 0.05; Figure 3 and Table 1).

Table 1. Average values and number of observations in baseline and extension insulin sensitivity indices, blood

pressure, CRP, and fasting plasma glucose and insulin. *p < 0.01 versus baseline (BL). **p < 0.05 versus baseline (BL).

	BL Average	EXT Average	Number of Observations in BL	Number of Observations in EXT
Matsuda	6.7	5.3*	17	14
HOMA-IR	1.3	1.6**	18	17
Systolic BP (mmHg)	110	110	20	18
Diastolic BP (mmHg)	69	69	20	18
CRP (mg/L)	0.3	0.3	20	17
Fasting PG (mg/dl)	84.1	87.8	19	17
Fasting Insulin (microU/ml)	6	7	18	17

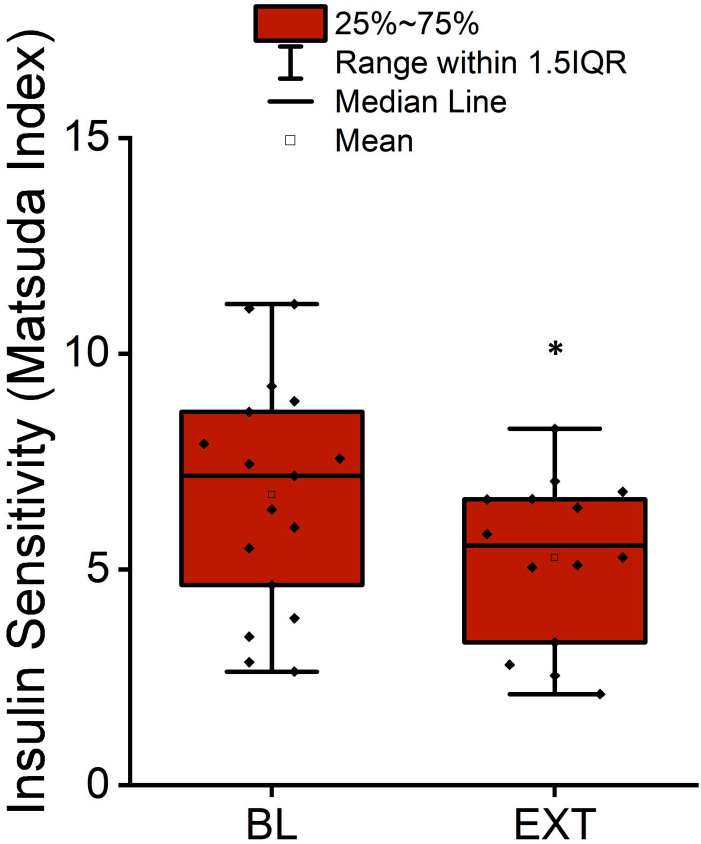

Figure 2. Mean, median, interquartile range, and 1.5 interquartile range of the Matsuda index measuring insulin sensitivity at the end of baseline period and after completion of sleep extension. *p < 0.01 versus baseline (BL).

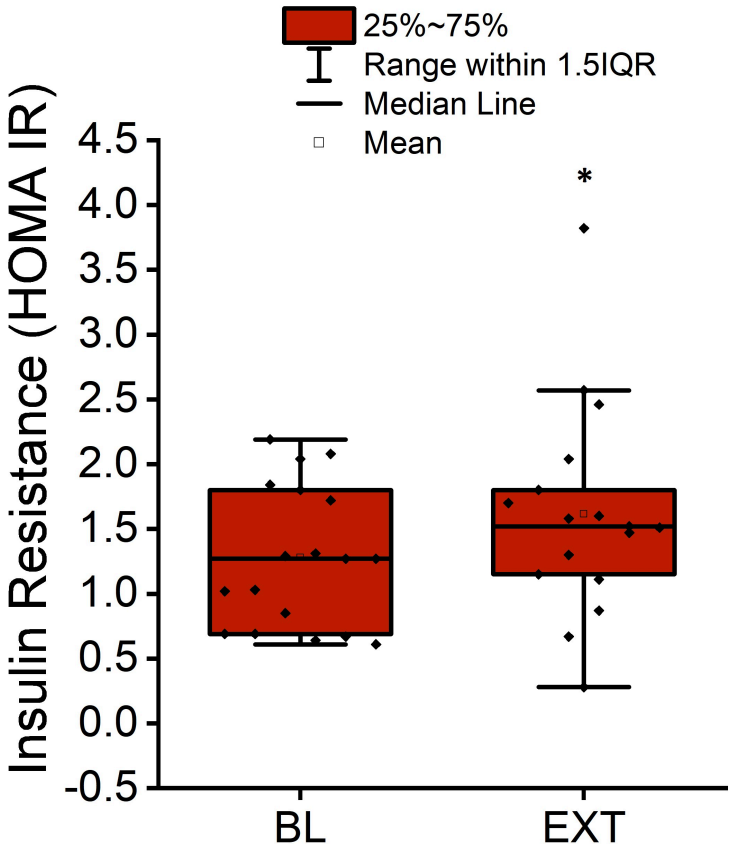

Figure 3. Mean, median, interquartile range, and 1.5 interquartile range of HOMA-IR measuring insulin resistance at the end of baseline period and after completion of sleep extension. *p < 0.05 versus baseline (BL).

In model 1 adjusting for sex and body weight, the Matsuda index significantly decreased (P < 0.01) by 1.1 ± 0.4 (SE) from baseline to extension. HOMA-IR significantly increased (P < 0.05) by 0.4 ± 0.1 (SE) from baseline to extension (Table 2).

Table 2. Model 1 linear mixed-effects regression

analysis results for insulin sensitivity indices, blood pressure, CRP, and fasting plasma glucose and insulin. Model 1 adjusted for sex and body weight. *p < 0.01 versus baseline (BL). **p < 0.05 versus baseline (BL).

	Estimate	Standard Error	P	Number of Observations
Matsuda	-1.1*	0.4	0.003	31
HOMA-IR	0.4**	0.1	0.01	35
Systolic BP (mmHg)	0	2	0.82	38
Diastolic BP (mmHg)	0	2	0.87	38
CRP (mg/L)	0.0	0.1	0.67	37
Fasting PG (mg/dl)	3.7	2.6	0.16	36
Fasting Insulin (microU/ml)	1	1	0.05	35

In model 2 adjusting for sex, body weight, and MVPA, the Matsuda index again significantly decreased (P < 0.05) by 1.2 ± 0.5 (SE) from baseline to extension. HOMA-IR significantly increased (P < 0.05) by 0.4 ± 0.2 (SE) from baseline to extension (Table 3). Adding MVPA as a covariate in model 2 decreased the number of observations in the regression analysis due to a large number of MVPA data being missing. Running the analysis for systolic blood pressure and for fasting plasma glucose in model 2 resulted in a singular fit error due to the shortage of data.

Table 3. Model 2 linear mixed-effects regression analysis results for insulin sensitivity indices, blood pressure, CRP, and fasting plasma glucose and insulin. Model 2 adjusted for sex, body weight, and MVPA. *p < 0.05 versus baseline (BL).

	Estimate	Standard Error	P	Number of Observations
Matsuda	-1.2*	0.5	0.01	23
HOMA-IR	0.4*	0.2	0.04	26
Systolic BP (mmHg)	0	3	0.95	27
Diastolic BP (mmHg)	2	2	0.44	27
CRP (mg/L)	0.0	0.1	0.99	26
Fasting PG (mg/dl)	5.1	2.8	0.06	26
Fasting Insulin (microU/ml)	1	1	0.16	26

There were no significant differences between baseline and extension measurements of systolic blood pressure, diastolic blood pressure, CRP, fasting plasma glucose, or fasting plasma insulin. An exploratory linear regression model analyzing systolic blood pressure at baseline by sex did reveal a significant difference between systolic blood pressure in male and female participants. Systolic blood pressure was higher ($P < 0.05$) by 9 mmHg ± 4 mmHg (SE) in male versus female participants at baseline (Figure 4).

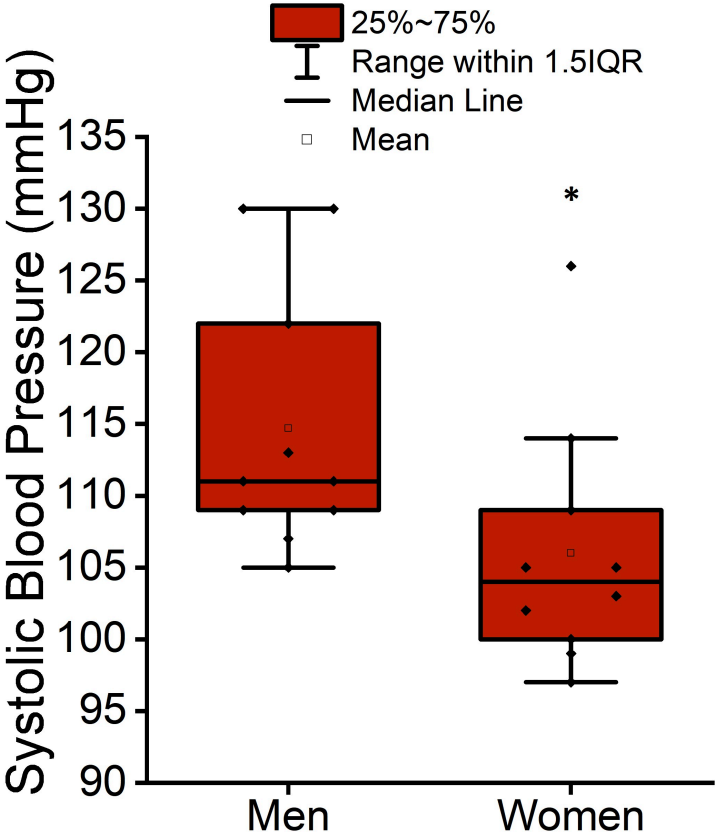

Figure 4. Mean, median, interquartile range, and 1.5 interquartile range of systolic blood pressure at baseline in men and women participants. *p < 0.05 versus women.

Discussion

In the current study, our findings show extending or increasing sleep duration in individuals who habitually obtain short sleep reduced insulin sensitivity. These findings were consistent for both the Matsuda index and HOMA-IR and in statistical models with or without MVPA included as a covariate, contrary to our hypothesis. This outcome is also inconsistent with findings from Leproult

et al.'s study, which similarly investigated the effects of a sleep extension intervention in adults chronically receiving short sleep.[6] Both studies resulted in an approximately one-hour increase in sleep duration, though Leproult et al.'s study involved a six-week intervention compared to the current project's four-week intervention. This longer duration may have contributed to the mixed findings between studies, and additional research with longer term interventions may be helpful to explain the observed differences.

One possible explanation for the decrease in insulin sensitivity in our data may lie in a potential adverse circadian shift driven by adapting to the sleep extension intervention. The current project did not control whether participants slept earlier, woke later, or both to increase their sleep duration. Additionally, though target bed and waketimes were provided, the participants did not strictly adhere to these times every day. There may be a possibility that participants' circadian clocks were shifted so that melatonin offset was delayed to occur later after waking, causing melatonin levels to remain high at the time of insulin sensitivity testing.

Prior evidence demonstrates that high melatonin concentrations can decrease insulin sensitivity and glucose tolerance. One study found that providing 1 mg of exogenous melatonin to postmenopausal women in the morning after fasting resulted in reduced insulin sensitivity and glucose tolerance.[18] Moreover, another study examined a 5 mg dose of melatonin in young women and found that glucose tolerance was lower in the melatonin group compared to the placebo group.[19] Given this potential for altered melatonin to influence

insulin sensitivity in our study, we are planning to analyze melatonin concentrations during the insulin sensitivity testing portion of the protocol. Future analysis of these melatonin samples would further the investigation into the possibility that an adverse circadian shift and delayed melatonin offset could contribute to the decrease in insulin sensitivity after sleep extension. If so, such findings would suggest that interventions targeting the timing and regularity of sleep may be more effective than interventions focused explicitly on increasing sleep duration.

Furthermore, if sleep extension did alter the timing of participants' sleep schedules, the resulting sleep irregularity could explain the decrease in insulin sensitivity. Besides short sleep, irregular sleep is also highly prevalent in modern populations.[20] One study investigating sleep irregularity's impact on metabolic syndrome using cross-sectional and prospective analyses on the participants in the Multi-Ethnic Study of Atherosclerosis (MESA) demonstrated that variation above a certain level in both sleep duration and sleep onset timing was associated with a higher risk of metabolic syndrome.[20] Though this study did not explicitly investigate insulin sensitivity, metabolic syndrome is a condition closely linked to insulin resistance.[21] Additionally, a different analysis on women in the Study of Women's Health Across the Nation (SWAN) Sleep Study observed increased insulin resistance with higher bedtime variability and with greater delay from habitual bedtime.[22]

Leproult et al.'s study specifically recruited participants who had differing sleep durations between weekdays and

weekends, and their baseline measurements indicated the participants slept over an hour longer during weekends compared to weekdays.[6] As participants increased their sleep duration during the week but did not significantly change sleep duration on weekends,[6] this gap between weekday and weekend sleep duration would shrink during the sleep extension period, which could reflect a decrease in sleep duration variability. However, this would not necessarily mean reduced irregularity in sleep onset timing. The current project did not require nor investigate differences between weekday and weekend sleep schedules. Some participants reported more consistent daily sleep schedules in their sleep diaries while others had varying bed and waketimes throughout the week. Further analysis of sleep and waketimes to compare sleep regularity at baseline and during extension could help verify whether a link between sleep irregularity and decreased insulin sensitivity exists in the outcomes of the current project. Regardless, future study into sleep irregularity's effect on insulin sensitivity and cardiometabolic risk factors would be a beneficial direction to further elucidate the link between poor sleep and increased risk of type 2 diabetes and heart disease.

The current project did not find any significant differences between baseline and extension measurements of CRP, systolic blood pressure, diastolic blood pressure, fasting glucose, or fasting insulin. The participants were young, healthy adults with low risk of cardiovascular disease, so their levels of these measures were likely normal to begin with and were minimally impacted by an increase

in sleep duration. However, systolic blood pressure was

higher in men than in women at baseline. Thus, among short sleepers, men may be more susceptible to hypertension than women. This finding is consistent with existing knowledge on sex differences in blood pressure, which generally state that men have higher blood pressure, have higher prevalence of hypertension (except after the age that women reach menopause), and are at risk of cardiovascular disease at an earlier age.[23]

Expanding on this project to continue searching for clues behind the underlying mechanisms between short sleep duration and cardiometabolic disease risk would help advance development of precision medicine for these issues, such as by determining which individuals at which ages would benefit most from sleep extension interventions. As CRP, blood pressure, and fasting glucose and insulin were not significantly impacted by sleep extension in young adults with no observed health issues, future studies would focus on a population with higher cardiovascular and metabolic disease risk. These could include a cohort of older and overweight adults habitually receiving short sleep to determine if these individuals have elevated CRP and whether sleep extension would be an effective intervention to lowering CRP and chronic disease risk.

In regard to the current project, the results suggest men who receive short sleep may need to be more vigilant regarding hypertension risk than women. However, for the age range of young adults, sleep extension did not appear to be beneficial. As such, although the sleep intervention was a feasible means of increasing sleep duration, a different course of treatment or preventative measures for hypertension or other cardiometabolic disease risk factors

could be a more useful focus for this particular population. As mentioned earlier, circadian interventions focusing on sleep regularity over duration is an emerging area of research requiring more study. The advancement of knowledge and potential interventions for sleep and cardiometabolic health is crucial to promoting patient-provider discussions and increased focus on these intertwined aspects of health, particularly due to the high prevalence of issues in these areas and because during medical interviews, patients often fail to report receiving insufficient sleep, posing another obstacle to addressing health issues completely and comprehensively.[24]

One limitation of the current project is the lack of consideration for additional covariates that may affect metabolism such as food intake and timing. Though the parent study is collecting data on these variables, they have not been tabulated at the time of the current project. However, a linear mixed-effects regression model of body weight by segment adjusted for sex did not reveal any significant differences between weight at baseline and extension, suggesting that the effect of food intake may have been limited or remained fairly consistent between baseline and extension. A continuance of the current project could confirm whether this variable differed between the two segments.

Another limitation of the current project is the small sample size included in the analysis. Both glucose and insulin data as well as the covariate MVPA data were missing for some participants, restricting the number of observations included in both models 1 and 2. In model 2 in particular, many MVPA data points were missing, causing many observations to be excluded and producing

singular fit errors for systolic blood pressure and fasting glucose analyses. Furthermore, as potential effects of sleep duration on CRP have been shown to vary by race, a much larger-scale project both in size and diversity would be required to adequately analyze CRP, particularly for any future project in populations with higher risk of elevated CRP.

References

1. Watson NF, Badr MS, Belenky G, et al. Recommended Amount of Sleep for a Healthy Adult: A Joint Consensus Statement of the American Academy of Sleep Medicine and Sleep Research Society. *Sleep*. Jun 1 2015;38(6):843-4. doi:10.5665/sleep.4716

2. Pankowska MM, Lu H, Wheaton AG, et al. Prevalence and Geographic Patterns of Self-Reported Short Sleep Duration Among US Adults, 2020. *Prev Chronic Dis*. Jun 29 2023;20:E53. doi:10.5888/pcd20.220400

3. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Quantity and quality of sleep and incidence of type 2 diabetes: a systematic review and meta-analysis. *Diabetes Care*. Feb 2010;33(2):414-20. doi:10.2337/dc09-1124

4. Eckel RH, Depner CM, Perreault L, et al. Morning Circadian Misalignment during Short Sleep Duration Impacts Insulin Sensitivity. *Curr Biol*. Nov 16 2015;25(22):3004-10. doi:10.1016/j.cub.2015.10.011

5. Broussard JL, Wroblewski K, Kilkus JM, Tasali E. Two Nights of Recovery Sleep Reverses the Effects of Short-term Sleep Restriction on Diabetes Risk. *Diabetes Care*. Mar 2016;39(3):e40-1. doi:10.2337/dc15-2214

6. Leproult R, Deliens G, Gilson M, Peigneux P. Beneficial impact of sleep extension on fasting insulin

sensitivity in adults with habitual sleep restriction. *Sleep*. May 1 2015;38(5):707-15. doi:10.5665/sleep.4660

7. Cappuccio FP, Cooper D, D'Elia L, Strazzullo P, Miller MA. Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies. *Eur Heart J*. Jun 2011;32(12):1484-92. doi:10.1093/eurheartj/ehr007

8. Petrie JR, Guzik TJ, Touyz RM. Diabetes, Hypertension, and Cardiovascular Disease: Clinical Insights and Vascular Mechanisms. *Can J Cardiol*. May 2018;34(5):575-584. doi:10.1016/j.cjca.2017.12.005

9. Mullington JM, Haack M, Toth M, Serrador JM, Meier-Ewert HK. Cardiovascular, inflammatory, and metabolic consequences of sleep deprivation. *Prog Cardiovasc Dis*. Jan-Feb 2009;51(4):294-302. doi:10.1016/j.pcad.2008.10.003

10. Libby P, Ridker PM, Maseri A. Inflammation and atherosclerosis. *Circulation*. Mar 5 2002;105(9):1135-1143. doi:10.1161/hc0902.104353

11. Ridker PM. High-sensitivity C-reactive protein and cardiovascular risk: rationale for screening and primary prevention. *Am J Cardiol*. Aug 21 2003;92(4B):17K-22K. doi:10.1016/s0002-9149(03)00774-4

12. Chiang JK. Short duration of sleep is associated with elevated high-sensitivity C-reactive protein level in Taiwanese adults: a cross-sectional study. *J Clin Sleep Med*. Jul 15 2014;10(7):743-9. doi:10.5664/jcsm.3862

13. Grandner MA, Buxton OM, Jackson N, Sands-Lincoln M, Pandey A, Jean-Louis G. Extreme sleep durations and increased C-reactive protein: effects of sex and ethnoracial group. *Sleep*. May 1 2013;36(5):769-779E. doi:10.5665/sleep.2646

14. Farmer HR, Slavish DC, Ruiz J, et al. Racial/ethnic variations in inflammatory markers: exploring the role of sleep duration and sleep efficiency. *J Behav Med*. Dec 2022;45(6):855-867. doi:10.1007/s10865-022-00357-8

15. van Leeuwen WM, Lehto M, Karisola P, et al. Sleep restriction increases the risk of developing cardiovascular diseases by augmenting proinflammatory responses through IL-17 and CRP. *PLoS One*. 2009;4(2):e4589. doi:10.1371/journal.pone.0004589

16. Meier-Ewert HK, Ridker PM, Rifai N, et al. Effect of sleep loss on C-reactive protein, an inflammatory marker of cardiovascular risk. *J Am Coll Cardiol*. Feb 18 2004;43(4):678-83. doi:10.1016/j.jacc.2003.07.050

17. Leng Y, Ahmadi-Abhari S, Wainwright NW, et al. Daytime napping, sleep duration and serum C reactive protein: a population-based cohort study. *BMJ Open*. Nov 11 2014;4(11):e006071. doi:10.1136/bmjopen-2014-006071

18. Cagnacci A, Arangino S, Renzi A, et al. Influence of melatonin administration on glucose tolerance and insulin sensitivity of postmenopausal women. *Clin Endocrinol (Oxf)*. Mar 2001;54(3):339-46. doi:10.1046/j.1365-2265.2001.01232.x

19. Rubio-Sastre P, Scheer FA, Gomez-Abellan P, Madrid JA, Garaulet M. Acute melatonin administration in humans impairs glucose tolerance in both the morning and evening. *Sleep*. Oct 1 2014;37(10):1715-9. doi:10.5665/sleep.4088

20. Huang T, Redline S. Cross-sectional and Prospective Associations of Actigraphy-Assessed Sleep Regularity With Metabolic Abnormalities: The Multi-Ethnic Study of

Atherosclerosis. *Diabetes Care*. Aug 2019;42(8):1422-1429. doi:10.2337/dc19-0596

21. Roberts CK, Hevener AL, Barnard RJ. Metabolic syndrome and insulin resistance: underlying causes and modification by exercise training. *Compr Physiol*. Jan 2013;3(1):1-58. doi:10.1002/cphy.c110062

22. Taylor BJ, Matthews KA, Hasler BP, et al. Bedtime Variability and Metabolic Health in Midlife Women: The SWAN Sleep Study. *Sleep*. Feb 1 2016;39(2):457-65. doi:10.5665/sleep.5464

23. Maranon R, Reckelhoff JF. Sex and gender differences in control of blood pressure. *Clin Sci (Lond)*. Oct 2013;125(7):311-8. doi:10.1042/CS20130140

24. Chattu VK, Manzar MD, Kumary S, Burman D, Spence DW, Pandi-Perumal SR. The Global Problem of Insufficient Sleep and Its Serious Public Health Implications. *Healthcare (Basel)*. Dec 20 2018;7(1)doi:10.3390/healthcare7010001

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Alisha Chong

30.

RESEARCH REFLECTION BY ALISHA CHONG

Alisha Chong

Faculty Mentor: Christopher Depner (Health, University of Utah)

Participating in undergraduate research has given me the chance to work with some amazing people and has been one of the most fulfilling activities I have done in university. I gained valuable experience and confidence in creating and giving presentations. I have had the opportunity to discuss my research as well as to learn from graduate students and other sleep researchers. These experiences have given me useful insight into the research process that have opened my mind to considering

continuing research, looking into more lab work, or looking into sleep research or medicine-related fields.

About the Author

Alisha Chong

31.

THE EFFECTS OF EXTREME WEATHER CONDITIONS AND EPISODIC POOR AIR QUALITY ON PEOPLE EXPERIENCING HOMELESSNESS

Fernanda Guzman; Jeff Rose; Meagan Ricks; and Yulisa Padilla-Fragosso

Faculty Mentor: Jeff Rose (Parks, Recreation & Tourism, University of Utah)

Poor and unsafe air quality is a public health risk as

it poses serious health dangers to those exposed. Some groups are disproportionately exposed to unsafe air quality and the illnesses that are caused by it. The unsheltered homeless population of Salt Lake City is exposed to the city's environmental hazards at high levels. Not only are they affected by hazards such as extreme heat and cold weather, but they are also directly exposed to episodic poor air quality each day that it occurs in the Salt Lake City region. This study strives to uncover the struggles that people experiencing homelessness endure by conducting primary data collection through interviews. People experiencing unsheltered homelessness may include people living on the street, in parks, alleyways, cars, abandoned buildings, and more. These individuals also may be using resources from shelters as well as residing in shelters temporarily. Living conditions for people experiencing unsheltered homelessness are highly affected by the surrounding poor air quality as well as extreme weather conditions. These environmental hazards cause the physical and mental health and wellbeing of people experiencing homelessness to be directly impacted. The disproportionate exposure to unsafe air quality and extreme weather among those experiencing homelessness poses large environmental justice concerns in the Salt Lake City area. The results of this experiment showed the true struggles that people experiencing homelessness endure living uncovered from extreme weather conditions as well as air quality. Participants shared their stories of times of difficulty and times where displacement and local policies have led them to live in extreme discomfort and survival mode. Ultimately, the research also showed that resources and

policies were failing this population, and it was deemed impossible to live a healthy life uncovered from the listed environmental hazards. This research is a call for action to protect people experiencing homelessness from dangerous living conditions.

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32.

RESEARCH REFLECTION BY FERNANDA GUZMAN

Fernanda Guzman

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This summer program was my first experience in undergraduate research, and it has helped me find out who I am as a researcher. I have always been very passionate about social justice concerns so getting to conduct hands on research in the field has been a great experience. SPUR has made me more confident in my academic abilities as well as my abilities as a researcher. This program has also helped me solidify what my goals will be after graduation. I hope to pursue a long career in

the public health field in order to advocate for the health of marginalized communities.

About the Author

Fernanda Guzman

33.

GENERATION OF NOVEL HUMAN INDUCED PLURIPOTENT STEM CELL LINES TO STUDY PROTEINOPATHY IN CARDIOMYOCYTES

Taylor James and Rajeshwary Ghosh

Faculty Mentor: Rajeshwary Ghosh (Nutrition and Integrative Physiology, University of Utah)

Cardiovascular disease (CVD) is a major problem in the United States and is one of the leading causes of death

with over 300,000 deaths annually (1). This is a grave concern but is specifically detrimental to the African American community. The age of onset is much younger than the typical 50 and over age range. 1 in 100 Black Males and Females are expected to develop CVD before the age of 50 (2). This is likely due to social factors as well as genetic determinants. Not only are members of the black community more likely to develop heart disease, but they are also 30% more likely to die from heart disease than non-Hispanic whites.

Cardiac Proteinopathy is a common feature of different types of heart failure. Cardiac proteinopathy is a protein conformational disorder which results in the accumulation of misfolded and mutant proteins in the heart. An example of cardiac protienopathy in cells is the Crystalline ab r120g model. Crystallin (CryAB) is a small heat shock protein which acts as a chaperone and participates in intermediate filament formation and maintenance. A missense mutation in CryAB, R120G, causes the formation of dense protein aggregates and is linked to familial desminopathy. The accumulation of R120G causes progressive muscle weakness, cataracts, and cardiac disorders like cardiomyopathy leading to disability and death.

Human Induced Pluripotent Stem cells (hiPSC) sourced from human fibroblasts, can be reprogrammed into new cell types under appropriate growth conditions. This ethically sourced approach was chosen over other models as hiPSC derived cardiomyocytes (hiPSC-CM) can faithfully recapitulate a human disease phenotype. We aim to generate a human induced pluripotent stem cell (hiPSC) line harboring the CryABWT or CryABR120G gene

that can be differentiated into cardiomyocytes. Both CryAB wild-type (WT) and R120G mutant genes were knocked-in to the genome of hiPSCs. They were then cultured and differentiated into cardiomyocytes. More specifically, these cells were grown in vitronectin-coated plates and maintained in Essential 8 (E8) and Stem Flex (SF) media. Cells were differentiated using the stem cell cardiomyocyte differentiation media over 24-day period. The hiPSC-CM were then treated with doxycycline to induce WT or R120G gene expression.

Quantitative polymerase chain reaction (qPCR) was used to validate differentiation of hiPSCs into cardiomyocytes by determining the mRNA expression of several cardiomyocyte-related genes (i.e., Tbx5, Actn1, Cryab, Hcn4, etc.) Next, immunocytochemistry was employed to determine the levels of the induced proteins: crystallin and mCherry. The qPCR results show increased expression of several cardiomyocyte markers in the differentiated cells vs. the non-differentiated cells. Confocal imaging revealed increased expression of both mCherry and CryAB protein aggregates in mutant R120G line but not in the WT cells. While the WT cell lines indicated increased expression of both mCherry and CryAB, the extent of mCherry or CryAB protein expression was lower in the mutant line. Ongoing experiments involve culturing the mutant lines in Matrigel-coated plates with mTeSR Plus media to achieve higher expression of the proteins. Our novel WT or R120G hiPSC-CM cells will serve as an important tool in the study of clearing mutant protein aggregates.

References

1. Centers for Disease Control and Prevention. (2023,

May 15). Heart disease facts. Centers for Disease Control and Prevention. https://www.cdc.gov/heartdisease/facts.htm#:~:text=Heart%20disease%20is%20the%20leading,groups%20in%20the%20United%20States.&text=One%20person%20dies%20every%2033,United%20States%20from%20cardiovascular%20disease.

2. U.S. Department of Health and Human Services. (2015, July 2). Heart failure before age 50 more common in black people. National Institutes of Health. https://www.nih.gov/news-events/nih-research-matters/heart-failure-age-50-more-common-black-people#:~:text=According%20to%20a%20new%20study,rate%20than%20for%20white%20people

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34.

THE IMPACT OF THE ENVIRONMENT AND AIR QUALITY ON PEOPLE EXPERIENCING UNSHELTERED HOMELESSNESS IN SALT LAKE COUNTY

Yulisa Padilla-Fragosso; Jeff Rose; and Meagan Ricks

Faculty Mentor: Jeff Rose (Health, Kinesiology, and Recreation, University of Utah)

The Salt Lake City region and its environment experience weather in extreme ways through heat, cold, and episodic poor air quality. As an already vulnerable population, people experiencing unsheltered homelessness are impacted in drastic and disproportionate ways. Our research project has aimed to better understand this impact through 20 semi-structured interviews with people from this population recruited by both the Youth Resource Center and Men's Resource Center in Salt Lake City. Using thematic analysis to analyze the interviews we conducted, we found 4 common themes among our participants in relation to our topic. These themes were displacement, survival, place/safety, and policy. Displacement captures our participants' experiences of being pushed further into places where they are less protected from environmental hazards. Survival explores the importance of survival and being in constant fight or flight mode when experiencing unsheltered homelessness, but how environmental issues are not top priority when it comes to survival. Place/safety covers all of the places that our participants commonly mentioned as environmental refuge. Their top priority in these spaces was overall safety. Policy explores some challenges that our participants have found in protecting themselves from the environment due to various policies and also some suggestions on what would help them with that protection. This information shows the lack of conversation surrounding the overlap between environmental justice and unsheltered homelessness. People who impose displacement onto this population,

are not taking into account the environmental safety of the spaces they are pushing these groups into. We aren't talking to this group enough about the impacts of extreme heat, extreme cold, and air quality despite the challenges they face due to these factors. We need to make spaces of environmental refuge safer and more accessible and also create more spaces that provide greater consistent protection. To achieve this, we need improved policy that considers environmental justice, especially in respect to the extreme weather and episodic poor air quality found in the Salt Lake County region of Utah.

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35.

PROMOTING WELL-BEING IN ASSISTED LIVING RESIDENTS AND STAFF THROUGH ADAPTIVE BIKING

Riley Page

Faculty Mentor: Rhonda Nelson (Occupational and Recreation Therapies, University of Utah)

Project Overview

Older adults residing in assisted living facilities often face declining health, reduced

social interactions, and lack of meaningful activity (Tan et al., 2019). This can negatively impact their wellbeing. Staff are also at risk for decreased wellbeing due to employment issues such as staffing shortages and increased care needs of residents (Woodhead et al., 2016).

One intervention that holds potential to positively impact wellbeing in both residents and staff is adaptive biking. While past research has documented improvements in mood for residents (Buettner & Fitzsimmons, 2002; Buettner et al., 2013; Cotnam, 2020; Fitzsimmons, 2001; Fitzsimmons & Schoenfelder, 2011, McNeil & Westphal) and both physical and psychological functioning for staff (McNeil & Westphal, 2020) following shared bike rides, data are currently lacking on the impact of specific adaptive biking programs on additional aspects of wellbeing. Thus, the purpose of this study was to examine the impact of an adaptive biking program on the wellbeing of residents and staff by using the PERMA model of well-being (Butler & Kern, 2016) as a framework and assessing positive and negative emotions, engagement, relationships, meaning, accomplishment, and health.

Residents (n = 12) and staff (n = 11) were paired into "biking buddies" to complete

eight shared bike rides over a six-week period using a side-by-side adaptive bike (Figure 1). Standardized wellbeing assessments including The PERMA Profiler (for residents) and the Workplace PERMA Profiler (for staff) were administered pre- and post-program (Butler & Kern, 2016). Additionally, a study-specific Post-Ride Assessment was used following each of the eight bike rides. Resident and staff perceptions of that ride's impact on each of the focus areas of wellbeing was evaluated using an 11-point numeric rating scale (0 – 10). Qualitative data were also collected to better understand the subjective experience of participants.

During my time working on this project, we have completed baseline PERMA assessments and documented preliminary findings based on analysis of resident and staff post-ride assessments following the first four rides. Descriptive statistics were used to summarize each ride's ability to promote wellbeing in terms of positive and negative emotions, engagement, meaning, relationships, accomplishments and health (Tables 1 and 2). Thematic analysis of qualitative comments has provided additional insight on the program's contribution to resident and staff wellbeing.

Based on results from data that have been

collected to date in this ongoing study, we have concluded that residents and staff have a strong interest in an adaptive biking program as an activity to promote their well-being. Pre-intervention PERMA scores indicated good overall well-being at baseline with opportunities for improvement for residents and staff. Based on qualitative data, we have also concluded that participants perceive the bike rides as a positive contributor to all aspects of their well- being. Generally, residents enjoy the socialization, fresh air, and scenery the bike rides provide, and staff enjoy conversation with the resident and the opportunity to learn more about them.

Contribution to my Professional Development

I have learned an astounding amount during the course of this project that has had an extremely positive impact on my professional development. I have gained skills in communication, Recreational Therapy-based facilitation techniques, computer competency, data analysis, organizational skills, and improved response to ambiguity. I have been fortunate enough to observe the positive impact the intervention has had on the individuals I have worked with. I am leaving this program full of immense satisfaction and gratitude knowing I have helped improve the lives and well-being of others. Being a part of this project has also motivated me to further pursue research and other opportunities in the field of Recreational Therapy. Furthermore, I have gained

valuable knowledge to better recognize the importance of the roles recreational therapy professionals play in an individual's overall well-being. In addition, my knowledge of adaptive equipment and the role it plays in Recreational Therapy for older adults has been drastically impacted and improved due to my participation in this project. Throughout the entirety of my time working on this project, I was given the opportunity to showcase my strengths, whilst continuously and persistently improving on a variety of unique skills.

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This project would not have been possible without the help and support of several individuals and organizations. I would first like to express my gratitude to the Office of Undergraduate Research at the University of Utah, and specifically the Summer Program for Undergraduate Research (SPUR) for granting me such an incredible opportunity. I would also like to thank Crescent Senior Living in Sandy, UT for being incredibly welcoming and dependable throughout the entirety of my time there. Next, I would like to extend my appreciation to all participants of this study who were continuously flexible and dedicated in their participation despite their busy schedules. Finally, I would like to thank my mentor, Rhonda Nelson, Ph.D, MTRS, CTRS, FDRT as well as the Memory Care Director of Crescent Senior Living,

Rebecca Westenskow, MS, TRS, CTRS. Dr. Nelson has been a remarkable mentor who has taught me so much and shared her expertise that will truly help prepare me for my future endeavors. Rebecca has worked with me side by side daily every step of the way of this project. This truly would not have been possible without her guidance, and I am immensely grateful for the knowledge she has shared with me. Each of these organizations and individuals have contributed to this incredible experience in profound ways. They have allowed me to make memories that I will always cherish and gain skills that I will always utilize in the pursuit of future opportunities.

Figure 1: Van Raam Fun2Go Adaptive Bike

Table 1: Resident Well-Being (n = 12)

Well-Being Theme	PERMA Pre-Program Scores *M(SD)*	PERMA Post-Program Scores *M (SD)*	Post-Ride Assessment Rides 1 – 4 *M (SD)*
Positive Emotions	7.33 (1.10)	TBD	9.20 (1.20)
Negative Emotions	5.69 (1.75)	TBD	9.83 (0.64)
Engagement	6.92 (1.23)	TBD	9.22 (1.46)
Relationships	8.08 (1.04)	TBD	9.52 (1.43)
Meaning	8.00 (1.29)	TBD	8.57 (1.75)
Accomplishment	7.05 (1.64)	TBD	8.61 (1.83)
Health	7.64 (1.26)	TBD	8.96 (1.78)

Table 2: Staff Well-Being (n = 11)

Well-Being Theme	Workplace PERMA Pre- Program Scores *M (SD)*	Workplace PERMA Post-Program Scores *M (SD)*	Post-Ride Assessment Rides 1 – 4 *M (SD)*
Positive Emotions	7.91 (1.32)	TBD	9.67 (0.65)
Negative Emotions	2.24 (1.77)	TBD	9.72 (1.45)
Engagement	7.55 (1.66)	TBD	9.71 (0.65)
Relationships	8.24 (1.63)	TBD	9.65 (0.74)
Meaning	8.85 (1.20)	TBD	9.67 (0.59)
Accomplishment	8.39 (1.15)	TBD	9.54 (0.71)
Health	7.82 (1.68)	TBD	9.51 (0.92)

Bibliography

Butler, J. & Kern, M. L. (2016). The PERMA-Profiler: *International Journal of Welllbeing*, 6(3), 1-48 doi:10.5502/ijw.v6i3.1

Buettner, L. L., & Fitzsimmons, S. (2002). AD-venture program: Therapeutic biking for the treatment of depression in long-term care residents with dementia. *American Journal of Alzheimer's Disease and Other Dementias*, *17*(2), 121–127. https://doi.org/10.1177/153331750201700205

Buettner, L., Fitzsimmons, S., Labban, J. D., & Barba, B. E. (2013). Active lifestyle for older adults with dementia: Wheelchair biking versus other recreational therapy

interventions. *American Journal of Recreation Therapy*, *12*(1), 31-40. https://doi.org/10.5055/ajrt.2013.0038

Cotnam, V. (2020). Exploring the effects of the cycling without age program on older adults living in long-term care. Electronic Thesis and Dissertation Repository. 7374. https://ir.lib.uwo.ca/etd/7374

Fitzsimmons, S. (2001). Easy rider wheelchair biking: A nursing-recreation therapy clinical trial for the treatment of depression. *Journal of Gerontological Nursing*, *27*(5), 14-23. https://doi.org/10.3928/0098-9134-20010501-06

Fitzsimmons, S., & Schoenfelder, D.P. (2011). Evidence-based practice guideline: Wheelchair biking for the treatment of depression. *Journal of Gerontological Nursing, 37* (7), 8-15. https://doi.org/10.3928/00989134-20110602-03

McNiel, P., & Westphal, J. (2020). Cycling without age program: The impact for residents in long-term care. *Western Journal of Nursing Research*, *42*(9), 728–735. https://doi.org/10.1177/0193945919885130

Tan, J., Abdin, E., Shahwan, S., Zhang, Y., Sambasivam, R., Vaingankar, J., Mahendran, R.,Chua, H., Chong, S., & Subramaniam, M. (2019). Happiness and cognitive impairment among older adults: investigating the mediational roles of disability, depression, social contact frequency, and loneliness. *International Journal of Environmental Research and Public Health*, *16*(24), 4954–. https://doi.org/10.3390/ijerph16244954

Woodhead, E. L., Northrop, L., & Edelstein, B. (2016). Stress, social support, and burnout among long-term care nursing staff. *Journal of Applied Gerontology*, *35*(1), 84–105. https://doi.org/10.1177/0733464814542465

About the Author

Riley Page

36.

EXPLORING INSTAGRAM'S IMPACT ON NICOTINE AND CANNABIS BELIEFS FOR PUBLIC HEALTH: A RESEARCH REFLECTION

Kayla Rebentisch

Faculty Mentor: Jessica Jensen (Health, University of Utah)

The College of Health is aptly named. It focuses on the health and well-being of our community in a multitude of different settings, including nutrition, exercise, and public health. As a future health care professional, I

wanted to be a part of research to learn and understand more about public health and public health policy.

Dr. Jensen's research focus is on tobacco control and tobacco control policies within the United States. I was able to contribute (data collection, coding, analysis, and writing) to several projects, including "Examining Cigar Pack Quantity Purchases by Cigar Type in the United States Between 2014 and 2017" and "Price, convenience, the buying experience, and other motivations for purchasing tobacco and e-cigarettes online." Yet, in my own project, I wanted to go beyond just the worldwide web and explore how social media, in particular, is being used to perpetuate beliefs on nicotine and cannabis use.

Content on social media platforms such as Snapchat, Facebook, Twitter, and Instagram is created, posted, and shared at breakneck speeds. Not only is social media used to dictate new fads, but it is dramatically changing marketing strategies. Following my previous work with Dr. Jensen, I was concerned with how this phenomenon is impacting substance use, particularly among youth and young adults. I chose Instagram as the primary social media platform to explore because, as the old adage goes, "a picture is worth 1,000 words." Instagram is also one of the most widely used social media platforms.

I wanted to explore what makes a nicotine or cannabis product post popular within the platform and evaluate the extent to which these posts are shared and viewed. I reviewed a variety of hashtags spanning different substances, including e-cigarettes, cigarettes, cigars, and cannabis. The results from this study highlight that posts regarding nicotine and cannabis products receive considerable exposure. Because social media represents

a gray area in regards to abiding by FDA legislation, exposure to nicotine and cannabis products remains unregulated. The lack of warnings leaves youth and young adults vulnerable to perpetuated beliefs, such as "vaping is just flavored water."

Additional regulation is needed in order to decrease the viewership of posts related to nicotine and cannabis products and to minimize youth exposure to such posts. For example, any post relating to vaping should not be viewable by individuals under the age of 18. Prevention campaigns targeting specific substances through hashtag usage can also be created based on the findings from this study. Future prevention-based posts should continue to incorporate aspects of what makes a post popular within a certain substance's community (such as vaping) in order to increase anti-use campaign exposure and more directly influence behavior. For example, based on our findings, a prevention post to reduce cigarette usage on Instagram will likely obtain the most exposure if it features a white, young adult male.

Social media usage by the general population will continue to grow, and with it, the immediate perpetuation of potentially harmful behaviors, such as nicotine and cannabis usage. Reducing smoking, vaping, cannabis use, etc., is imperative from a public health perspective. Through its ability to rapidly target large audiences and specific substances, social media platforms, such as Instagram, represent the next frontier in minimizing usage and promoting community health.

About the Author

Kayla Rebentisch

37.

THE EFFECT OF HIGH-INTENSITY INTERVAL TRAINING (HIIT) ON MOTOR SEQUENCE LEARNING AND MEMORY

Paulina Vargas

Faculty Mentor: Geneviève Albouy (Health, Kinesiology, and Recreation, University of Utah)

Abstract

Previous research has demonstrated that physical exercise is beneficial for cognitive functioning. In this pilot study, we examined the specific effects of a

highintensity interval training (HIIT) exercise intervention on the learning of a movement sequence and its subsequent consolidation into long-term memory. Young (18-35 years old), apparently healthy adults performed a bimanual serial reaction time task following a bout of high intensity cycling (exercise intervention) or a period of rest (control). The exercise intervention consists of alternating intervals of high (90-95% max HR) and low (50-75% max HR) intensity exercise on a stationary bike (17 minutes in total). Approximately 24 hours after the first session, participants were retested on the motor learning task, affording the assessment of motor memory consolidation. We hypothesized that the exercise intervention, as compared to the control condition, would enhance the acquisition and consolidation of the motor sequence. Preliminary results indicate that the HIIT intervention did not modulate the initial learning of a motor sequence. However, and in contrast to our hypothesis, the HIIT intervention appeared to interfere with memory consolidation processes, as evidenced by smaller offline changes in reaction time in 3 out of 4 HIIT participants. Besides contributing to the narrow selection of existing literature on this specific intervention and motor learning and memory consolidation, the result of this study provides further foundation for future research that will examine the specific neural mechanisms underlying the effects of exercise on learning and memory.

About the Author

Paulina Vargas

38.

RESEARCH REFLECTION BY PAULINA VARGAS

Paulina Vargas

Faculty Mentors: Geneviève Albouy and Bradley Ross King (Health, Kinesiology, and Recreation, University of Utah)

I am profoundly touched by my summer research experience through SPUR. I have made lifelong friends that explored, and connected me to the culture and history of the state of Utah. My confidence and belonging within the scientific community grew tenfold thanks to my daily student mentor Anke Van Roy, and collaborative faculty mentors Dr. Bradley Ross King and Dr. Genevieve Albouy.

About the Author

Paulina Vargas

39.

EFFECTS OF DIFFERENT THICKNESS OF CARBON FIBER INSOLES ON FOOT MOTION USING X-RAYS

Megan Weaver; Kota Takahashi; and Amy Lenz

Faculty Mentor: Kota Takahashi (Health, Kinesiology, and Recreation, University of Utah)

Abstract

Carbon fiber has been incorporated into high performance running shoes and found to reduce energy expenditure during running because of carbon fiber's ability to act as an energy storage and release material. Outside of high-performance settings, the energy storage

and return capacity of carbon fiber has many other clinical applications, including assistance with locomotion and foot mechanical limitations in the elderly, those with limited walking abilities, and everyday use, as carbon fiber may reduce the work done by the foot during locomotion. However, whether the energy storage and return capability of carbon fiber plates results in changes to the foot mechanics is largely unknown, as due to data collection limitations, the in-shoe foot mechanics when ambulating with carbon fiber insole has not been studied. Therefore, the purpose of this study was to determine how different thicknesses of carbon fiber changed foot joint angles during a typical walking gait cycle. We hypothesized that increasing shoe stiffness via carbon fiber insoles would cause the: 1) toe joint to decrease dorsiflexion [toe will bend less] 2) arch to decrease plantarflexion [arch will be flatter] 3) ankle to increase peak dorsiflexion [foot will increase forward lean]. Through the use of a biplane fluoroscopy (i.e., x-ray) system, bone motion was captured inside of the shoe to analyze foot joint angles. One participant (N=1, F, 21) walked across the biplane fluoroscopy under four different conditions: barefoot, shoe, shoe with 1.6 mm carbon fiber, and shoe with 3.2 mm carbon fiber.

Analysis of the joint angles for the metatarsophalangeal joint (i.e., toe), midtarsal joint (i.e., arch), and ankle were conducted through use of the Kinovea software. Overall, the results found comparing baseline Shoe vs Carbon 3.2 mm supported the hypothesis: 1) toe decreased dorsiflexion by 16.28° 2) arch decreased plantarflexion by 2.3° 3) ankle increased dorsiflexion by 2.96°. These results indicate that, at toe off, increasing the CF plate thickness

resulted in a flatter foot at the toe and arch, but greater ankle dorsiflexion, potentially reducing work/energy requirements of foot through energy storage and release capability of the CF plate. The research utilized a novel state-of-the-art method via high-speed X-rays to analyze foot motion inside of the shoe during walking. This data is meaningful in helping further the development of footwear for people of all ages with the goal to reach new athletic records, walk with less energy requirement, and wear a more comfortable shoe.

Introduction

In recent years, carbon fiber (CF) has been slowly incorporated into many high-performance running shoes, e.g., Alphyflys, Vaporflys, and Carbon X. Many athletic shoe companies utilize the advantages of carbon fiber proven to reduce energy expenditure during running (Hoogkamer). Carbon fiber provides a stiff material property which acts as an energy storage and release material (Willwacher), helping to enhance the performance of athletes. Recent experiments comparing running shoes with standard versus CF insoles have found that the use of carbon fiber insoles significantly reduced the energy expenditure in elite athletes (Hoogkamer), and significantly increased the stride length, ground reaction force (GRF), and running speed in non-elite athletes (Reynolds). The improvement in performance metrics in both elite and non-elite runners indicates that CF insoles provide additional assistance and performance beyond that of standard running shoes, perhaps due to the energy storage and return property of CF.

Carbon fiber technology has shown to be an endurance performance enhancer, but limited research has been

studied on population other than athletes or non-running activities. The advantages of carbon fiber should not be limited to runners, instead it should be applied to daily activities such as walking. By studying the effects of carbon fiber on walking, it allows a wider population range to utilize carbon fiber including the elderly. Older adults struggle to maintain faster walking speeds as they age due to natural causes. Their bones become less dense, cartilage that lines the joints tends to thin, and ligaments/tendons become less elastic, making the body less active and harder to walk('Aging'). Future research could use carbon fiber to enable non-athletes/elderly walk faster with less energy required, allowing them to keep pace better.

While we understand that CF insoles can reduce energy expenditure (Hoogkamer), it is unclear whether energy expenditure results in changes to foot mechanics within the shoes during locomotion. Due to limitations such as marker misplacement on the shoes during data collections, the assumption that the foot does not move relative to the shoe during gait, and other data collection limitations, the current technology standards may result in error within the estimated foot kinematics. Marker placement, on average, can be 2 mm off, with a high of 7 mm off from the desired location on repeated trial experiments (Bruening). To reduce the errors associated with marker misplacement, and to understand the movement of the foot more clearly within the shoe with a CF insole, a biplane fluoroscopy machine can be utilized. Biplane fluoroscopy, a real-time 'X-Ray Movie,' allows the continuous capture of data instead of a standard one photo 'X-Ray,' allowing repeatable, and accurate video

data to be collected. The continuous capture of data can be utilized to eliminate the errors presented in marker placement and allow the bones inside of the shoes to be visualized, so that each trial can confidently choose the right segment to be tracked.

Our experiment investigated the effects of carbon fiber thickness on joint angles using biplane fluoroscopy. We hypothesized that increasing shoe stiffness via carbon fiber insoles would cause: 1) the toe joint to decrease dorsiflexion [toe will bend less] 2) the arch to decrease plantarflexion [arch will be flatter] 3) the ankle to increase peak dorsiflexion [foot will increase forward lean].

Methods

Our experiment examined different thicknesses of carbon fiber using the biplane fluoroscopy system. Carbon fiber thickness of 1.6 mm and 3.2 mm were cut to be inserted into the New Balance 880v13. These shoes provided the desired stiffness and comfort with their fresh foam cushion.

To evaluate the effectiveness of the carbon fiber, subjects were asked to walk across the X-ray machine under four different conditions: barefoot, shoe, shoe with 1.6 mm CF, and shoe with 3.2 mm CF. Each condition required three trials to help average inconsistencies formed during the 'break-in' period. 'Good' trials meant that the subject's entire foot was in the frame during their typical gait cycle.

The subject was asked to walk at a comfortable, self-selected speed where a metronome was used to maintain a consistent pace during the duration of the experiment. This ensured that the change in joint angles came solely from the carbon fiber rather than stride frequency. The

biplane fluoroscopy set to a sample rate of 100 Hz with a period of interest set right before heel leaves ground to right after toe off ensuring all three segments were in frame.

Kinovea, a 2D video annotation software, measured the joint angles. Each trial was uploaded onto the software where segment placement for the different joints were measured.

Joint angles of the metatarsophalangeal joint (i.e., toe), midtarsal joint (i.e., arch), and ankle were investigated, with joint angles defined as in Figure 1 and as follows. Metatarsophalangeal joint angle was centered at the dorsum of the 1st metatarsal head with endpoints at the hallux nail and dorsal surface of the base of the 4th metatarsal. Midtarsal joint angle was centered on the navicular bone with endpoints at the calcaneus on the Achilles tendon insertion and medial aspect of the 1st metatarsal. Lastly, the ankle was centered around the medial ankle with endpoints at the calcaneus on the Achilles tendon insertion and 2.5 inches above the medial ankle on the anterior tibia.

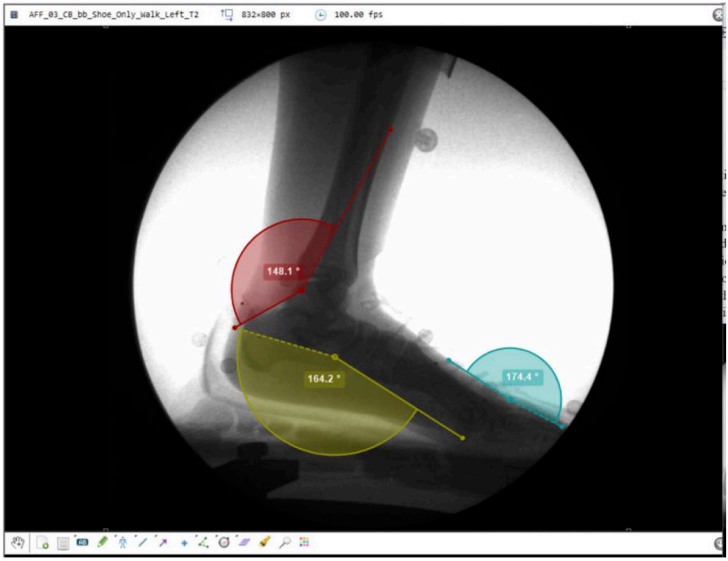

Figure 1: Placement of tracking landmarks and joint angles investigated during walking at self- selected speed with different CF insole thickness. Yellow: Metatarsophalangeal, Blue: Midtarsal, Red: Ankle

Measurements were placed to track the joint angle throughout their gait cycle to analyze each joint's maximum dorsiflexion/ plantarflexion. The metatarsophalangeal peak dorsiflexion angle was found right before toe-off with smaller angles indicating more dorsiflexion. Midtarsal peak plantarflexion occurs right after the heel leaves the ground. A greater angle formed between those joints means less plantarflexion and less of an arch. Ankle peak dorsiflexion occurs around the same time as the midtarsal joint, right after the heel leaves

the ground, where a larger angle form indicates increased dorsiflexion experienced (increased forward lean).

Each condition measured all three joint angles, and trials were averaged together to determine how the carbon fiber influenced the joint angles. All trials were compared to the baseline barefoot conditions, where difference can be compared though.

Results

Notably, all three joint angles found changes as the carbon fiber thickness increased (Table 1, Fig. 2-4).

Table 1: Average joint angle (Difference from barefoot conditions) before toe-off during walking with different CF insole thickness

	Toe	Arch	Ankle
Barefoot	149.07	168.2	148.57
Shoe	151.33 (-2.27)	164.3 (-3.9)	150.67 (2.02)
Shoe 1.6 mm	159.56 (-10.51)	165.4 (-2.8)	152.93 (4.28)
Shoe 3.2 mm	167.4 (-18.5)	166.6 (-1.6)	153.63 (4.98)

A positive value in parentheses indicates an increase in joint angle and negative value in parentheses indicates a decrease in joint angle relative to barefoot condition.

Each CF condition was compared to the barefoot condition, with the changes in the toe joint (Table 1, Fig. 2) during the shoe, 1.6 mm CF, and 3.2 mm CF to be -2.27°, -10.51°, and -18.5° respectively.

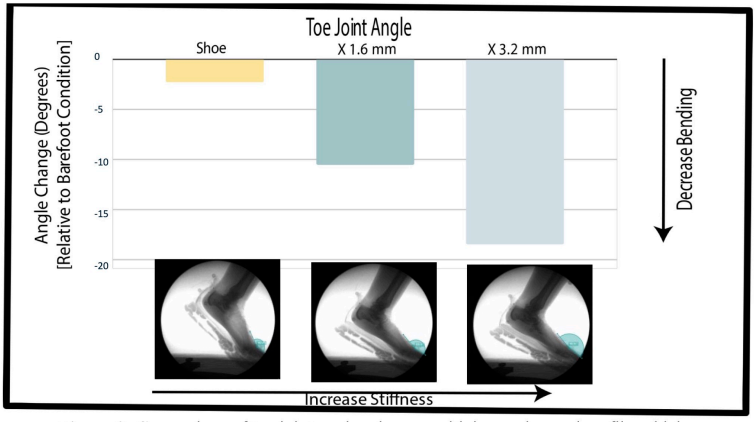

Figure 2: Comparison of toe joint angles changes with increasing carbon fiber thickness. Larger joint angle changes indicate decrease dorsiflexion or bending of the foot.

Following the same pattern of comparison, the midtarsal joint (Table 1, Fig 3) changed of – 3.9°, -2.8°, and -1.6 ° for the shoe, 1.6 mm CF, and 3.2 mm

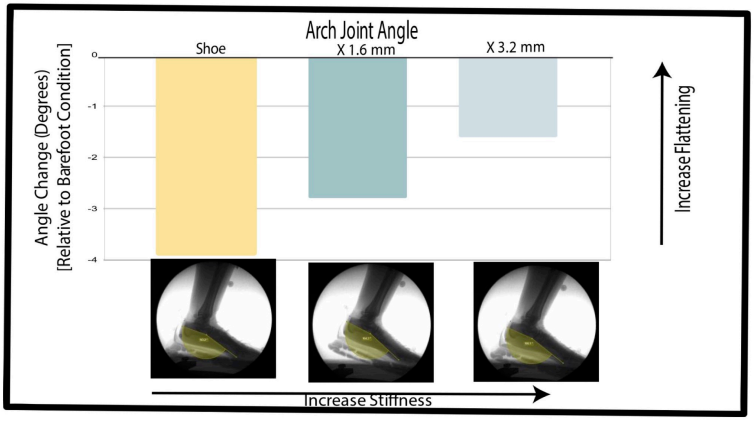

Figure 3: Arch joint angles change over different

conditions. Smaller joint angles changes indicate decreased plantarflexion or flattening of the foot.

At the ankle, the joint angle (Table 1, Fig. 4) changes, compared to barefoot condition, were 2.02°, 4.28°, and 4.98° for the shoes, 1.6 mm CF, and 3.2 mm CF condition.

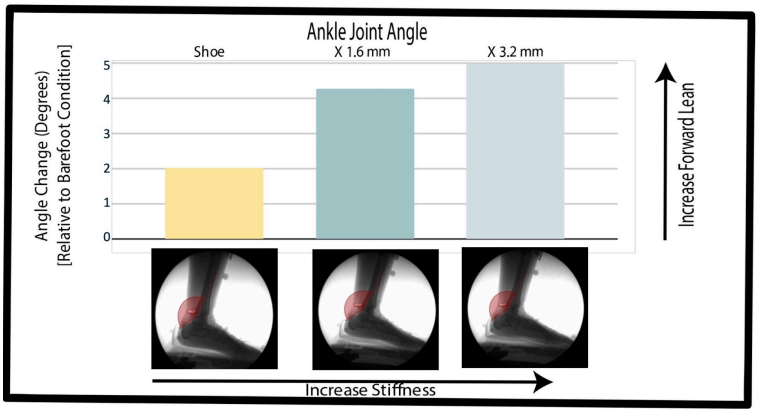

Figure 4: Change in ankle joint angles with different thickness of carbon fiber. Larger joint angle change indicates greater dorsiflexion at the ankle.

Discussion

The study aimed to analyze how foot motion varies under different carbon fiber thicknesses using biplane fluoroscopy. This study provided the ability to see the bones inside the shoe allowing better tracking placement and a new innovative way to analyze joint angles.

All hypotheses were supported during this experiment. Results supported the prediction that increasing carbon fiber thickness will cause the toe joint to bend less, arch to become flatter, and the ankle to increase forward lean.

Toe joint angle decreased bending by 16.28° when comparing baseline shoe condition (degrees changed relative to barefoot condition) to the baseline 3.2 mm CF.

The results matched previous studies where increasing the CF thickness led to a stiff toe joint which caused decreased bending while providing less energy expenditure (Hoogkamer). Our research supports the idea that increased carbon fiber stiffness results in reduced bending, and therefore may result in more efficient energy usage.

The foot arch was found to flatten by 2.3° when comparing baseline shoe and baseline 3.2 mm CF, supporting the hypothesis. The effects of carbon fiber on the midtarsal joint angle are unknown and limited studies have been conducted to analyze the impact. This research provides a baseline knowledge that stiff carbon fiber forces the arch to flatten trending towards the barefoot conditions.

Subjects walking during the barefoot condition experienced the flattest arch with the 3.2 mm CF having the second flattest arch. This indicates that the increased carbon fiber allows the arch to act more naturally as compared to shoes only conditions. The benefit of barefoot walking includes strengthening and tightening foot muscles, improving balance, better walking efficiency, and injury prevention. Since the carbon fiber allows the arch to act in a more natural barefoot way, it could provide all the benefits that barefoot walking offers.

The ankle joint angle was found to increase forward lean by 2.96° in the baseline 3.2 mm CF compared to baseline shoe condition, as carbon fiber thickness increased. Prior investigations on the effects of carbon fiber on the ankle found similar results (Ray). The study looked at different thicknesses of carbon fiber on walking speeds while measuring muscle activation. The stiff

carbon fiber insole caused increased ankle dorsiflexion (forward lean) by 10% between low and high conditions (Ray). They concluded that the extra insole benefitted the foot-ankle system at faster speeds with a metabolic reduction of 7.1% (Ray). Our results could help further knowledge as to how the joint angle of the ankle changes and why it causes an energy reduction.

Significance

Using the biplane fluoroscopy system allows a massive barrier in biomechanics to be overcome by enabling accurate tracking of the bones within the foot. This innovative study allows foot motion to be visualized so more accurate and precise results can be found. Our results matched previous studies while giving new insight into the arch motion over the different thicknesses of carbon fiber.

Utilizing the information found provides a vital tool to analyze how joint angles are modified through carbon fiber, giving insightful information on what is favorable for performance, injuries, and shoe design. Previous knowledge is that carbon fiber reduces endurance athletes' energy at faster speeds (Hoogkamer), and the information gained from our studies provides baseline knowledge as to how carbon fiber influences walking. Understanding how CF insoles change the foot mechanics may be useful in designing new innovative shoes for everyday use, with the goal would be to create shoes using carbon fiber that reduce energy at comfortable walking speeds for everyone. The elderly population could greatly benefit from these shoes where walking speeds that once were considered 'hard to maintain' could become comfortable and manageable. Future carbon fiber research

could also help prevent injuries where modification of the carbon fiber could be made to create a shoe design that is most applicable for injury prevention.

Research knowledge gained from our study provides the ability to study foot motion in a new, exciting way. Biplane fluoroscopy allows researchers the tools to analyze bone motion in ways never seen before, which gives the ability to create better shoes, enhance performance at all levels, and visually see how the foot changes to prevent injuries.

Acknowledgements: This work was supported by the University of Utah Office of Undergraduate Research. I want to thank my mentor, Dr. Takahashi, for allowing this innovative research to be conducted and for challenging my knowledge throughout this internship. In addition, I appreciate the advice and guidance I received from post-doc, Dr. Burnetts. Special thanks to the Orthopedics Department for the use of the biplane fluoroscopy, and Dr. Lenz and her grad students (Kassidy Knutson, Katina Cernucan, and Katee Anderson) for all their help!

Bibliography

"Aging: What to Expect." *Mayo Clinic*, 3 Nov. 2022, www.Mayoclinic.org/healthy-lifestyle/healthy- aging/in-depth/aging/art-20046070.

Bruening, Dustin A et al. "Analysis of a kinetic multi-segment foot model. Part I: Model repeatability and kinematic validity." *Gait & posture* vol. 35,4 (2012)

Hoogkamer, Wouter et al. "A Comparison of the Energetic Cost of Running in Marathon Racing Shoes." *Sports medicine (Auckland, N.Z.)* vol. 48,4 (2018)

Ray, Samuel F, and Kota Z Takahashi. "Gearing Up the Human Ankle-Foot System to Reduce Energy Cost of Fast Walking." *Scientific reports* vol. 10,1 8793. 29 May. 2020

Reynolds, Sophia R. Lauren M. Hastert, Nina M. Nodland, Ian R. Matthews, Brad W. Wilkins & Alexis D. Gidley (2023): The effect of carbon fiber plated shoes on submaximal running mechanics in non-elite runners, Footwear Science

Willwacher, Steffen et al. "Does specific footwear facilitate energy storage and return at the metatarsophalangeal joint in running?." *Journal of applied biomechanics* vol. 29,5 (2013): 583-92. doi:10.1123/jab.29.5.583

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40.

RESEARCH REFLECTION BY MEGAN WEAVER

Megan Weaver

Faculty Mentor: Kota Takahashi (Health, Kinesiology, and Recreation, University of Utah)

My experience at the University of Utah's summer undergraduate research program exceeded my greatest expectations. I learned endless knowledge on steps taken to conduct a research project, different graduate programs, and the NSF-GRP. The knowledge I gained during this program will carry with me for the rest of my life. After attending this program, I plan to attend graduate school to obtain my Ph.D. in biomedical engineering, focusing on biomechanics. I am highly interested in studying at the University of Utah under my

current mentor, Dr. Takahashi. He is very knowledgeable in the field, always excites me to learn more, and keeps me thinking of new exciting research methods. Using the biplane fluoroscopy, I was allowed to analyze joint angles innovatively, which had never been studied before. I am so thankful that I was selected to participate in this program, and I will cherish this opportunity for the rest of my life!

First and most importantly, I want to thank God for allowing me this opportunity. Thanks to Alex, Emily, Lillian, Mauro, Owen, Paulina, Riley, and Wyn for all the summer adventures! I am so lucky to meet such amazing people that will become lifelong friends.

About the Author

Megan Weaver

SECTION VII

SCHOOL OF MEDICINE

41.

THE EFFECTS OF PM2.5 EXPOSURE ON DEPRESSIVE SYMPTOMS AMONG MARGINALIZED IDENTITIES

Laila Batar and Amanda Bakian

Faculty Mentor: Amanda Bakian (Psychiatry, University of Utah)

Depression is a common mental disorder from which nearly one in five Americans suffer (CDC). Depression is also one of the most treatable mental health disorders and is treated by a wide variety of health care specialists

including primary care providers. Because many people suffering from depression are frequently under- or mis-diagnosed, a rapid, reliable, and valid screening tool is necessary. The nine-item Patient Health Questionnaire scale (PHQ-9) is a self-assessment completed at primary care clinics that screens and assesses the severity of depressive symptoms. Previous research has established the PHQ-9 diagnostic validity, showing consistency even when an individual is retested (Rahman et al.).

Additionally, previous research has found that life events, physical health, and environment can increase depressive symptoms. Particulate Matter (PM) is an air pollutant that results from many sources including gasoline combustion and wildfire smoke (EPA). PM2.5 is Particulate Matter less than 2.5 micrometers that, when inhaled, can induce adverse health effects including exacerbating symptoms of depression. We examined the correlation between monthly PM2.5 exposure levels and symptoms of depression as measured by the PHQ-9 from patients from the University of Utah and the Intermountain health care systems from 2015-2019. We also investigate how PHQ-9 scores vary by an individual's education, gender, and race/ethnicity. Based on our findings, the average PHQ-9 score for participants was 9 (out of 27), which corresponds with mild depression. We also found that individuals with marginalized identities had higher PHQ-9 scores compared to more socially privileged groups. Additionally, we found that monthly county PM2.5 concentrations showed a small positive correlation with PHQ-9 scores, however more research needs to be completed to investigate this relationship.

Bibliography

Centers for Disease Control and Prevention. (2023, June 15). National, state-level, and county-level prevalence estimates of adults aged ≥18 years self-reporting a lifetime diagnosis of Depression – United States, 2020. Centers for Disease Control and Prevention. https://www.cdc.gov/mmwr/volumes/72/wr/mm7224a1.htm?s_cid=mm7224a1_w

Environmental Protection Agency. (n.d.). EPA. https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. J Gen Intern Med. 2001 Sep;16(9):606-13. doi: 10.1046/j.1525-1497.2001.016009606.x. PMID: 11556941; PMCID: PMC1495268.

Rahman, M. A., Dhira, T. A., Sarker, A. R., & Mehareen, J. (n.d.). Validity and reliability of the Patient Health Questionnaire Scale (PHQ-9) among university students of Bangladesh. PLOS ONE. https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0269634

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42.

VISUALIZING MOVIE MAGIC: GRAPHING CHARACTER CONNECTIONS IN BELOVED FILMS

Porter Bischoff and George Vega Yon

Faculty Mentor: George Vega Yon (Internal Medicine, University of Utah)

Introduction

Network visualization tools are crucial in enabling researchers and professionals to comprehend complex data structures. Analyzing networks holds significant importance across various fields, including business (Jack, 2010), biology (Alm & Arkin, 2003), social sciences

(Garton et al., 1997), health sciences (Deri, 2005), and more. In the field of network visualization and analysis, the tool most commonly used is R. The most common R packages for network visualizations include `igraph` (Csardi & Nepusz, 2005), `sna` (Butts, 2023), and `ggraph' (Pedersen, 2022). Network visualization is both an art and a science and can be described as a visual aid to discover or analyze patterns in complex systems.

Graph visualization aspects

Network visualization involves choosing how to position nodes, also known as vertices, and edges, the connections, in the space, which in network science is called layout algorithms. Popular algorithms like Circle (Six & Tollis, 1999), DrL (Martin et al., 2007), Fruchterman-Reingold (Fruchterman & Reingold, 1991), Kamada-Kawai (Kamada & Kawai, 1989), and LGL (Adai et al., 2004) each have their strengths in displaying specific network structures. Graphing parameters, such as vertex size (Sharma & Chou, 2022; Zien et al., 1999), color (Ognyanova, n.d.), shape (Grapov & Newman, 2012), and edge width (Lin, 2018), play a crucial role in conveying information and highlighting patterns. By skillfully utilizing these components, network visualization becomes a powerful tool for understanding intricate relationships within the data. Additionally, considering the type of data is essential; egocentric data focuses on social network measurements surrounding a central individual (Marsden & Hollstein, 2023), while network analysis involves small networks with high clustering and short path lengths (Amaral et al., 2000; Bassett & Bullmore, 2006; Newman, 2001) and large networks with billions of nodes and edges (Blondel et al., 2008),

capturing connections within communities. Bipartite networks, which model relationships between two distinct sets of entities, find applications in various fields (Banerjee et al., 2017). Understanding these different data types and their applications provides valuable insights into the complexities of interconnected systems.

`Netplot` (Yon & Bischoff, 2023) was created as an alternative option for plotting network data to those mentioned above. It is built on the grid plotting system, the same used by the popular `ggplot2`. Like `ggplot2`, its focus is mainly on aesthetics, providing beautiful visualizations right out of the box. The plot below shows the differences between `netplot` and the most popular alternatives; which we presented during the 2023 SPUR program at the University of Utah:

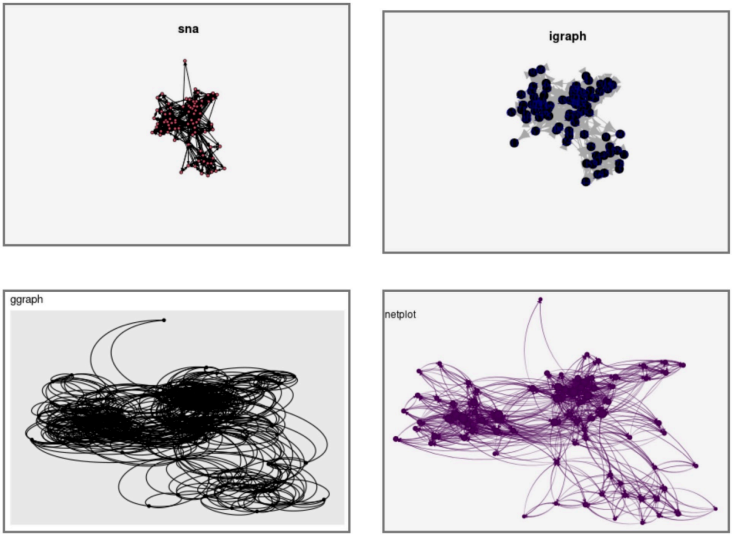

Figure 1

In what follows, I present a few examples of the

`netplot` R package using data from the `networkdata` R package (Schoch, 2021).

Movie walkthrough

The `networkdata` package features 979 datasets with 2,135 networks, giving us a great place to explore some of the strengths of the `netplot` package. Here, I will focus on a subset including ~775 networks of movie characters. Of the latter, I will use `netplot` to visualize five of my favorites.

First, we need to load in the packages, as taught by Schochastics in 2019:

```{r}
# install from drat
# install.packages("drat")
# drat::addRepo("schochastics")
# install.packages("networkdata")

# load packages
library(igraph)
library(networkdata)
library(netplot)

# explore what datasets we have
data(package = "networkdata")
```

Figure 2

Following that, we are ready to identify our movies. Here is our code showing how to do that with the `networkdata` package:

```{r}
xmen                <- movie_766
dumb_and_dumber     <- movie_226
indiana_jones       <- movie_367
mission_impossible  <- movie_483
star_wars           <- movie_656
```

Figure 3

The "xmen" dataset comes from the film titled "X-Men" (*X-Men (2000) – IMDb*, n.d.). The "dumb_and_dumber" dataset comes from the film titled "Dumb and Dumber" (*Dumb and Dumber (1994) – IMDb*, n.d.), while the "indiana_jones" dataset comes from the film titled "Indiana Jones and the Last Crusade" (*Indiana Jones and*

the Last Crusade (1989) – IMDb, n.d.). Lastly, the dataset titled "mission_impossible" is from the film titled "Mission: Impossible" (Palma, 1996), and the "star_wars" dataset comes from the film titled "Star Wars: Episode IV – A New Hope" (*Star Wars: Episode IV – A New Hope (1977) – IMDb*, n.d.)

X-Men

First, let's plot the "xmen" dataset:

```
```{r}
set.seed(33)
nplot(xmen,
      vertex.nsides              = 3,
      edge.color                 = ~ego(alpha = .75, col = "gray")
                                   + alter(alpha = .75, col = "gray"),
      vertex.color               ="dodgerblue4",
      vertex.label.show          = .5,
      vertex.size                = 6,
      edge.width                 = 3,
      vertex.label.fontsize      = 30,
      vertex.label.color         = "black",
      vertex.label.fontfamily    = "Courier")
```
```

Figure 4

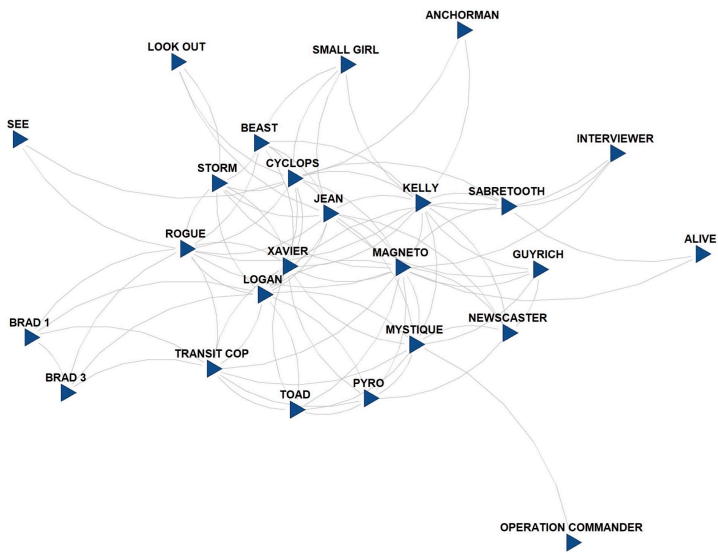

Figure 5

As we can see, Magneto, Logan, Rogue, and others are

very connected, while characters like Anchorman or See are not as connected. As for what `netplot` shows, the nodes are blue triangles, and the edges are gray.

Dumb and Dumber

We will next run an analysis on the "dumb_and_dumber" network data. Here is the code to create the plot:

```
```{r}
set.seed(33)
nplot(dumb_and_dumber,
      vertex.nsides              = 8,
      edge.color                 = ~ego(alpha = .75, col = "darkslategray3")
                                   + alter(alpha = .75, col = "gray"),
      vertex.color               ="deeppink",
      vertex.frame.color         = "darkorchid4",
      vertex.size                = 6,
      edge.width                 = 3,
      vertex.label.color         = "black",
      vertex.label.fontfamily    = "Courier",
      vertex.label.range         = c(1,30))
```
```

Figure 6

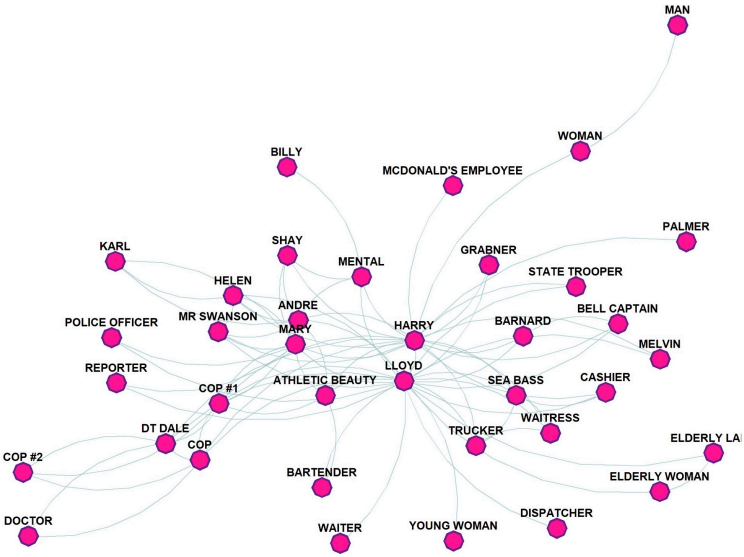

Figure 7

We manipulated the number of sides, vertex and vertex frame colors, and the color of the edges. This helps us see

that Harry and Lloyd are some of the most connected in the movie.

Indiana Jones

Let's take a look at the "Indiana_jones" dataset:

```{r}
set.seed(33)
nplot(indiana_jones,
      bg.col                    = "linen",
      vertex.nsides             = 5,
      vertex.label.show         = 1,
      edge.color                = ~ego(alpha = .75, col = "ivory4") + alter,
      vertex.color              ="darkred",
      vertex.frame.color        = "slategray",
      edge.width                = 3,
      edge.line.lty             = 2,
      edge.line.breaks          = 15,
      edge.curvature            = 1.57,
      vertex.label.color        = "black",
      vertex.label.fontfamily   = "Courier",
      vertex.label.range        = c(15,50))
```

Figure 8

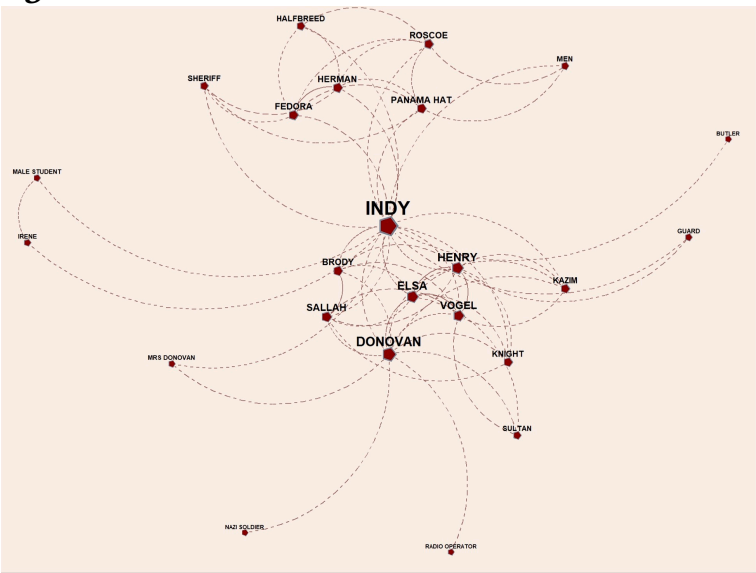

Figure 9

Here, we adjusted the size of the names according to how many connections they have while adding a background color, making the lines dotted, changing the

vertices to a red pentagon, and making the lines have a steeper curve.

Mission: Impossible

Our next step will be working with the "mission_impossible" dataset:

```{r}
set.seed(33)
nplot(mission_impossible,
      bg.col          = "lightslategray",
      edge.color      = "lightgoldenrod",
      edge.width      = 100,
      skip.vertex     = TRUE)
```

Figure 10

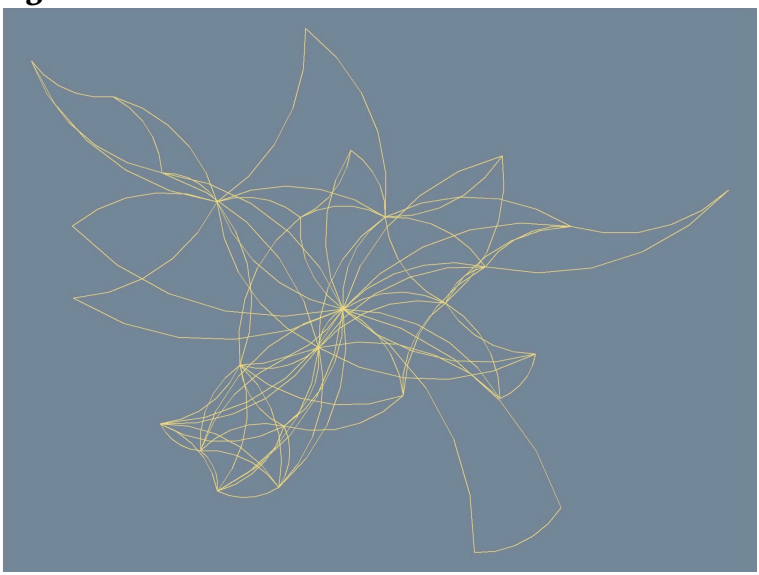

Figure 11

Here, we see that we can skip drawing vertices altogether to focus on the connections alone, which is a convenient approach when dealing with large networks.

Star Wars

Lastly, we will visualize the "star_wars" dataset. Our first step for this is to manually assign the roles the characters

had in the movie, whether they were “Rebels”, “Empire”, or part of the supporting cast:

```{r}
# Add new character groups
rebels     <- c("BEN", "BIGGS", "DODONNA", "GOLD LEADER", "HAN", "LEIA", "LUKE",
               "RED LEADER", "RED NINE", "RED TEN", "THREEPIO", "WEDGE",
               "WILLARD", "WINGMAN")

empire     <- c("CHIEF", "COMMANDER", "DEATH STAR INTERCOM VOICE", "FIRST
                OFFICER", "FIRST TROOPER", "GANTRY OFFICER", "IMPERIAL OFFICER",
                "MOTTI", "OFFICER", "SECOND OFFICER", "SECOND TROOPER", "TAGGE",
                "TARKIN", "TROOPER", "VADER")

outlaws    <- c("GREEDO", "JABBA")

supporting <- c("AUNT BERU", "BARTENDER", "BERU", "CAMIE", "CREATURE", "FIXER",
                "HUMAN", "INTERCOM VOICE", "MAN", "OWEN", "TECHNICIAN")
```

Figure 12

After, we add these attributes back to the original dataset we had:

```{r}
# Set alignment for each group
library(netplot)
alignment                                      <- star_wars$alignment
alignment[match(rebels, V(star_wars)$name)]    <- "rebel"
alignment[match(empire, V(star_wars)$name)]    <- "empire"
alignment[match(outlaws, V(star_wars)$name)]   <- "outlaw"
alignment[match(supporting, V(star_wars)$name)] <- "supporting"
V(star_wars)$alignment                         <- alignment

# Plot with alignment coloring
source("../../../../others/netplot-sunbelt2023/misc/color_nodes_function.R")
```

Figure 13

And lastly, we need to plot the data with a legend:

```{r}
set.seed(33)
nplot(star_wars,
      vertex.color = color_nodes(star_wars, "alignment",
                                 c("firebrick2", "goldenrod1",
                                   "dodgerblue3", "darkseagreen")),
      vertex.label.color = "black",
      vertex.label.fontfamily = "Courier",
      vertex.label.range = c(15,50))

# Add legend
legend("bottomright",
       legend = c("Rebels", "Empire", "Outlaws", "Supporting"),
       fill = c("dodgerblue3", "firebrick2", "goldenrod1", "darkseagreen"))
```

Figure 14

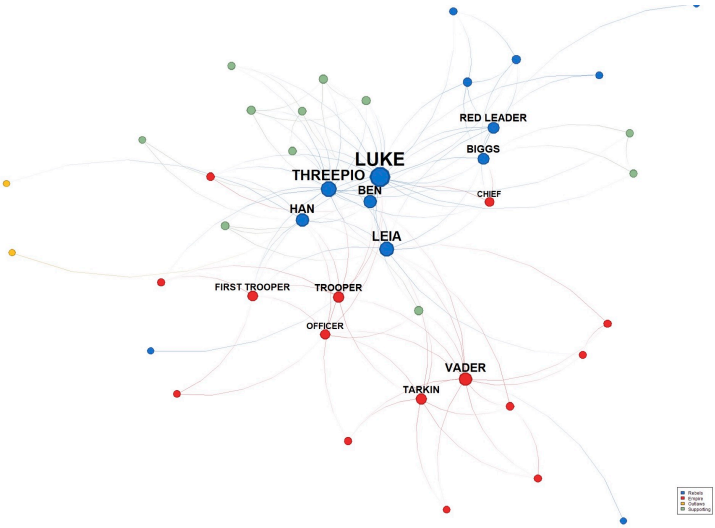

Figure 15

The vertices colored according to their alignment, the edges are on a gradient, and the most connected characters have a larger vertex and label.

Conclusion:

`netplot` is an innovative package that gives the user full customization over their network visualizations. It can be used on different types of network datasets, and this paper walks through how to use some of the customization aspects with examples from character interactions in movies.

Bibliography

Adai, A. T., Date, S. V., Wieland, S., & Marcotte, E. M. (2004). LGL: Creating a Map of Protein Function with an Algorithm for Visualizing Very Large Biological Networks. *Journal of Molecular Biology*, *340*(1), 179–190. https://doi.org/10.1016/j.jmb.2004.04.047

Alm, E., & Arkin, A. P. (2003). Biological networks.

Current Opinion in Structural Biology, *13*(2), 193–202. https://doi.org/10.1016/S0959-440X(03)00031-9

Amaral, L. A. N., Scala, A., Barthélémy, M., & Stanley, H. E. (2000). Classes of small-world networks. *Proceedings of the National Academy of Sciences*, *97*(21), 11149–11152. https://doi.org/10.1073/pnas.200327197

Banerjee, S., Jenamani, M., & Pratihar, D. K. (2017). Properties of a projected network of a bipartite network. *2017 International Conference on Communication and Signal Processing (ICCSP)*, 0143–0147. https://doi.org/10.1109/ICCSP.2017.8286734

Bassett, D. S., & Bullmore, E. (2006). Small-World Brain Networks. *The Neuroscientist*, *12*(6), 512–523. https://doi.org/10.1177/1073858406293182

Blondel, V. D., Guillaume, J.-L., Lambiotte, R., & Lefebvre, E. (2008). Fast unfolding of communities in large networks. *Journal of Statistical Mechanics: Theory and Experiment*, *2008*(10), P10008. https://doi.org/10.1088/1742- 5468/2008/10/P10008

Butts, C. T. (2023). *sna: Tools for Social Network Analysis*. https://CRAN.R-project.org/package=sna

Csardi, G., & Nepusz, T. (2005). The Igraph Software Package for Complex Network Research. *InterJournal*, *Complex Systems*, 1695.

Deri, C. (2005). Social networks and health service utilization. *Journal of Health Economics*, *24*(6), 1076–1107. https://doi.org/10.1016/j.jhealeco.2005.03.008

Dumb and Dumber (1994)—IMDb. (n.d.). Retrieved August 4, 2023, from https://www.imdb.com/title/tt0109686/?ref_=fn_al_tt_1

Fruchterman, T. M. J., & Reingold, E. M. (1991). Graph drawing by force-directed placement. *Software: Practice*

and Experience, *21*(11), 1129–1164. https://doi.org/10.1002/spe.4380211102

Garton, L., Haythornthwaite, C., & Wellman, B. (1997). Studying Online Social Networks. *Journal of Computer-Mediated Communication*, *3*(1), JCMC313. https://doi.org/10.1111/j.1083-6101.1997.tb00062.x

Grapov, D., & Newman, J. W. (2012). imDEV: A graphical user interface to R multivariate analysis tools in Microsoft Excel. *Bioinformatics*, *28*(17), 2288–2290. https://doi.org/10.1093/bioinformatics/bts439

Indiana Jones and the Last Crusade (1989)—IMDb. (n.d.). Retrieved August 4, 2023, from https://www.imdb.com/title/tt0097576/?ref_=nv_sr_srsg_2_tt_5_nm_1_q_indiana%2520jones%2520and%2520the%2520last%2520

Jack, S. L. (2010). Approaches to studying networks: Implications and outcomes. *Journal of Business Venturing*, *25*(1), 120–137. https://doi.org/10.1016/j.jbusvent.2008.10.010

Kamada, T., & Kawai, S. (1989). AN ALGORITHM FOR DRAWING GENERAL UNDIRECTED GRAPHS. *INFORMATION PROCESSING LETTERS*, *31*(1).

Lin, L. (2018). Quantifying and presenting overall evidence in network meta-analysis. *Statistics in Medicine*, *37*(28), 4114–4125. https://doi.org/10.1002/sim.7905

Marsden, P. V., & Hollstein, B. (2023). Advances and innovations in methods for collecting egocentric network data. *Social Science Research*, *109*, 102816. https://doi.org/10.1016/j.ssresearch.2022.102816

Martin, S., Brown, W. M., & Wylie, B. N. (2007). *Dr.L: Distributed Recursive (Graph) Layout* (dRl). Sandia National

Lab. (SNL-NM), Albuquerque, NM (United States). https://doi.org/10.11578/dc.20210416.20

Newman, M. E. J. (2001). Who is the best connected scientist? A study of scientific coauthorship networks. *Physical Review E*, *64*(1), 016132. https://doi.org/10.1103/PhysRevE.64.016132

Ognyanova, K. (n.d.). *Network visualization with R*.

Palma, B. D. (Director). (1996, May 22). *Mission: Impossible* [Action, Adventure, Thriller]. Paramount Pictures, Cruise/Wagner Productions.

Pedersen, T. L. (2022). *ggraph: An Implementation of Grammar of Graphics for Graphs and Networks*. https://CRAN.R- project.org/package=ggraph

Schoch, D. (2021). *networkdata: Repository of Network Datasets*. https://github.com/schochastics/networkdata Sharma, S., & Chou, J. (2022). Accelerate Incremental TSP Algorithms on Time Evolving Graphs with Partitioning

Methods. *Algorithms*, *15*(2), Article 2. https://doi.org/10.3390/a15020064

Six, J. M., & Tollis, I. G. (1999). A Framework for Circular Drawings of Networks. In J. Kratochvíyl (Ed.), *Graph Drawing* (pp. 107–116). Springer. https://doi.org/10.1007/3-540-46648-7_11

Star Wars: Episode IV – A New Hope (1977)—IMDb. (n.d.). Retrieved August 4, 2023, from https://www.imdb.com/title/tt0076759/?ref_=fn_al_tt_1

X-Men (2000)—IMDb. (n.d.). Retrieved August 4, 2023, from https://www.imdb.com/title/tt0120903/

Yon, G. V., & Bischoff, P. (2023). *netplot: Beautiful Graph Drawing*. https://github.com/USCCANA/netplot

Zien, J. Y., Schlag, M. D. F., & Chan, P. K. (1999). Multilevel spectral hypergraph partitioning with arbitrary

vertex sizes. *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, *18*(9), 1389–1399. https://doi.org/10.1109/43.784130

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43.

RESEARCH REFLECTION BY PORTER BISCHOFF

Porter Bischoff

Faculty Mentor: George Vega Yon (Internal Medicine, University of Utah)

I plan on pursuing an MD/PhD degree following my time at Utah Valley University. I want to be a pediatric endocrinologist that also studies some of the social science connections with blood sugar data and type 1 diabetics. My experience in SPUR has helped me learn how to code in a new way, gaining new skills, and it has also helped me become a better professional, giving me opportunities to present in a new field I didn't know much about before. It helped me become more confident in

myself and in my skills as a researcher, which will be a major advantage for my future goals.

About the Author

Porter Bischoff

44.

PLANOVALGUS DEFORMITIES AROSS VARYING BODY MASS INDEXES: TWO-DIMENSIONAL ANALYSIS FROM WBCT

Megan Carter and Amy Lenz

Faculty Mentor: Amy Lenz (Orthopaedics, University of Utah)

Introduction

Progressive collapsing foot deformity (PCFD) is a

complex foot and ankle condition characterized by peritalar subluxation [1]. Individuals with PCFD have unique and intricate morphologies with complex articular relationships, often causing pain, malalignment, and loss of function [2][3]. This foot deformity is more prevalent among high BMI patients, as their increased weight places higher stress on the medial longitudinal arch, causing it to flatten [4]. However, there is a scarcity of research investigating how BMI impacts the morphology of foot bones in PCFD patients. Typically, conditions of the foot and ankle, such as PCFD, are evaluated using x-rays and 2D measurements [5]. In this study, we aimed to observe several common 2D clinical measures of PCFD among groups of varying BMIs to check for statistical significance. We hypothesized that BMI would influence foot morphology and therefore, clinical measures would vary with BMI.

Methods

In this study, seventy-four patients (age: 44.4 ±18.4 years; 28 females, 98 feet) presenting with PCFD underwent WBCT scans (Planmed Verity; 0.4 x 0.4 x 0.4 mm voxels) with IRB approval. Using two-dimensional digitally reconstructed radiographs from DISIOR 2.1, comparisons were made across relevant clinical values determined from literature. Those chosen values were Talonavicular Coverage (TNC), Meary's Angle (MA, sagittal), Calcaneal Inclination Angle (CIA), and Hindfoot Moment Arm (HMA). The data was then tested for normality using MATLAB. Parametric values (MA and CIA) were analyzed using a one-way ANOVA while non-parametric values (HMA and RNC) were analyzed using a Kruskal-Wallis test.

Results

The only statistically different clinical measure was HMA between BMI groups 2 and 3 (Group 2 = 25-29.99 BMI, Group 3 = 30-34.99 BMI). Comparisons of all other values among the varying BMI groups yielded no statistically significant p-values.

Discussion

The results from the 2D radiographs demonstrated a lack of significance among common 2D clinical measures, suggesting that BMI may not be a major factor in the morphology of PCFD. This information is important in understanding the etiology and treatment of PCFD. However, to further investigate these findings, the results from the 2D analyses should be compared with 3D measurements of the bones and joints. The bones of the foot have complex and unique orientations that are difficult to assess with conventional 2D radiographs.

Superimposition of these bones is often misrepresented in the conversion of 3D surfaces (bones) to 2D images (radiographs), leading to inaccurate measurements [6]. However, the development of weightbearing computed tomography (WBCT) has allowed accurate 3D visualization, comprehensive analyses, and a new grading system to report degenerative progression throughout the ankle joints [7]. This technology is a vital tool in the future of this study. Future work will include segmenting the WBCT scans of these PCFD patients and performing 3D evaluations of their bones. This data can then be compared to the 2D results, offering further insight into the role of BMI in PCFD. This study highlights the complexity of the foot and ankle complex as well as the need to consider complicated morphological variations of

bones and joints when considering surgical intervention in PCFD.

Significance

These findings help surgeons to better understand the underlining mechanism of PCFD, while also suggesting that the selection of surgical procedures and treatments for PCFD may not need to be adapted for BMI. This information contributes to the growing database of information regarding PCFD, offering valuable insight that could be used to improve the diagnosis and treatment of pathological feet.

Acknowledgements: Funding was provided by the National Institutes of Health for the Medical Student Research Program. Additional funding was provided by the University of Utah for the Summer Program for Undergraduate Research

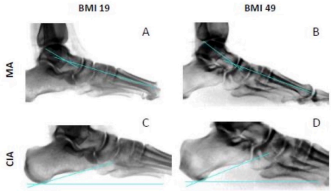

Figure 1

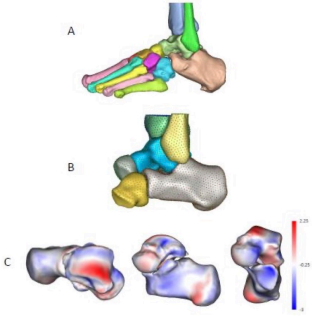

Figure 2

Figure 1: DISIOR digitally reconstructed radiographs. (A) Patient of BMI 19 with MA of -13.45°, (B) Patient of BMI 49 with MA of -16.46°, (C) Patient of BMI 19 with CIA of 16.05°, (D) Patient of BMI 49 with CIA of 21.72°

Figure 2: Future work with 3D modeling. (A) Segmented

bones from Mimics Innovative Suite, (B) Multi-domain shape modeling, (C) Joint measurement analysis performed on segmented bones

References

[1] Godoy-Santos AL, Schmidt EL, Chaparro What Are the Updates on Epidemiology of Progressive Collapsing Foot Deformity? Foot Ankle Clin. 2021 Sep;26(3):407-415. doi: 10.1016/j.fcl.2021.05.006. Epub 2021 Jun 27. PMID: 34332726.

[2] Toullec Adult flatfoot. Orthop Traumatol Surg Res. 2015 Feb;101(1 Suppl):S11-7. doi: 10.1016/j.otsr.2014.07.030. Epub 2015 Jan 13. PMID: 25595429.

[3] Flores DV, Mejía Gómez C, Fernández Hernando M, Davis MA, Pathria MN. Adult Acquired Flatfoot Deformity: Anatomy, Biomechanics, Staging, and Imaging Findings. Radiographics. 2019 Sep-Oct;39(5):1437-1460. doi: 1148/rg.2019190046. PMID: 31498747.

[4] Rosende-Bautista C, Munuera-Martínez PV, Seoane-Pillado T, Reina-Bueno M, Alonso- Tajes F, Pérez-García S, Domínguez-Maldonado G. Relationship of Body Mass Index and Footprint Morphology to the Actual Height of the Medial Longitudinal Arch of the Int J Environ Res Public Health. 2021 Sep 17;18(18):9815. doi: 10.3390/ijerph18189815. PMID: 34574735; PMCID: PMC8465021.

[5] Perry MD, Mont MA, Einhorn TA, Waller The validity of measurements made on standard foot orthoroentgenograms. Foot Ankle. 1992 Nov-Dec;13(9):502-7. doi: 10.1177/107110079201300902. PMID: 1478578.

[6] Richter M, de Cesar Netto C, Lintz F, Barg A, Burssens A, Ellis The Assessment of Ankle Osteoarthritis

with Weight-Bearing Computed Tomography. Foot Ankle Clin. 2022 Mar;27(1):13-36. doi: 10.1016/j.fcl.2021.11.001. Epub 2022 Jan 31. PMID: 35219362.

[7] Conti MS, Ellis SJ. Weight-bearing CT Scans in Foot and Ankle Surgery. J Am Acad Orthop Surg. 2020 Jul 15;28(14):e595-e603. doi: 10.5435/JAAOS-D-19-00700. PMID

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45.

RESEARCH REFLECTION BY MEGAN CARTER

Megan Carter

Faculty Mentor: Amy Lenz (Orthopaedics, University of Utah)

It has been a privilege to partake in the Summer Program for Undergraduate Research here at the University of Utah. This opportunity helped me form many valuable connections with knowledgeable, inspirational people who helped me grow. Additionally, I've had many new research experiences that have allowed me to apply information from the classroom to the real world. This research program also allowed me to explore several career possibilities and helped me gain clarity on

my path after college. I'm grateful for this experience and everyone that made it possible.

About the Author

Megan Carter

46.

INVESTIGATING DIFFERENCES IN BLACK VS OTHER RACE/ETHNIC GROUP VETERANS WHEN ATTAINING CONTROLLED BLOOD PRESSURE POST TREATMENT

Ariyanna Clark-Drew and April Mohanty

Faculty Mentor: April Mohanty (Internal Medicine, University of Utah)

Abstract

Hypertension is one of the primary risk factors contributing to cardiovascular diseases (CVD), including related premature morbidity and mortality. Risk factors for hypertension include lifestyle factors such as, high sodium diets, tobacco exposure, as well as genetics, and older age. The Veterans Health Administration (VHA) recently updated its hypertension diagnosis guidelines in 2017 which aligns with many of the updated recommendations of the American College of Cardiology/ American Heart Association. Hypertension in the VHA is now diagnosed at 130 mmHg systolic and 90 mmHg diastolic blood pressure. Diagnosing hypertension at a lower threshold not only increases the number of individuals with hypertension but, more importantly, helps to promote earlier initiation of antihypertensive treatment, delaying CVD. This study aims to identify clinically meaningful differences in the initial treatment and management of blood pressure in Blacks and Veterans of other race/ethnicities achieving controlled blood pressure after initial treatment. Identifying racial disparity gaps is essential to treating and managing hypertension to prevent related comorbidities. To accomplish this, we will conduct a retrospective cohort study, to evaluate blood pressure control one year following treatment initiation. The study will be conducted with nationwide data already collected by the VHA's electronic health record system. Participants in this study will include individuals over 18 years old, seeking care at the VHA, and having a hypertension diagnosis. We will identify if there is a clinically meaningful difference

in blood pressure control post-treatment initiation across race/ethnic groups. Our results show a blood pressure control prevalence range of 27.1% to 31.5% across different race/ethnic groups. Our analysis also detected a 4.4% difference in blood pressure control prevalence between NH-Black and NH-White Veterans. Our primary findings conclude that no clinically meaningful difference exists between controlled blood pressure in Black vs. other race/ethnic group Veterans. Our findings show that improving equity in blood pressure control according to the current guidelines by race/ethnicity is needed to prevent disparities of more severe CVD outcomes later in life (1). Strengths of the study include a large national patient sample and data on variables with validated definitions. The limitations presented in our study were limited generalizability due to the underrepresentation for example female gender presented in the study. Future directions for this study include longer follow-up periods for outcomes and include individuals who are not new initiators of hypertension medications.

References

1. Whelton PK, Carey RM, Aronow WS, Casey DE, Jr., Collins KJ, Dennison Himmelfarb C, DePalma SM, Gidding S, Jamerson KA, Jones DW, et al. 2017

ACC/AHA/AAPA/ABC/ACPM/AGS/APHA/ASH/ASPC/NMA/PCNA Guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: A report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. J Am Coll Cardiol. 2018;71:e127-e248

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47.

RESEARCH REFLECTION BY ARIYANNA CLARK-DREW

Ariyanna Clark-Drew

Faculty Mentor: April Mohanty (Internal Medicine, University of Utah)

My experience with SPUR [Summer Program of Undergraduate Research] was very impactful and has helped shape my future direction for my career path. Throughout my time in the program, I experienced all stages of research; literature reviews, data extraction plans, and poster presentations of our findings. This program also allowed me to grow as a student by instilling me with new skills and refining the skills I already possessed. The impact this experience has had on my future career goals is significant; it has shown me that

I enjoy research and has led me to consider a career in academia. My education has also been significantly impacted because the program has given me a wealth of knowledge I can continue using in my undergraduate career. I am forever grateful for SPUR and have enjoyed my time in the program.

About the Author

Ariyanna Clark-Drew

48.

LONG TERM PM2.5 EXPOSURE AND VIOLENT SUICIDE

Andrew Clothier; Amanda Bakian; Mathilda Scott; Dirga Lamichhane; Austin Clark; and Danli Chen

Faculty Mentor: Amanda Bakian (Psychiatry, University of Utah)

Utah has had a consistently higher suicide rate than the national average. There are many risk factors to an individual's suicide risk including personal, relationship, community, and societal risk factors (CDC). Recent studies have examined the potential link of environmental pollutant exposures. Previous research has also examined the role of air pollution in suicide. Utah is a state known

for its poor air quality due to its geography, its largely urban population, and its industry. One of the primary pollutants of concern is PM2.5 due to its ability to bypass filtration in the lungs. This study seeks to examine the gap in the current literature surrounding how PM2.5 affects the incidence ratio of violent to nonviolent suicide. In other words, we seek to investigate how monthly exposures to PM2.5 might contribute to a higher rate violent suicides as compared to non-violent suicides. Previous studies have found a correlation with non-violent attempt methods and low PM2.5 (Miyazaki et al.). We collected suicide data recorded by the office of the medical examiner in Utah from 2013 to 2019. We collected PM2.5 concentrations from the Environmental Protection Agency's Downscaler Model and aggregated the data to monthly concentrations for each County in Utah. We found a small correlation between county-level incidence of violent suicide and average monthly county PM2.5 concentrations ($p=0.03$). There was also a small correlation between county-level incidence of nonviolent suicide and average monthly county PM2.5 concentrations ($p=0.02$). We found no statistically significant correlation between PM2.5 and the ratio of violent to non-violent suicide. There were significant limitations in the study design due to low numbers of suicides in large portions of Utah and the aggregation of PM2.5 data over large geographies. We recommend that future studies be done at finer spatial and temporal scales.

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49.

DEVELOPING AN EFFECTIVE DRUG-SCREENING ASSAY FOR TREATING CARDIAC ENERGETIC DEFICIENCIES

Ashley Cluff; Dipayan Chaudhuri; Sandra Lee; and Enrique Balderas

Faculty Mentor: Dipayan Chaudhuri (Internal Medicine, University of Utah)

The mitochondrial calcium uniporter (MCU) may help compensate for energetic deficiencies characteristic of some heart diseases, via a mechanism dependent on

breaking an interaction between its N-terminal domain (NTD) and complex I of the electron transport chain [1]. Drugs that inhibit this interaction may offer new treatments for such heart diseases, but to identify such compounds we need a screening assay for MCU NTD interactions. The MCU NTDs also mediate dimerization of the MCU. To quantify the MCU NTD interactions, we used fluorescence resonance energy transfer (FRET), the process through which energy is transferred from a donor to an acceptor fluorescent protein, in this case mCerulean and mVenus respectively (figure 1). This process is highly distance dependent as the FRET efficiency is inversely proportional to the sixth power of the separation between the fluorescent proteins.

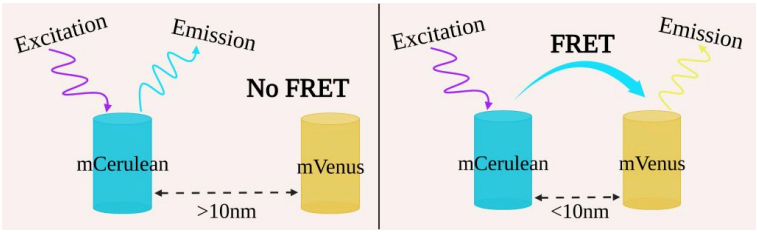

Figure 1: Process of FRET

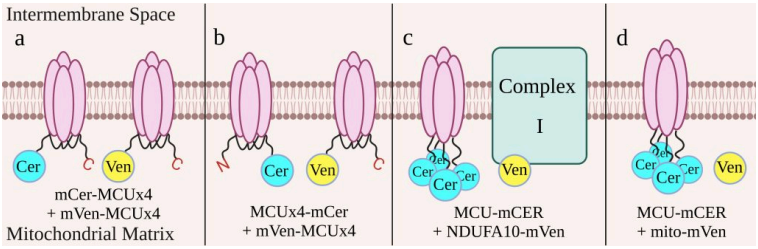

Figure 2: Cell Constructs

We constructed four cell lines to determine which construct would be the most effective indicator of drug

effectiveness (figure 2). The first two cell lines have the MCU subunits linked to one another. One cell line has mCerulean and mVenus, both on the N-terminus of the linked MCU (figure 2a), while the other has mCerulean on the C-terminus and mVenus on the N-terminus (figure 2b). These cell lines will take advantage of the dimerization of MCU to produce FRET. The last two cell lines have each of the four MCU subunits tagged with mCerulean. One cell line also has NDUFA10, a subunit of complex I, tagged with mVenus (figure 2c) and uses the interaction between complex I and the MCU to produce FRET. The other has mVenus free in the mitochondrial matrix (figure 2d) and is used as a control to determine background levels of FRET. Each cell construct has a bidirectional promoter that ensures both elements of the construct are expressed at similar levels. This promoter is activated by doxycycline, so we are able to control when the constructs are expressed in the cells in order to minimize the risk that the constructs may harm the cell. To prevent immature fluorescent proteins, which would lead to an underestimate of the FRET efficiency, we treated the cell lines with cycloheximide, a protein synthesis inhibitor, before measuring fluorescence with flow cytometry.

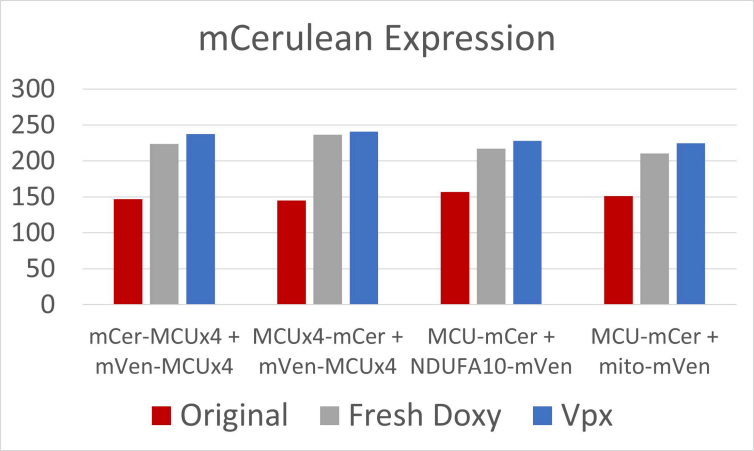

Figure 3: mCerulean Expression

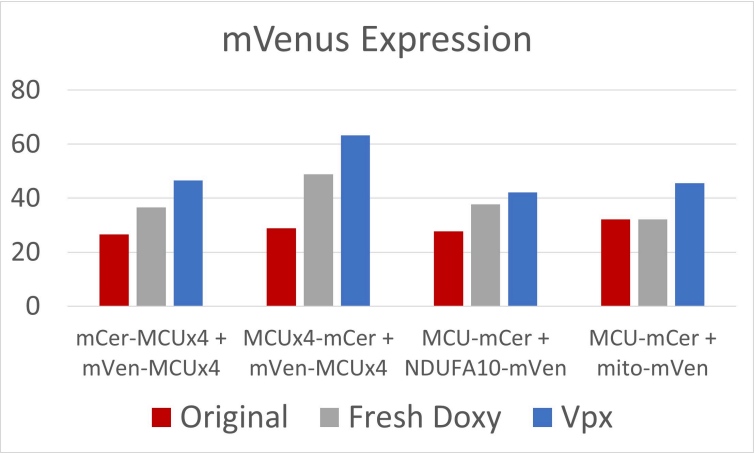

Figure 4: mVenus Expression

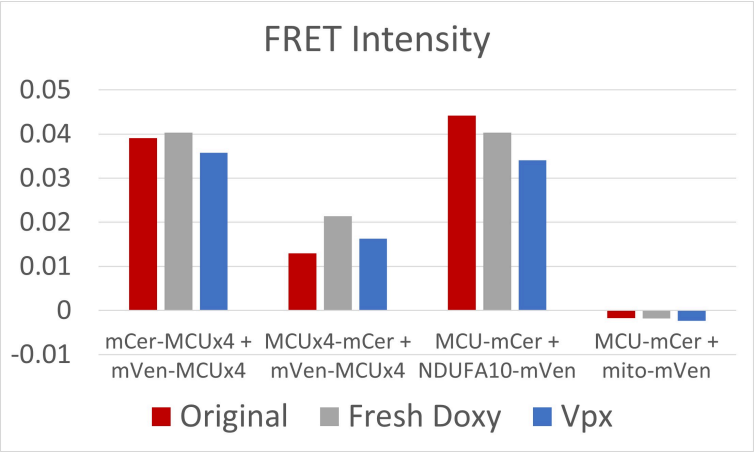

Figure 5: FRET Intensity

Due to low initial MCU expression in the cells, we used fresh doxycycline and transfected the cells with Vpx, a viral protein that has allowed for the transcription of long coding mRNA in similar cells [2]. Both were effective at increasing MCU expression (figures 3 and 4). The cell constructs with mCerulean and mVenus on the N-terminals, and mCerulean-tagged MCU with mVenus-tagged NDUFA10, exhibited the most FRET because of the closer proximity of the fluorescent proteins due to the NTD interactions involved in both dimerization of the MCU and MCU interactions with complex I (figure 5). These constructs will be used to quantify the efficacy of drugs in breaking the interaction between complex I and the MCU. Additionally, we are creating constructs where mCerulean and mVenus are linked to one another through varying numbers of amino acids. We would expect the constructs with the shortest linkers to have the most FRET. These standards can be used to calculate the FRET efficiency, as opposed to the FRET intensity found simply by measuring fluorescence. FRET efficiency

is the proportion of donor fluorescent proteins which have transferred their excitation energy to the acceptor fluorescent proteins. The FRET efficiency value is important for comparing FRET across different instruments and throughout time due to instrument wear.

References

[1] Balderas, , Eberhardt, D.R., Lee, S. et al. Mitochondrial calcium uniporter stabilization preserves energetic homeostasis during Complex I impairment. Nat Commun 13, 2769 (2022). https://doi.org/10.1038/s41467-022-30236-4

[2] Yurkovetskiy, , Guney, M.H., Kim, K. et al. Primate immunodeficiency virus proteins Vpx and Vpr counteract transcriptional repression of proviruses by the HUSH complex. Nat Microbiol 3, 1354–1361 (2018). https://doi.org/10.1038/s41564-018-0256-x

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50.

EXPLORING THE RELATIONSHIP OF INSTRUCTOR-LED SCAFFOLDING, SCIENTIFIC OBSERVATION, AND SOCIAL GROUP DYNAMICS IN GEOSCIENCE FIELD SETTINGS

Ryan De Los Santos; Kelly Baron; Adrienne Smith; Andrea Baxter; Chelsea Allen; and Steven Carlson

Faculty Mentor: Kelly Baron (Medicine, University of Utah)

Background

Individuals tend to exhibit a higher risk propensity in the afternoon compared to the morning and evening. In recent years previous studies have shown that individuals with later bedtime tend to engage in risky behavior and that people are more risk prone in the afternoon. However we do not know the difference in risk taking behavior between morning and night. The goal of this study was to find out is risk taking behavior is higher in the morning vs the evening, and are participants with shorter sleep duration and later chronotype more prone to risk taking.

Methods

we enrolled patients aged 18-65 and a BMI between 25-39.9. In the procedure we administered a battery of cognitive tests, including the Balloon Analogue Risk Task (BART), a measure of risk taking behavior. We had two testing sessions separated by approximately 14 days, once morning around eleven a.m, or evening around seven p.m, administered in a counterbalanced order. Between the sessions we measured objective sleep duration using an actigraph.

Results

The study participants included 73 participants (32 women 41 men) with a mean age of (35). Overall we did not find any difference in morning and evening BART performance. Sleep duration and timing were also not related to BART performance. However we did find a difference in time of day based on the order the test was administered. Participants had more risk taking behavior

on the evening BART if they completed the second test in the evening. Participants had similar performance on the morning BART regardless of order.

Discussion

Overall, these results indicate that there is increased risky behavior in the evening, but only with more experience in the BART task. These results in part support that people are more prone to risk taking behavior in the evening.

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51.

RESEARCH REFLECTION BY RYAN DE LOS SANTOS

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Faculty Mentor: Kelly Baron (Medicine, University of Utah)

Of all of my college experiences thus far, My SPUR [Summer Program for Undergraduate Research] experience is one of the most unique ones I have had. During my time under Dr.Baron I assisted her with a few of her current studies. In one of which, we ran cognitive, taste and other tests on participants! In terms of impact on my education this experience definitely opened my eyes to different graduate degrees. One in particular being a masters in public health.

About the Author

Ryan De Los Santos

52.

THE AUTISM-ASSOCIATED GENE KIRREL3 IN DEVELOPED SYNAPSE MAINTENANCE

Olivia Raines; Megan Williams; and Omar Shennib

Faculty Mentor: Megan Williams (Neurobiology, University of Utah)

Kirrel3 is a synaptic cell adhesion protein necessary for the formation of a specific type of synapse in the hippocampus, a brain region that is important for learning and memory. During development, Kirrel3 is expressed in excitatory dentate gyrus (DG) neurons and inhibitory GABAergic neurons and binds trans-cellularly with itself.

This synapse contributes to a neuronal circuit consisting of DG, GABA, and CA3 neurons in the hippocampus (figure 1). Part of this circuitry is a huge synapse between the DG and CA3 called Mossy Fiber Bouton. In the presence of Kirrel3, the mossy fiber bouton extends filopodia to synapse with GABAergic neurons creating a feedforward inhibition loop that allows the regulation of inhibition and excitation communication to the CA3 neurons of the hippocampus. When excited, the filopodia activates the GABAergic neuron to then inhibit the CA3 neuron (figure 2). Previously the Megan William's lab found that germline Kirrel3 knock-out mice are missing these specific synapses in the hippocampus. These mice also have an increase in neuronal activity in the hippocampus most likely due to the loss of synapses.

Interestingly, mice expressing Kirrel3 during development continue to express it after a synapse is formed. However, it is unknown if Kirrel3 is needed to hold the synapse together after development. I will test this by using an AAV virus containing a Cre recombinase protein to knock out Kirrel3 in adult neurons after synapse formation is complete. After injection, I will use confocal microscopy to image, analyze, and compare the morphology of these synapses. This investigation of Kirrel3 in adult mice will bring us closer to understanding the mechanical role of Kirrel3 in synaptic formation and neuronal connectivity. Moreover, understanding the function of Kirrel3 may be clinically beneficial as variations in Kirrel3 are associated with neurodevelopmental disorders like autism and learning disabilities.

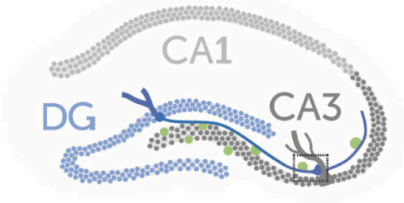

Figure 1. The Hippocampus DG-CA3_GABA circuit. The DG neuron projects a long axon that synapses and excites CA3 neurons of the hippocampus. GABAergic neurons, shown in green, receive input from filopodia and inhibit the CA.

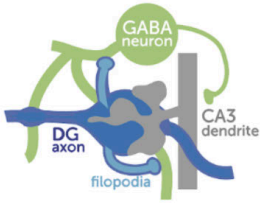

Figure 2. Mossy fiber bouton (MFB). The MFB forms a large synapse between the dentate gyrus (DG) and CA3 region of the hippocampus and a GABAergic neuron. The mossy fiber extends filopodia that synapses onto a GABAergic neuron.

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53.

STRUCTURAL HOMOLOGY OF EPITOPE BINDING MIMICRY IN THE ONSET OF TYPE 1 DIABETES MELLITUS

Ryan Gardner and Jullio Facelli

Faculty Mentor: Julio Facelli (Biomedical Informatics, University of Utah)

Abstract

Molecular mimicry occurs when foreign and self-peptides contain similar epitopes that may lead to autoimmune responses in susceptible individuals.

Identifying molecular mimics and studying their properties is key to understanding the onset of autoimmune diseases such as type 1 diabetes mellitus (T1DM). Previous work identified 61 pairs of infectious epitopes (EINF) and T1DM epitopes (ET1D) that show sequence homology. 35 of these pairs were conserved among different pathogenic species; however, the previous study only assessed sequence homology and did not consider structural homology. The purpose of this work was to evaluate the structures and electrostatic potentials of these 35 pairs of epitopes. First, we calculated the root mean square deviation (RMSD) between predicted structures and electrostatics of each pair of epitopes. Structures were predicted using the AlphaFold and I-TASSER software programs. Overall, we found that successful structurally matched EINF and ET1D pairs yielded RMSD of < 1.5 Å, of which AlphaFold found a 76.5% success rate and I-TASSER, 82.35%. Of the pairs that could not be structurally matched (< 3 residues aligned), AlphaFold found four unique pairs, and I-TASSER found two unique pairs. Therefore, both AlphaFold and I-TASSER agreed on four EINF/ET1D structurally unmatched pairs. Despite structural differences, these four EINF/ET1D pairs show similar electrostatic distributions, indicating that they may still bind to the same protein targets (MHC molecules) for T1DM. This shows that finding epitope pairs using sequence homology, a less computationally demanding approach, leads to very good candidates for further study.

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54.

RESEARCH REFLECTION BY RYAN GARDNER

Ryan Gardner

Faculty Mentors: Julio Facelli, Ramkiran Gouripeddi, and Sejal Mistry (Biomedical Informatics, University of Utah)

In the Fall of 2021, I was enrolled in a computational physics class at Weber State University. It was here that I learned what the "protein folding problem" was for the first time. My project ended up being a ball-and-stick representation of a generic protein situated on a two-dimensional lattice that moved in a clunky way. I was nevertheless captivated by the problem and began spending my personal time reading and writing papers on the subject. This was the one of the first problems that I became fascinated with that has yet to find a solution.

Having spent the last few years buried in textbooks and pounding out problem sets, I wanted to gain some actual research experience. As a senior majoring in physics, I knew I'd be passing up a great opportunity if I didn't at least try my hand. I knew the opportunity would be one that would likely inform whether I'd want to pursue a graduate degree, a notion that has been floating around in my head for some time.

So, I began my search online and found Dr. Julio Facelli in the biomedical informatics department whose interests culminated in everything that I enjoyed in the academic arena. As I dug further, I learned that protein folding was an important part of Dr. Facelli's research. I was excited by the prospect of being able to use AlphaFold, the leading protein structure prediction software, and being able to learn more about protein folding. I was especially excited to learn that there was a clinical premise to his work. Having spent a decade working in a clinical setting, I found his research to be important.

Dr. Facelli welcomed me with open arms and introduced me to two other mentors: Dr. Ramkiran Gouripeddi, MD, PhD, and Dr. Sejal Mistry, MD, PhD. They gave me the tools I needed to succeed and the confidence that I could contribute in my own way. I had the opportunity to work on research design and methodologies, developing a manuscript, and present our findings at the Summer Undergraduate Research Symposium. It was a steep learning curve, especially coming from a world of physics and entering a world of biochemistry, immunology, and bioinformatics, but after a few weeks of hard study and work, the fog slowly started to lift, and I was able to start piecing things together. This is not to say spending ten

weeks on a problem is sufficient for a working, professional knowledge, but it does provide a jumpstart for an aspiring researcher.

I have met many people who were inspiring, including my mentors, my research partner, Joshua Wilkins, and several people in the bioinformatics department who spent personal time talking with me about their experiences and offering advice on how to pursue a career in academia. Building these relationships is perhaps the most valuable thing I gained this summer, something that can't be obtained through pounding out problem sets and reading textbooks.

Having completed the summer of research, I will be confidently applying to graduate school to study medical physics. Cancer is the great problem of our time, and I hope to contribute to the wonderful science done all around the world to address that problem. I am excited to take what I've learned from Dr. Facelli and his team and port those skills into a graduate program that will train me to be the best medical physicist I can be.

About the Author

Ryan Gardner

55.

LOSS OF SOLUBLE (PRO)RENIN RECEPTOR ATTENUATES KIDNEY INJURY AND FIBROSIS IN UNILATERAL URETERAL OBSTRUCTION

Dhruvan Gopinath and Nirupama Ramkumar

Faculty Mentor: Nirupama Ramkumar (Internal Medicine, University of Utah)

Abstract

The prorenin receptor (PRR) is a recently discovered

component of the Renin-Angiotensin-Aldosterone System (RAAS) that is involved in the maintenance of kidney function and blood pressure. Cleavage of the extracellular domain of the (pro)renin receptor yields a soluble fragment termed soluble PRR (sPRR). We previously demonstrated that loss of sPRR attenuates angiotensin-II-induced hypertension and kidney injury. To further characterize the role of sPRR in chronic kidney disease and fibrosis, we used an experimental model known as unilateral ureteral obstruction (UUO) to induce kidney disease in male wild type and mutant mice with loss of sPRR. UUO surgery was performed, and mice were followed for 3-day or 7-day time periods. Markers of kidney injury, fibrosis, and kidney inflammation were examined by qRT-PCR and kidney fibrosis by Picro Sirius Red staining. Our results showed that 1) UUO mice had markedly increased expression of markers of kidney injury, inflammation and fibrosis compared to Sham at 3 and 7 days following UUO; 2) loss of sPRR attenuated gene expression of fibronectin and Monocyte Chemoattractant Protein-I (MCP-I) with a trend toward lower expression of Kidney Injury Molecule-1 (KIM-1), Collagen-I (COL-I) and Vascular Cell Adhesion Molecule-I (VCAM-I), compared to WT UUO mice; 3) no differences were observed in expression of Tumor Necrosis Factor (TNF-α), Transforming Growth Factor Beta (TGF-β), and Interleukin-6 (IL6) between WT and mutant mice that underwent UUO; 4) At 7 days following UUO, all markers were similar between WT and mutant UUO mice. Additionally, Sirius Red staining showed reduced fibrosis in mutant UUO mice compared to WT UUO mice. Thus, loss of sPRR had acute kidney protective effects in UUO

at 3 days but not 7 days. Further studies are needed to examine the effect of sPRR in kidney disease and fibrosis.

Keywords: soluble (pro)renin receptor, kidney injury, fibrosis, chronic kidney disease

Introduction

Chronic kidney disease (CKD) has emerged as a leading cause of death in the 21st century (Kovesdy, 2022). Estimates show that as many as 843 million individuals are affected by CKD stages 1-5 worldwide. This is largely in part due to an increased prevalence of risk factors such as obesity, diabetes, and hypertension. Additionally, moderate to severe CKD patients have greatly increased mortality, primarily due to cardiovascular disease (CVD) (Jankowski et al., 2021). Between 40-50% of Stage 4 and End Stage Renal Disease (ESRD) patients result in cardiovascular mortality, thus, improved treatment of CKD can reduce the prevalence of CVD. C KD is defined as the presence of kidney damage or loss of estimated glomerular filtrate rate (GFR) of <60 mL/min per 1.73 m2 for more than three months (Levey & Coresh, 2012). It is commonly regarded to be a silent killer; the vast majority of patients remain asymptomatic until CKD is severely progressed. Thus, CKD is diagnosed solely through routine screenings (blood tests, or urinary dipstick)

(Webster et al., 2017). While there is no cure for CKD, interventions include treatment of risk factors such as diabetes, hypertension, irregular solute balance, irregular hormone balance, and high cholesterol. Further, dietary or lifestyle changes are often helpful in improving kidney longevity. Unfortunately, these treatments do not provide a definitive solution to CKD, thus, further research is needed to identify potential targets for the detection, and treatment of chronic kidney disease.

The renin-angiotensin-aldosterone pathway (RAAS) is an important mediator of arterial blood pressure (BP), sodium balance, and extracellular volume in the body (Fig. 1) (Patel et al., 2017). In this system, Angiotensinogen is secreted by the liver and is converted by renin to Angiotensin I. Angiotensin I is then converted by Angiotensin-Converting Enzyme (ACE) to Angiotensin II (Ang-II). Ang-II is the ultimate effector of the RAAS pathway. Over or under-regulation of Ang-II can alter blood pressure, sodium and fluid balance in the body. Further, drugs targeting the RAAS are the mainstay of treatment of hypertension and CKD (Pohl et al., 2005).

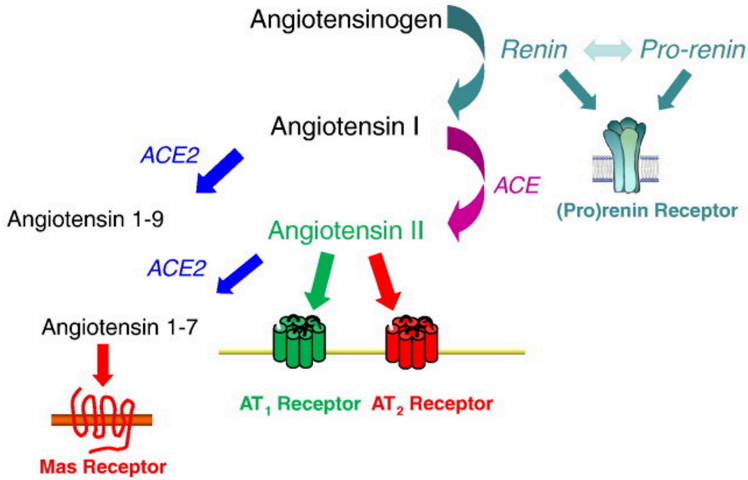

Fig. 1. Schematic of the renin-angiotensin-aldosterone system (RAAS) pathway (Crowley SD, Coffman TM. Expr Res, 2012)

The pro renin receptor (PRR) is a recently discovered component of the renin-angiotensin-aldosterone system (RAAS) (Fig. 2) (Danser & Deinum, 2005; Nguyen & Muller, 2010). PRR binds to prorenin, causing the non-proteolytic activation of prorenin. This enables it to cleave angiotensinogen. Renin, when bound to the PRR, has a four-fold greater catalytic efficiency when cleaving angiotensinogen. These both lead to increased angiotensin II (Ang II) synthesis (Nguyen et al., 2002). In addition, prorenin or renin when bound to the PRR independent of Ang-II synthesis can lead to activation of intracellular signaling pathways such as extracellular signal-regulated kinase (ERK1/

2) and p38 mitogen-activated protein kinase (p38 MAPK) (Nguyen et al., 2002; Feldt et al., 2008; Saris et al., 2006). Both of which are related to cell growth, and proliferation, as well as cell stress response and death.

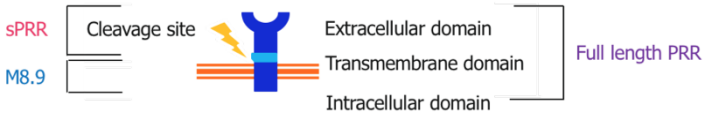

Fig. 2. Structure of the (pro)renin receptor

The role of PRR varies depending on whether it is in its intact or cleaved forms (Nguyen et al., 2002). The PRR consists of a smaller intracellular domain, a transmembrane domain, and a much larger extracellular domain. The large extracellular component can be cleaved close to the membrane, yielding the soluble (pro)renin receptor (sPRR). sPRR can be circulated throughout the blood plasma and urine allowing for RAAS dependent and independent effects. While PRR has been fairly well described since its discovery, sPRR is much less documented (Danser & Deinum, 2005; Nguyen et al., 2010; Ichihara et al., 2007; Danser et al., 2007). Although our knowledge is limited, preliminary studies suggest that sPRR may play a role in the mediation of kidney injury, fibrosis, and hypertension. Recent studies have described

elevated plasma sPRR levels in humans with kidney disease and/or heart failure (Amari et al., 2016; Gong et al., 2019; Hamada et al., 2013; Morimoto et al., 2014; Fukushima et al., 2013). Studies involving the administration of recombinant sPRR have shown hypertension (Gatineau et al., 2019; Gatineau et al., 2019; Wu et al., 2016). Further study is needed to determine the extent to which sPRR influences kidney damage, kidney function, and blood pressure. Thus, our aim in this study is to describe the actions of sPRR in kidney tissue, specifically upon kidney injury markers, fibrosis markers, and inflammation markers.

Recently, our laboratory developed a mouse model such that sPRR is not generated (Ramkumar et al., 2021). Using CRISPR-Cas9, we generated a mutation in the cleavage site, located as part of the *ATP6AP2* gene (Fig. 3). This mutation effectively prevents sPRR from being produced. Since the *ATP6AP2* gene coding the PRR is located on the X chromosome, male mice are hemizygous, while female mice are heterozygous for the cleavage site mutation. Mutant mice with loss of sPRR are born at the normal frequency and do not display any evidence of organ dysfunction although they are lower in body weight. In addition, male mice are infertile

and thus, the female heterozygous mutant mice were used for breeding.

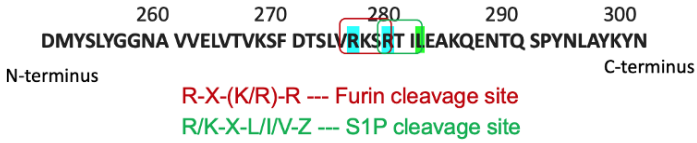

Fig. 3. CRISPR-Cas9 mutagenesis of the cleavage site of the PRR

We recently showed that sPRR attenuates Angiotensin-II mediated hypertension and kidney injury in male mice with loss of sPRR (Ramkumar et al., 2021). Additionally, preliminary studies have shown that sPRR is influential in attenuating kidney injury and inflammation. Thus, we hypothesized that compared to wild type, loss of sPRR will show decreased kidney injury, fibrosis, and inflammation.

The Unilateral Ureter Obstruction (UUO) is a widely used model of kidney injury in mice (Chevalier et al., 2009; Aranda-Rivera et al., 2021; Manucha, 2007; Rodríguez-Peña et al., 2008; Martinez-Klimova et al., 2019). A single ureter is tied off, obstructing the flow of urine and causing tubular injury to the obstructed kidney (Chevalier et al., 2009). The UUO model is most similar to chronic obstructive nephropathy, which, in the long term, leads to CKD. Typically, in the UUO, we are able to collect and analyze the kidneys post sacrifice of the mice. Messenger RNA (mRNA) is extracted to measure for 1) kidney injury markers, 2) markers of fibrosis or scarring, and 3) inflammation markers within the damaged kidneys. Markers of kidney injury include Kidney Injury Molecule 1 (KIM-1), which is not normally present unless the kidneys

have been damaged (Timmeren et al., 2007; Bonventre, 2008). KIM-1 is a well-known marker of proximal renal tubular injury in laboratory settings (Han et al., 2002). Fibrosis markers include Collagen-I (COL-I), and Fibronectin (FN), and Transforming Growth Factor Beta (TGF-β). COL-I and FN are structural proteins seen in scar tissue (Buchtler et al., 2018; Dixon et al., 1980), while TGF-β is noted for its role in signaling collagen production (Roberts et al., 1986). Inflammation markers include Interleukin 6 (IL6), and Tumor Necrosis Factor α (TNF-α). Both are proinflammatory cytokines partly responsible for controlling immune response (Su et al., 2017; Ramseyer et al., 2013). Other inflammation markers include Monocyte Chemoattractant Protein-I (MCP-I), and Vascular Cell Adhesion Molecule-I (VCAM-I). Both are involved in the migration and action of immune cells in response to injury (Segerer et al., 2000; Wuthrich, 1992).

It is important to note that while we can measure mRNA levels within the kidneys, we are unable to analyze systemic markers such as blood urea nitrogen/creatinine or urinary markers in the UUO model. This is because the tying of the ureter obstructs urine production from the damaged kidney, while the other kidney continues to function normally and does not change blood or urinary markers of injury, fibrosis, or inflammation.

Methods

Generation of Mutant sPRR Mice

Cleavage of the PRR gene is performed by furin and site-1 protease. Through use of CRISPR-Cas9, cleavage sites of both enzymes were mutated so that sPRR cannot be generated (Fig. 3). In short, guide RNAs introduced two point mutations (R276A and R279A) into exon 8 of

the ATP6AP2 gene. Homology-directed repairs altered the furin and site-1 protease sites of the gene. Founder mice were developed through co-injection of Cas9 mRNA and gRNA with donor oligo and targeting vectors into mice embryos. Mice were later genotyped, and genome sequencing was performed.

Unilateral Ureteral Obstruction

The Unilateral Ureteral Obstruction (UUO) procedure is able to cause scarring, inflammation, and fibrosis within the obstructed kidney through forcing the backflow of urine. Male mutant sPRR (MUT) and littermate wild type (WT) mice between four to seven months of age underwent surgical procedures. All mice were on a C57BL/6J strain. UUO mice had their left ureter tied off at the lower pole of the left kidney, while Sham mice underwent the motions of the UUO without actual tying of the ureter. Incisions were sutured closed, and mice were closely monitored in the following days. All mice successfully survived the procedure and survived until the time of sacrifice. Each cohort was sacrificed at a period of 3 days or 7 days post operation. Due to limited number of mice, we were unable to perform sham surgery in mutant sPRR mice. Only male mice were examined in this study. Details on surgical protocol are included in the appendix.

Plasma and Kidney Collection

Mice were sacrificed at 3 days or 7 days post UUO/Sham operation. 500 µL of blood was collected by cardiac puncture under anesthesia to measure plasma sPRR concentration. Kidneys were weighed, flash frozen in liquid nitrogen, and stored at -80°C. UUO/Sham kidneys were sectioned into thirds. One third underwent fixation

for histology, one third underwent mRNA extraction for qRT-PCR, and one third was stored for immunoblotting.

Plasma sPRR Measurement

Plasma sPRR was measured using soluble (pro)renin receptor EIA assay kit (Immuno-Biological Laboratories Co., Gunma, Japan; 20898). The kit is a solid phase ELISA that yields coloring that is proportional to the concentration of PRR. Colored samples were run in a UV-vis spectrophotometer against pre-prepared standards. Concentrations were calculated by comparing samples to a standard curve .

RNA Extraction and Verification

mRNA was isolated from UUO kidneys using PureLink RNA Mini Kit (Thermo Fisher Scientific, Carlsbad, CA, USA; 12183025). In short, one third of the UUO/Sham kidneys were homogenized with a rotor-stator homogenizer. Samples underwent multiple washes with Invitrogen's wash buffers followed by centrifugation. Finally, mRNA was extracted with Invitrogen's elution buffer.

Before analysis, RNA concentration was quantified and checked for purity via NanoDrop 2000 UV-vis Spectrophotometer. Both 260/280 and 260/230 ratios were compared to determine whether the mRNA was usable. Nucleic acids absorb at 260 nm, while common organic and inorganic contaminants absorb at 280 nm and 230 nm, respectively. For RNA, good purity at 260/280 are values between 2.0-2.3, while good values for 260/230 are between 1.6-1.8. Once concentrations were calculated, the same amount of mRNA was used from each sample for reverse transcription.

Reverse Transcription

Isolated RNA (0.5-1 µg) was reverse transcribed to complimentary DNA (cDNA) using a High-Capacity cDNA Reverse Transcription Kit (Thermo Fisher Scientific, Vilnius, Lithuania; 4368814). Samples were prepared in polymerase chain reaction (PCR) tubes and ran in Veriti 96-Well Thermocycler. Amount of RNA varied per cohort dependent on maximum RNA yield. Reverse transcription converts mRNA strands into cDNA preparing for rapid amplification during polymerase chain reaction.

Quantitative Reverse Transcription Polymerase Chain Reaction

mRNA levels were quantified through Quantitative Reverse Transcription Polymerase Chain Reaction (qRT-PCR). qRT-PCR was performed using TaqMan Gene Expression Master Mix (Thermo Fisher Scientific, Waltham, MA, USA; 4369510) and SYBR Green PCR Master Mix (New England BioLabs, Ipswich, MA, USA; M3003) in a 96-well StepOne Real-time PCR System (Applied Biosystems, Foster City, CA, USA; 4376357). $2^{-\Delta\Delta CT}$ method was used to measure relative expression levels of mRNA. Markers were normalized to glyceraldehyde 3-phosphate dehydrogenase (GAPDH). GAPDH is 1) essential to cell survival and 2) expressed similarly in many tissue types (Sikand et al., 2012). TaqMan primer sequences (Table 1) (Thermo Fisher Scientific, Pleasanton, CA, USA; 4316034) were synthesized by Thermofisher (Thermo Fisher Scientific, Waltham, MA, USA). SYBR Green primer sequences (Table 1) were synthesized at the University of Utah Primer Synthesis Core.

GENE	PRIMER SEQUENCE
KIM-1	F 5' CGTGGGTGGTTCAATGACATGA 3'
	R 5' TGACGGTTGGAACAGTTGTGAC 3'
COL-I	F 5' AACAACGTCTGCAACTTCGC 3'
	R 5' CTTCACAAACCGCACACCTG 3'
FN	F 5' TCGAGGAGGAAATTCCAATG 3'
	R 5' ACACACGTGCACCTCATCAT 3'
TNF-A	F 5' GGCAGGTCTACTTTGGAGTCA 3'
	R 5' CACTGTCCCAGCCATCTTGTG 3'
TGF- B	F 5' TCGCCAGAGTGGTTATCTT 3'
	R 5' TAGTGAACCCGTTGATGTCC 3'
IL6	F 5' ACAAAGCCAGAGTCCTTCAGAGAG 3'
	R 5' TTGGATGGTCTTGGTCCTTAGCCA 3'
MCP-I	F 5' GCTCTCTCTTCCTCCACCAC 3'
	R 5' ACAGCTTCTTTGGGACACCT 3'
VCAM-I	F 5' GCCACCCTCACCTTAATTGCTATG 3'
	R 5' TGTGCAGCCACCTGAGATCC 3'

Table 1. List of TaqMan and SYBR Green primers for qRT-PCR. Top five rows are TaqMan, and the bottom three rows are SYBR Green. All primers were normalized to GAPDH.

Table 1. List of TaqMan and SYBR Green primers for qRT-PCR. Top five rows are TaqMan, and the bottom three rows are SYBR Green. All primers were normalized to GAPDH.

Histology and Immunofluorescence

One third of UUO/Sham kidney were fixed overnight in 10% formaldehyde and sent to the University of Utah Histology Core for paraffin fixation. Received slides were deparaffinized and Picro Sirius red staining was performed. To assess cross-sectional areas of inflammation and scarring, quantification was measured with ImageJ software. Picro Sirius red staining highlights structural tissue bright red, while other tissues are left as light yellow in color. ImageJ software allows a color threshold to be selected at which the percentage of red can be measured. Full protocols for staining and analysis are attached in the appendix.

Statistical Analysis

All mice were used for the analysis. 3-day UUO and 7-day UUO were analyzed separately. qRT-PCR data was compared through measuring the CT values. CT values are measured as the number of cycles required to amplify the cDNA to the preset threshold. $2^{-\Delta\Delta CT}$ values were calculated and WT UUO/ mutant UUO were compared to the WT Sham. 1-way ANOVA with Tukey's multiple comparisons test was used to compare fold values between each group. Statistical significance was marked at $^{*}P < 0.05$.

Results

Male WT and mutant sPRR mice were used in this study for two reasons (1) ease of interpretation when comparing WT mice with mice with complete loss of sPRR in male mice as opposed to partial reduction of sPRR seen in female mutant sPRR mice, (2) female mice are less susceptible to kidney injury (Hodeify et al., 2013; Lima-Posada et al., 2017; Shepard, 2019).

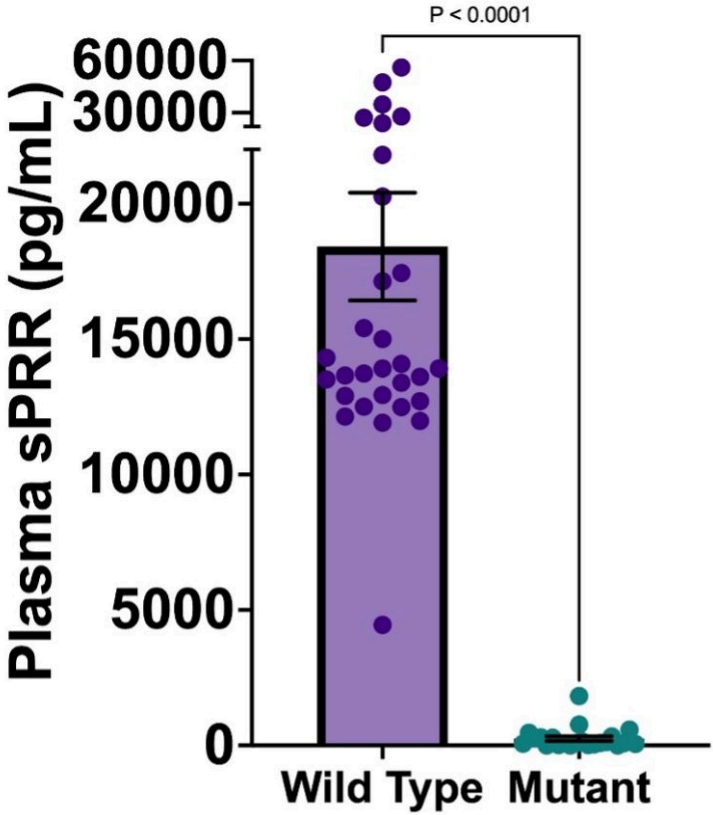

Fig. 4. Plasma sPRR concentrations of wild type and mutant mice for both 3-day and 7-day; Mean +/- SEM. *$P < 0.05$.

Stark differences in plasma sPRR levels can be seen between the mutant sPRR and WT groups. WT mice on average had a plasma sPRR concentration of 18,420 +/- 1,990 pg/mL while mutant sPRR mice on average had a plasma sPRR concentration of 258.2 +/- 86.6 pg/mL. This suggests that mutant mice on average showed a 99.6% decrease in plasma sPRR levels when compared to WT mice.

The length of time until the UUO mice are sacrificed is directly proportional to the extent of kidney damage, scarring, and inflammation. Preliminary studies were performed at 21 days following UUO. 21-Day mice showed far too severe structural damage and scarring to the kidney, thus, further studies were performed at 3 and 7 days post- UUO. Results of 3-day and 7-day qRT-PCRs are shown below.

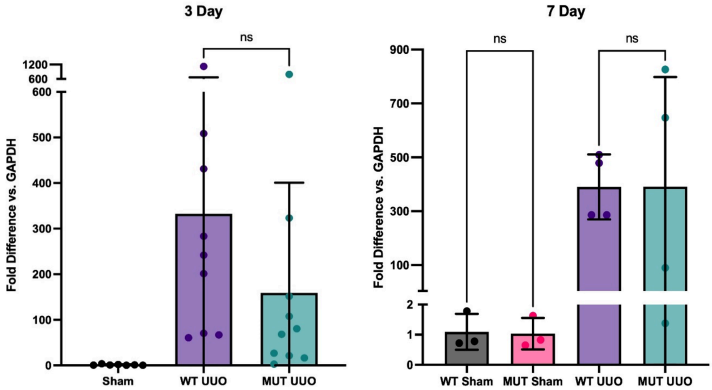

Fig. 5. Gene expression of KIM-1 by RT-PCR at 3-day (left; n = 7-10/group) and 7-day UUO (right; n = 3-4/ group); Mean +/- SEM of fold difference comparing GAPDH to KIM-1 is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. $^{*}P < 0.05$.

For our kidney injury marker, both WT UUO and MUT UUO groups had significantly greater levels of Kidney Injury Marker 1 (KIM-1) compared to WT Sham and MUT Sham for both 3-day and 7-day. For the 3-day mice, WT UUO had an average fold increase of 332 +/- 113, while MUT UUO had an average fold of 159 +/- 76 compared to WT Sham with an average fold of 1.34 +/- 0.46. Meanwhile, for the 7-day mice, WT UUO had an average

increase of 390 +/- 60, while MUT UUO had an average fold of 391 +/- 204. Unlike the 7-day mice, however, the 3-day mice had a trend toward attenuated KIM-1 presence for MUT UUO compared to WT UUO. Although the difference is not statistically significant, this trend may be of interest, suggesting that the MUT UUO shows less kidney injury compared to wild type.

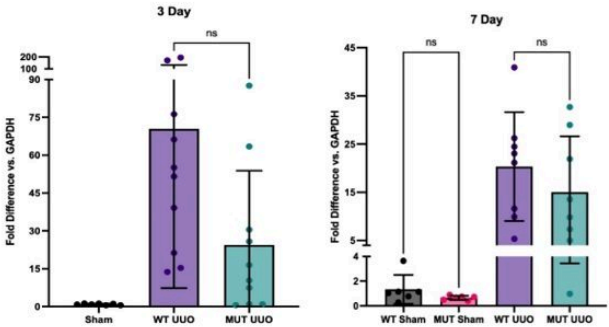

Fig. 6. Gene expression of COL-I by RT-PCR at 3-day (left; n = 7-10/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to COL-I is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Fig. 6. Gene expression of COL-I by RT-PCR at 3-day (left; n = 7-10/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to COL-I is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Markers of kidney scarring and fibrosis show similar results. Firstly, the UUO procedure causes dramatically increased levels of Collagen-I (COL-I) when compared to Sham as expected. COL-I levels are similar for 7-day mice with values of 20.3 +/- 4.0 and 15.0 +/- 4.1 for WT and MUT, respectively. COL-I levels for 3-day mice, however,

are moderately attenuated for MUT UUO compared to WT UUO despite lacking statistical significance (MUT: 24.4 +/- 9.3 and WT: 70.4 +/- 20.0).

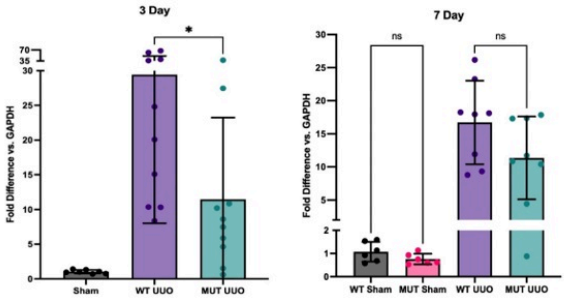

Fig. 7. Gene expression of FN by RT-PCR at 3-day (left; n = 7-10/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to FN is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Fig. 7. Gene expression of FN by RT-PCR at 3-day (left; n = 7-10/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to FN is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Similar to COL-I, Fibronectin (FN) was significantly attenuated in MUT UUO mice compared to WT UUO at the 3-day time-point. WT UUO and MUT UUO for 3-day show average folds of 29.4 +/- 6.8 and 11.5 +/- 3.7, respectively. Unlike COL-I, the difference between WT UUO and MUT UUO is statistically significant with a *p*-value of 0.033. Meanwhile, WT UUO and MUT UUO for 7-day show average increases of 16.7 +/- 2.2 and 11.4 +/- 2.2, respectively, which were no longer statistically different.

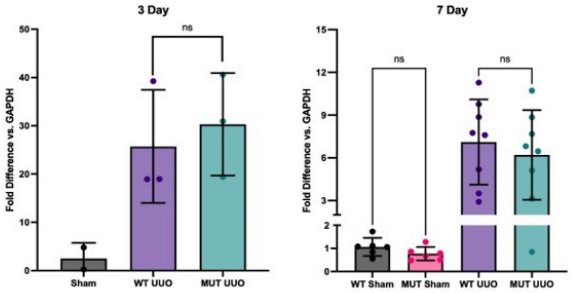

Fig. 8. Gene expression of TNF-α by RT-PCR at 3-day (left; n = 2-3/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to TNF-α is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Fig. 8. Gene expression of TNF-α by RT-PCR at 3-day (left; n = 2-3/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to TNF-α is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Unlike the kidney injury and fibrosis markers, there was no difference in TNF-α expression in the MUT UUO mice compared to WT UUO for either the 3-day or the 7-day mice. WT UUO and MUT UUO for 3-day show average increases of 25.7 +/- 6.8 and 30.3 +/- 6.1, respectively. WT UUO and MUT UUO for 7-day show average folds of 7.10 +/- 1.06 and 6.20 +/- 1.11, respectively relative to WT Sham.

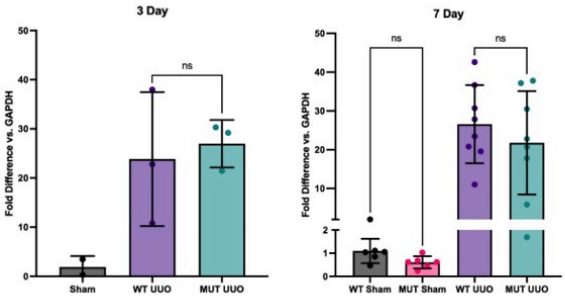

Fig. 9. Gene expression of TGF-β by RT-PCR at 3-day (left; n = 2-3/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to TGF-β is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Fig. 9. Gene expression of TGF-β by RT-PCR at 3-day (left; n = 2-3/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to TGF-β is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Transforming Growth Factor β (TGF-β) expression was also similar between MUT UUO mice compared to WT UUO for either the 7-day or the 3-day mice. WT UUO and MUT UUO for 3-day show average folds of 23.9 +/-7.9 and 27.0 +/- 2.8, respectively compared to WT Sham. WT UUO and MUT UUO for 7-day show average folds of 6.24 +/- 1.35 and 4.75 +/- 1.04, respectively relative to WT Sham.

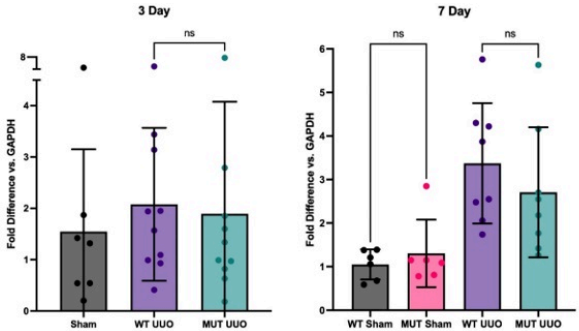

Fig. 10. Gene expression of IL6 by RT-PCR at 3-day (left; n = 7-10/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to IL6 is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Fig. 10. Gene expression of IL6 by RT-PCR at 3-day (left; n = 7-10/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to IL6 is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Similar to TNF-α and TGF-β, WT UUO and MUT UUO mice had similar Interleukin 6 (IL6) concentrations for both 3-day or 7-day time-points. WT UUO and MUT UUO for 3-day show average folds of 2.08 +/- 0.47 and 1.89 +/-0.69, respectively compared to WT Sham. WT UUO and MUT UUO for 7-day show average folds of 3.37 +/- 0.49 and 2.71 +/- 0.53, respectively relative to WT Sham.

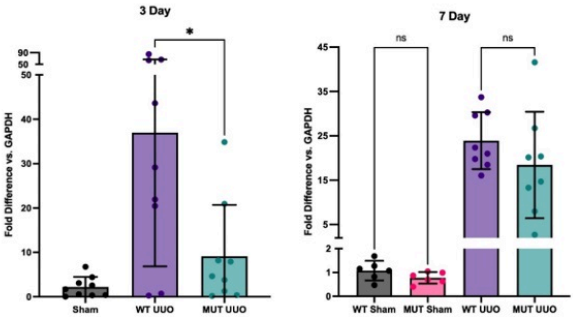

Fig. 11. Gene expression of MCP-I by RT-PCR at 3-day (left; n = 9/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to MCP-I is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Fig. 11. Gene expression of MCP-I by RT-PCR at 3-day (left; n = 9/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to MCP-I is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

At 3 days, there is a statistically significant difference between WT UUO and MUT UUO mice in Monocyte Chemoattractant Protein-I (MCP-I) concentrations with a *p*-value of 0.011. MUT UUO MCP-I concentrations appear to be much less than the WT UUO concentrations, almost similar to the Sham concentrations. Meanwhile, 7-day mice had similar expression of MCP-I between WT and MUT UUO. WT UUO and MUT UUO for 3-day show average folds of 36.0 +/- 10.0 and 9.13 +/- 3.86, respectively. WT UUO and MUT UUO for 7-day show average folds of 23.9 +/-2.3 and 18.4 +/- 4.2, respectively.

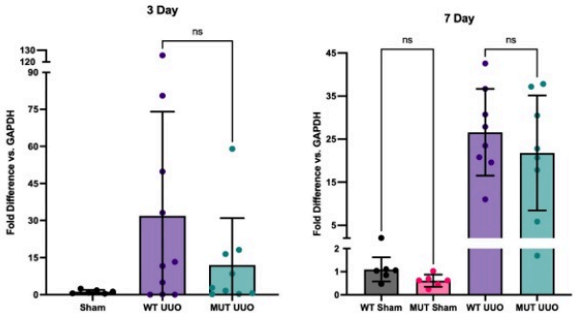

Fig. 12. Gene expression of VCAM-I by RT-PCR at 3-day (left; n = 6-10/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to VCAM-I is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

Fig. 12. Gene expression of VCAM-I by RT-PCR at 3-day (left; n = 6-10/group) and 7-day UUO (right; n = 6-8/group); Mean +/- SEM of fold difference comparing GAPDH to VCAM-I is shown. All groups are compared to WT Sham. *P*-values determined by one-way ANOVA with Tukey's multiple comparisons test. *$P < 0.05$.

At 3 days, there was a trend toward lower Vascular Cell Adhesion Molecule-I (VCAM-I) expression in the MUT UUO mice compared to WT UUO. This difference, however, was not statistically significant. No difference in VCAM-I expression was seen at the 7-day time-point. For the 3-day mice, WT UUO and MUT UUO for 3-day show average increase of 31.9 +/- 13.3 and 12.0 +/- 6.3, respectively compared to WT Sham. WT UUO and MUT UUO for 7-day show average folds of 26.6 +/- 3.6 and 21.8 +/- 4.7, respectively relative to WT Sham.

Fig. 13. Sirius Red staining for Sham, WT UUO, and MUT UUO at 3 days following UUO. Strong pink coloring indicates fibrous tissue.

Fig. 13. Sirius Red staining for Sham, WT UUO, and MUT UUO at 3 days following UUO. Strong pink coloring indicates fibrous tissue.

In the above slides, Picro Sirius Red stains normal tissue a light yellow in color, while Collagen-I found in fibrous and scar tissue stains bright pink as a. Vascular tissue (i.e. arteries and veins) and structural tissue contain Collagen-I, and thus, it is important to recognize these areas to discern them from scarring due to UUO. It is interesting to note that UUO causes tubular dilatation and injury in comparison to the Sham tissue due to the obstruction.

At 3 days, the Sham kidneys can clearly be seen to have the least scarring. Structural tissue can be seen closer to the center of the kidney at the renal pelvis, while normal blood vessels can be seen on occasion throughout the tissue. Comparatively, the WT UUO appears to have the most scarring as the greatest pockets of interstitial fibrosis are visible all throughout the sample. The MUT UUO tissue appears to have attenuated scarring in the WT UUO. Unfortunately, due to time constraints, staining is yet to be performed for the 7-day mice, and quantitative analysis for both groups is ongoing.

Discussion

We expected to find that: 1) Loss of sPRR would

attenuate kidney injury, fibrosis, and kidney inflammation when compared to wild type; 2) similar results would be found at both 3-day and 7-day time-points; 3) Sirius red staining would show attenuated fibrosis in the mutant sPRR mice compared to WT.

Our results show that at 3 days following UUO, Collagen-I (COL-I), Fibronectin (FN), Monocyte Chemoattractant Protein-I (MCP-I), and perhaps Vascular Cellular Adhesion Molecule-I (VCAM-I) are all reduced in the mutant sPRR mice compared to WT UUO mice. Loss of sPRR appears to attenuate, but not entirely reduce expression of kidney injury and fibrosis markers, and some, but not all kidney inflammation markers in the setting of UUO. This suggests that other factors than sPRR may influence kidney injury, fibrosis, and kidney inflammation. Furthermore, out of all markers, only FN and MCP-I show statistically significant differences while a strong trend towards attenuated presence in MUT UUO can still be seen in the other markers (KIM-1, COL-I, VCAM-I). It is likely that this is due to variation between individual mice; further testing increasing the sample size may potentially show significance. In addition, inconsistencies during mice surgeries, RNA sample purity, and analysis may have led to variances in the data. Regardless, sPRR does appear to play a role in kidney injury and fibrosis in the setting of UUO.

It is interesting to note that the 7-day results are quite different from the 3-day time-point. Differences between the MUT UUO and WT UUO at seven days do not show support towards a trend. This may presumably be due to the length of progression of the kidney damage. 7-day mice may have sustained more damage than protection

afforded by loss of sPRR. In other words, loss of sPRR may have an acute protective effect which is no longer present with ongoing obstruction at the 7-day time-point. This is not entirely unexpected as UUO models tend to increase in severity with ongoing obstruction and several pathways of injury, inflammation, and fibrosis are likely to be activated by then. Additional models not involving UUO may be helpful in determining the temporal trends of how sPRR protects against kidney injury and fibrosis.

In our 3-day qRT-PCR results, we found that both our fibrosis markers, COL-I and FN were reduced in MUT sPRR mice compared to wild type. Upon visible inspection, the Sirius red staining reflects this wherein interstitial fibrosis for the MUT UUO mice appears to be greatly reduced in comparison to the WT UUO mice although not quite to the same degree as the WT Sham mice. While the slides are straightforward to compare visually, due to time constraints, quantitative analyses are still ongoing and will be completed in the next month. We anticipate that the staining results would be in accordance with RT-PCR results with loss of sPRR reducing kidney fibrosis at 3-day time-point and not as much at the 7-day time-point.

In addition to performing quantitative analysis on the staining, immunoblotting of kidney injury, inflammation, and fibrosis is planned as RNA and protein expression may be quite different. Moreover, considering alternative mouse models of CKD such as treatment with adenine or folic acid, may provide valuable insights into the role of sPRR in kidney disease. These models induce fibrosis, inflammation, and injury differently from the UUO model, and may be able to further clarify the role of sPRR in kidney disease. Another potential consideration is

whether female mutant sPRR mice are protected against kidney disease. While mutant sPRR males have near complete reduction of sPRR, mutant females retain close to 50%, potentially resulting in different outcomes when subjected to UUO or other kidney disease models. Further investigations of these aspects could potentially enhance the understanding of the sPRR.

The results of this study are humbly contributive to the nature of the soluble (pro)renin receptor. The work presented here does not, by any means, represent a comprehensive explanation of the sPRR. Our aim is to describe sPRR in an instance of CKD such as the UUO. Although sPRR might be a promising target for medical treatments, further study of the sPRR is required to help understand the RAAS pathway, and the implications of sPRR on CKD, CVD, and hypertension.

References

1. Amari Y, Morimoto S, Nakajima F, Ando T, Ichihara A. Serum Soluble (Pro)Renin Receptor Levels in Maintenance Hemodialysis Patients. *PloS One*. 2016; 11(7): e0158068. doi: 10.1371/journal.pone.0158068

2. Aranda-Rivera AK, Cruz-Gregorio A, Aparicio-Trejo OE, Ortega-Lozano AJ, Pedraza-Chaverri J. Redox signaling pathways in unilateral ureteral obstruction (UUO)-induced renal fibrosis. *Free Radical Biology and* Medicine. 2021; 172: 65-81. doi: 10.1016/j.freeradbiomed.2021.05.034

3. Bonventre JV. Kidney Injury Molecule-1 (KIM-1): a specific and sensitive biomarker of

kidney injury. *Scandinavian Journal of Clinical and Laboratory Investigation*. 2009; 68: 78-83. doi: 10.1080/00365510802145059

4. Buchtler S, Grill A, Hofmarksrichter S, Stockert P, Schiechl-Brachner G, Gomez MR, Neumayer S, Schmidbauer K, Talke Y, Klinkhammer BM, Boor P, Medvinsky A, Renner K, Castrop H, Mack M. Cellular Origin and Functional Relevance of Collagen I Production in the Kidney. *Journal of American Society of Nephrology*. 2018; 29(7): 1859-1873. doi: 10.1681/ASN.2018020138

5. Chevalier RL, Forbes MS, Thornhill BA. Ureteral obstruction as a model of renal interstitial fibrosis and obstructive nephropathy. *Kidney International*. 2009; 75(11): 1145-1152. doi: 10.1038/ki.2009.86

6. Crowley SD, Coffman TM. Recent advances involving the renin-angiotensin system. *Experimental Cell Research*. 2012; 318(9): 1049-1056. doi: 10.1016/j.yexcr.2012.02.023

7. Danser AHJ, Deinum J. Renin, Prorenin and the Putative (Pro)renin Receptor. *Hypertension*. 2005; 46(5):1069-1076. doi: 10.1161/01.HYP.0000186329.92187.2e

8. Dixon AJ, Burns J, Dunnill MS, McGee JO. Distribution of fibronectin in normal and diseased human kidneys. *Journal of Clinical Pathology*. 1980; 33: 1021-1028. doi: 10.1136/jcp.33.11.1021

9. Feldt S, Batenburn WW, Mazak I, Maschke U,

Wellner M, Kvakan H, Dechend R, Fiebeler A, Burckle C, Contrepas A, Danser AHJ, Bader M, Nguen G, Luft FC, Muller DM. Prorenin and Renin-Induced Extracellular Signal-Regulated Kinase ½ Activation in Monocytes Is Not Blocked by Aliskiren or the Handle-Region Peptide. *Hypertension*. 2008; 51: 682-688. doi: 10.1161/HYPERTENSIONAHA.107.101444

10. Fu Z, Wang F, Liu X, Hu J, Su J, Lu X, Lu A, Cho JM, Symons JD, Zou CJ, Yang T. Soluble (pro)renin receptor induces endothelial dysfunction and hypertension in mice with diet-induced obesity via activation of angiotensin II type 1 receptor. *Clinical Science*. 2021; 135(6): 793-810. doi: 10.1042/CS20201047

11. Fukushima A, Kinugawa S, Homma T, Masaki Y, Furihata T, Abe T, Suga T, Takada S, Kadoguchi T, Okita K, Matsushima S, Tsutsui H. Increased plasma soluble (pro)renin receptor levels are correlated with renal dysfunction in patients with heart failure. 2013; 168(4): P4313-4314. doi: 10.1016/j.ijcard.2013.04.176

12. Gatineau E, Cohn DM, Poglitsch M, Loria AS, Gong M, Yiannikouris F. Losartan prevents the elevation of blood pressure in adipose-PRR deficient female mice while elevated circulating sPRR activates the renin-angiotensin system. *Heart and Circulatory Physiology*. 2019; 316(3): H506-H515. doi: 10.1152/ajpheart.00473.2018

13. Gatineau E, Gong MC, Yiannikouris F. Soluble

Prorenin Receptor Increases Blood Pressure in High Fat-Fed Male Mice. *Hypertension*. 2019; 74(4): 1014-1020. doi: 10.1161/HYPERTENSIONAHA.119.12906

14. Gong L, Zhang S, Li L, Gao X, Wang D, Wu D, Wang K, Liu Y. Elevated plasma soluble (pro)renin receptor levels are associated with left ventricular remodeling and renal function in chronic heart failure patients with reduced ejection fraction. *Peptides*. 2019; 111: 152-157. doi: 10.1016/j.peptides.2018.04.010

15. Hamada K, Taniguchi Y, Shimamura Y, Inoue K, Ogata K, Ishihara M, Hornio T, Fujimoto S, Ohguro T, Yoshimoto Y, Ikebe M, Yuasa K, Hoshino E, Iiyama T, Ichihara A, Terada Y. Serum level of soluble (pro)renin receptor is modulated in chronic kidney disease. *Clinical and Experimental Nephrology*. 2013; 17: 848-856. doi: 10.1007/s10157-013-0803-y

16. Han WK, Bailly V, Abichandani R, Thadhani R, Bonventre JV. Kidney Injury Molecule-1 (KIM-1): a novel biomarker for human renal proximal tubule injury. *Kidney International*. 2002; 62(1): 237-244. doi: 10.1046/j.1523-1755.2002.00433.x

17. Hodeify R, Megyesi J, Tarcsafalvi A, Mustafa HI, Seng NSHL, Price PM. Gender differences control the susceptibility to ER stress-induced acute kidney injury. *American Journal of Physiology-Renal Physiology*. 2013;

304:F875-F882. doi: 10.1152/ajprenal.00590.2012

18. Ichihara A, Kaneshiro Y, Takemitsu T, Sakoda M, Itah H. The (Pro)Renin Receptor and the Kidney. *Seminars in Nephrology*. 2007; 27(5): 524-528. doi: 10.1016/j.semnephrol.2007.07.005

19. Ichihara A, Yatabe MS. The (pro)renin receptor in health and disease. *Nature Reviews Nephrology*. 2019; 15: 693-712. doi: 10.1038/s41581-019-0160-5

20. Jankowski J, Floege J, Fliser D, Bohm M, Marx N. Cardiovascular Disease in Chronic Kidney Disease. *Circulation Research*. 2021; 143:1147-1172. doi: 10.1161/CIRCULATIONAHA.120.050686

21. Kovesdy CP. Epidemiology of chronic kidney disease: an update 2022. *Kidney International Supplements*. 2022; 12(1): 7-11. doi: 10.1016/j.kisu.2021.11.003

22. Lima-Posada I, Portas-Cortés C, Pérez-Villalva R, Fontana F, Rodríguez-Romo R, Prieto R, Sánchez-Navarro A, Rodríguez-González GL, Gamba G, Zambrano E, Bobadilla NA. Gender Differences in the Acute Kidney Injury to Chronic Kidney Disease Transition. *Scientific Reports*. 2017; 12270. doi: 10.1038/s41598-017-09630-2

23. Manucha W. Biochemical-molecular markers in unilateral ureteral obstruction. *Biocell*. 2007; 31(1): 1-12. doi: 10.32604/biocell.2007.31.001

24. Martinez-Klimova E, Aparicio-Trejo OE, Tapia E, Pedraza-Chaverri J. Unilateral Ureteral Obstruction as a Model to Investigate Fibrosis-Attenuating Treatments. 2019; 9(4): 141. doi: 10.3390/biom9040141

25. Morimoto S, Ando T, Niiyama M, Seki Y, Yoshida N, Watanabe D, Kawakami-Mori F, Kobori H, Nishiyama A, Ichihara A. Serum soluble (pro)renin receptor levels in patients with essential hypertension. *Hypertension Research*. 2014; 37: 642-648. doi: 10.1038/hr.2014.46

26. Nguyen G, Delarue F, Burckle C, Bouzhir L, Giller T, Sraer JD. Pivotal role of the renin/prorenin receptor in angiotensin II production and cellular responses to renin. *The Journal of Clinical Investigation*. 2002; 109(11): 1417-1427. doi: 10.1172/JCI14276

27. Nguyen G, Muller DN. The Biology of the (Pro)Renin Receptor. *Journal of the American Society of Nephrology*. 2010; 21(1):18-23. doi: 10.1681/ASN.2009030300

28. Ohashi N, Isobe S, Ishigaki S, Suzuki T, Iwakura T, Ono M, Fujikura T, Tsuji T, Otsuka A, Ishioi Y, Furuse H, Kato A, Ozono S, Yasuda H. Plasma Soluble (Pro)renin Receptor Reflects Renal Damged. *PloS One*. 2016; 11(5): e0156165. doi:10.1371/journal.pone.0156165

29. Patel S, Rauf A, Khan H, Abu-Izneid T. Renin-angiotensin-aldosterone (RAAS): The ubiquitous

system for homeostasis and pathologies. *Biomedical and Pharmacology Journal*. 2017; 94:317-325. doi: 10.1016/j.biopha.2017.07.091

30. Pohl MA, Blumenthal S, Cordonnier DJ, De Alvaro F, Defarrari G, Eisner G, et al. Independent and additive impact of blood pressure control and angiotensin II receptor blockade on renal outcomes in the irbesartan diabetic nephropathy trial: clinical implications and limitations. *J Am Soc Nephrol*. 2005; 16:3027–3037. doi: 10.1681/ASN.2004110919

31. Ramkumar N, Stuart D, Peterson CS, Hu C, Wheatley W, Cho JM, Symons JD, Kohan DE. Loss of Soluble (Pro)renin Receptor Attenuates Angiotensin-II Induced Hypertension and Renal Injury. *Circulation Research*. 2021; 129:50-62. doi: 10.1161/CIRCRESAHA.120.317532

32. Ramseyer VD, Garvin JL. Tumor necrosis factor-α: regulation of renal function and blood pressure. *American Journal of Physiology-Renal Physiology*. 2013; 304(10): F1231-F1242. doi: 10.1152/ajprenal.00557.2012

33. Roberts AB, Sporn MB, Assoian RK, Smith JM, Roche NS, Wakefield LM, Heine UI, Liotta LA, Falanga V, Kehrl JH, et al. Transforming growth factor type beta: rapid induction of fibrosis and angiogenesis in vivo and stimulation of collagen formation in vitro. *Proceedings of the National Academy of Sciences of the United States of*

America. 1986; 83(12): 4167-4171. doi: 10.1073/pnas.83.12.4167

34. Rodriguez-Pena AB, Grande MT, Eleno N, Arevalo M, Guerrero C, Santos E, Lopez-Novoa JM. Activation of Erk1/2 and Akt following unilateral ureteral obstruction. *Kidney International*. 2008; 74(2): 196-209. doi: 10.1038/ki.2008.160

35. Saris JJ, Hoen PAC, Garrelds IM, Dekkers DHW, Dunnen JT, Lamers JMJ, Danser AHJ. Prorenin Induces Intracellular Signaling in Cardiomyocytes Independently of Angiotensin II. *Hypertension*. 2006; 48(4): 564-571. doi: 10.1161/01.HYP.0000240064.19301.1b

36. Segerer S, Nelson PJ, Schlondorff D. Chemokines, chemokine receptors, and renal disease: from basic science to pathophysiologic and therapeutic studies. *Journal of American Society of Nephrology*. 2000; 11(1): 152-176. doi: 10.1681/ASN.V111152

37. Shepard BD. Sex differences in diabetes and kidney disease: mechanisms and consequences. *American Journal of Physiology-Renal Physiology*. 2019; 317: F456–F462. doi: 10.1152/ajprenal.00249.2019

38. Sikand K, Singh J, Ebron JS, Shukla GC. Housekeeping Gene Selection Advisory: Glyceraldehyde-3-Phosphate Dehydrogenase (GAPDH) and β-Actin Are Targets of miR-644a.

PLoS One. 2012; 7(10): e47510. doi: 10.1371/journal.pone.0047510

39. Su H, Lei CT, Zhang C. Interleukin-6 Signaling Pathway and Its Role in Kidney Disease: An Update. *Frontiers in Immunology*. 2017; 8: 405. doi: 10.3389/fimmu.2017.00405

40. Timmeren MM, Heuvel MC, Baily V, Bakker SJL, Goor H, Stegeman CA. Tubular kidney injury molecule-1 (KIM-1) in human renal disease. *The Journal of Pathology*. 2007; 212(2): 209-217. doi: 10.1002/path.2175

41. Vaughan ED, Marion D, Poppas DP, Felsen D. Pathophysiology of Unilateral Ureteral Obstruction: Studies From Charlottesville to New York. *Journal of Urology*. 2004; 172(6): 2563-2569. doi: 10.1097/01.ju.0000144286.53562.95

42. Webster AC, Nagler EV, Morton RL, Masson P. Chronic Kidney Disease. *The Lancet*. 2017; 389:1238-1252. doi: 10.1016/S0140-6736(16)32064-5

43. Wu CH, Mohammadmoradi S, Thompson J, Su W, Gong M, Nguyen G, Yiannikouris F. Adipocyte (Pro)Renin-Receptor Deficiency Induced Lipodystrophy, Liver Steatosis and Increased Blood Pressure in Male Mice. *Hypertension*. 2016; 68(1): 213-219. doi: 10.1161/HYPERTENSIONAHA.115.06954

44. Wuthrich RP. Intercellular adhesion molecules and vascular cell adhesion molecule-1 and the

kidney. *Journal of American Society of Nephrology*. 1992; 3(6): 1201-1211. doi: 10.1681/ASN.V361201

Acknowledgements

My work here and my thesis would not have been possible without the guidance of my mentor and principal investigator, Dr. Nirupama Ramkumar. Dr. Ramkumar has been instrumental in my understanding of this project, her research, and the work that I have completed. She is an amazing mentor for not only my research aspirations, but also for my path to medical school. I will be eternally grateful for the two years that I have had the opportunity to spend in her laboratory.

I am further grateful for Deborah Stuart, BS and Will Wheatley, MS, in the laboratory, not only for their assistance and contributions to this project, but also for their roles as mentors and leaders in my scientific journey. They have taught me much over the years and I am grateful for their willingness to help me learn and grow as a student in my college career.

Lastly, I am grateful to my parents for continuing to support me through all the ups and downs. It has not been the smoothest journey, but in the end, I am grateful for their love and support.

SUPPLEMENTARY MATERIALS

UUO Protocol/Notes:

Meds:

- Bupivacaine: working solution with 0.2 mg/mL bupivacaine in sterile PBS
  - Administer 2 mg/kg dose subq at incision site (10 uL working solution/g body weight)
  - To prepare 10 mL working solution: Add 400 uL of 50 mg/10mL bupivacaine HCl stock (AuroMedics Pharma LLC, E. Windsor NJ) to 9.6 mL sterile PBS
- Buprenorphine: working solution with 0.02 mg/mL buprenorphine in sterile PBS
  - Administer 0.2 mg/kg subq (10 uL working solution/g body weight)
  - To prepare 10 mL working solution: add 667 uL of 0.3 mg/mL buprenorphine HCl (Par Pharmaceutical, Chestnut Ridge NY) to 9.333 mL sterile PBS

Before surgery day:

- autoclave silk and tools

Day of surgery:

- turn on sterilizer
- microwave heating pad (~4 min) and place under metal plate
- load isoflurane (make sure level is between lines). Turn valve on to anesthesia chamber.

Preparing the animal:

- Put mouse in anesthesia chamber. Induce anesthesia with 3% isoflurane. Monitor breathing and adjust iso flow accordingly.
- Transfer mouse to table. Switch iso flow to nose cone. Reduce Iso flow to ~2.5% for maintenance.
- Use razor to shave mouse's left side around back/ribcage.
- Administer pain meds (bupivacaine and buprenorphine, subq)
- Sterilize skin 3x with betadine and 70% ethanol swabs.
- Position animal on its right side. Secure left forepaw with tape to keep nose in nose cone.

UUO:

- Pinch back paw/tail for responsiveness
- Make 1-1.5cm incision (see figure) through skin and fascia right below ribs and proximal to the spine
- Use sterile cotton swabs to isolate kidney and pop it out of the body cavity. I find it's easiest to 'pull' on perirenal fat pad with right swab and 'push' on abdominal cavity with left swab to pop out kidney.
- Blunt dissect to isolate ureter. Twist a saline-soaked cotton swab along ureter to remove fat/connective tissue. Prop up ureter with a sterile 1mL syringe plunger and ligate twice (above and below plunger) with 6-0 silk. Sever the ureter between ligatures.
- Replace the kidney into the body cavity with cotton swabs.
- Close peritoneum and skin with sutures.

Recovery/Pain

- Apply antibiotic cream to incision site
- Administer 0.5 mL warmed saline SC
- Place animal in clean cage containing a gel pack with ¼ carprofen tab on heating pad
- Give a second dose of buprenorphine subq 24h after surgery. Continue to monitor for distress and administer a third buprenorphine dose 48h after surgery, if needed.

Fig. 14. Full details of UUO surgical procedure.

Basic Protocol for Immunohistochemistry

Deparaffinization

1. Heat Slides in Holder at 70° Celsius for 60-75 Minutes
2. Soak the slides in the following solutions in series:
   a. 15 minutes 100% Xylene
   b. 15 Minutes 100% Xylene
   c. 7 minutes 75% Xylene, 25% Ethanol
   d. 5 minutes 50% Xylene, 50% Ethanol
   e. 5 minuets 25% Xylene, 75% Ethanol
   f. 5 minutes 100% Ethanol
   g. 5 minutes 100% Ethanol
   h. 5 minutes 75% Ethanol, 25% ddH_2O
   i. 5 minutes 50% Ethanol, 50% ddH_2O
   j. 5 minutes 25% Ethanol, 75% ddH_2O
   k. 5 minutes ddH_2O
3. Boil the Slides for 1 hour in 0.05% Citraconic Acid(500 ul in 1000 ml of water) at 98° Celsius
4. Place Slides in 1X PBS and store at 4° Celsius until needed

Fig. 15. Deparaffinization protocol that was used prior to Sirius Red staining.

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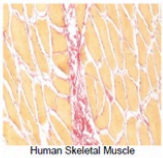
Human Skeletal Muscle

Picro-Sirius Red Stain Kit Procedure

1:05

100ml Kit Item #: N/A	**Liter Kit Item#:** N/A
Pint Kit Item #: KTPSRPT	**Gallon Kit Item#:** N/A

Control Slide(s)	Item#
Uterus	CSU0325P

Included Components	
Picro-Sirius Red Stain	Weigert's Hematoxylin A
0.5% Acetic Acid	Weigert's Hematoxylin B

PRINCIPLE AND RESULTS: This kit is intended for use by laboratory professionals to stain routinely prepared paraffin embedded tissue specimens or frozen sections (in vitro) to identify collagen and muscle. Collagen stains red, muscle yellow, thick fibers yellow to orange birefringence when viewed using polarized light, thin fibers green birefringence when viewed using polarized light, and nuclei black.

SPECIMEN CRITERIA: Appropriately fixed, paraffin-embedded 4-5µm tissue section.

STORAGE AND USAGE NOTES: Store/Use each component according to the temperature and expiration on the label.

PRECAUTIONS: For use by laboratory professionals. See SDS for complete warnings, precautions, hazard and precautionary statements, and disposal information.

WORKING WEIGERT'S HEMATOXYLIN PREPARATION:

#	Action	Amount	Chemical/Reagent	Details
1	Add	25ml	Weigert's Hematoxylin A	Into a chemically clean container or new/unused plasticware.
2	Add	25ml	Weigert's Hematoxylin B	Mix thoroughly.

STAINING PROCEDURE:

Color coordinated steps denote stain baths that can be reused during autostainer configuration.

#	Action	With	Heat °C	Time Mins	Time Secs	Details
1	Deparaffinize	Xylene or Substitute, 2 changes	--	5	--	5 minutes each change or as required if using a xylene substitute.
2	Rinse	Absolute Alcohol, 3 changes	--	1	--	1 minute each change or as required if using graded alcohols.
3	Rinse	Running Tap Water	--	1	--	
4	Immerse	Working Weigert's Hematoxylin	--	5	--	Once complete, rinse in running tap water (2 minutes) and continue.
5	Immerse	Picro-Sirius Red Stain	--	60	--	
6	Rinse	0.5% Acetic Acid, 2 changes	--	--	5	5 seconds each change.
7	Dehydrate	Absolute Alcohol, 3 changes	--	--	5-10	5-10 seconds each change.
8	Clear	Xylene or Substitute, 3 changes	--	1	--	1 minute each change or as required if using a xylene substitute.
9	Coverslip	Permanent Mounting Media*	--	--	--	

*NOTE: Some permanent Mounting Mediums may cause fading over time with picric acid based stains. While MicroMount™ or PermaSlip™ is recommended for optimal staining preservation, many other mounting mediums may also provide successful results. Be sure to test your preferred Mounting Medium with this stain if not using one of the recommended products.

Fig. 16. Picro-Sirius Red Staining protocol.

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56.

RESEARCH REFLECTION BY DHRUVAN GOPINATH

Dhruvan Gopinath

Faculty Mentor: Nirupama Ramkumar (Internal Medicine, University of Utah)

My work in Dr. Ramkumar's lab has been perhaps the most significant part of my undergraduate career. Having the ability to learn and explore in a groundbreaking field has been incredibly eye opening and enjoyable. I have had the opportunity to perform advanced techniques such as the RTPCR, Western Blots, Histology staining, as well as the UUO mice surgeries. Niru also taught me much about her work, helping me understand the relevance of her projects from some of our technological advances to how our specific projects leverage them. In the future, I

hope to be able to continue performing research while I remain in school and in my future career. There are many medical school programs that would allow me to continue building upon the foundation that I have received here. Alternatively, depending on acceptances, I have the option of working towards a Master's degree or a PhD. Wherever my career goes, I hope to continue pursuing research in the future.

About the Author

Dhruvan Gopinath

57.

A COMPREHENSIVE OVERVIEW: EVOLUTION OF TETR/TETO SYSTEM TOWARD ORTHOGONAL TRANSCRIPTIONAL REPRESSION

Alexa Gormick

Faculty Mentor: Justin G. English (Biochemistry, University of Utah)

The adverse consequences caused by misregulation of gene expression programs and their transcriptional

regulators are incredibly varied, meaning that much of the mechanisms of these programs are unknown and understudied, especially in the scope of cancer and disease treatment.

To more deeply understand the underlying factors influencing gene expression misregulation and corresponding cell signaling cascades, we are exploiting the Tet-On system as a switch-like tool to explore the limits of flexible exogenous gene expression in mammals. Tet-On allows the expression of any gene to be reversibly, specifically, and differentially controlled on command with the addition and removal of a miniscule dose of a tetracycline-class antibiotic from the system. In this system, a dimer of the tetracycline repressor (TetR) binds the tetracycline operator (TetO), impeding transcription of any downstream gene embedded by the researcher. The wild-type TetR-TetO pair of the Tet-On system offers one of the strongest and most precise controls over target gene expression, where TetR can bind TetO with a remarkably high affinity; this interaction can block transcription even downstream of some of the strongest virus-mediated promoters and remain faithfully functional even in the most sensitive tissues. However, the Tet-On system only exists as a singular wild-type circuit. To expand upon its diverse utility, we are in pursuit of developing novel TetR-TetO orthologous pairs that don't interfere with this wild-type circuit for use in parallel expression regulation. As a first step to generating TetR-TetO orthologs, we are mapping the usage of TetO by TetR in a massively-parallel reporter assay (MPRA) by engineering an extensive library of mutated TetOs paired with a unique molecular identifier (UMI) sequence to

accurately quantify the resulting range of TetR regulation through fluorescent reporter gene expression. From this screen, we will identify candidate TetO mutants with varying levels of detectable wild-type TetR binding activity, and use them to persuade Sindbis virus-mediated evolution of the wild-type TetR toward complementary states to those selected TetO mutant sequences. Finally, to showcase the zero cross-reactivity between our mutant Tet-On circuits and the wild-type-circuit, we plan to engineer a synthetic genetic circuit in mammalian cells, representative of complex circuits and patterns of synchronized cell signaling we observe in naturally-occurring systems. By generating a novel suite of TetR-TetO mutant pairs, we create a toolbox of expression "off-switches" for selective and dependable control over modified gene expression programs with unknown implications in the pursuit of disease prevention and treatment.

About the Author

Alexa Gormick

58.

OPIOID MISUSE IN RURAL AND URBAN PROSTATE CANCER SURVIVORS

Tashianna Gray; Brock O'Neil; and Mia Hashibe

Faculty Mentor: Brock O' Neil (Surgery, University of Utah)

Abstract

Background: Rural and urban cancer disparities in prostate cancer survival are well-documented. The cause of worse outcomes among rural prostate cancer survivors is not well-understood. Prior research has shown that rural communities have higher use of prescribed and illicit opioid use than many urban communities. Furthermore, opioid therapy is the utilization of drugs, short-term or

long term to reduce pain. Patients that experience moderate pain may be prescribed weak opioids that include Codeine or Tramadol; while those who experience severe pain may be prescribed stronger opioids such as Morphine. These opioids can be taken in various ways including slow release and a needle under the skin. Their versatility can make them highly addictive in treatment options: post-surgery, radiation therapy, and systematic therapies. For instance, one in four patients receiving long-term opioid therapy in a primary care setting struggles with opioid addiction. This addiction can spiral and can have grave side effects in patients.

Objective: The purpose of this research is to investigate whether persistent opioid use after treatment may explain the observed worse survival among rural prostate cancer survivors. We hypothesize that rural patients are more likely to receive a prescription for opioids more than a year after prostate cancer treatment than urban counterparts.

Methods: Our methods include the retrospective cohort study using the Utah Population Database linked with all-payer claims data. More specifically, men with prostate cancer were diagnosed between 2012 and 2017. Also, we reviewed relevant literature that identified health disparities that rural patients have compared to urban patients.

Results: Reviewing this data, we identified 960 rural prostate cancer survivors and matched them to 6,026 urban counterparts. We found that rural survivors are older, more likely to be non-Hispanic white, have higher-stage disease at diagnosis, and forgo initial treatment compared to urban men.

Conclusions: Overall, differences in persistent opioid

use after treatment for prostate cancer do not appear to explain observed differences between rural and urban prostate cancer survivors.

Persistent opioid use was not uncommon ranging from 12.6% to 19.9% and similar between rural and urban survivors. This trend was shown in all three figures; more specifically, patient use of opioids after the three different types of treatment is represented in those figures to interpret the insignificant differences.

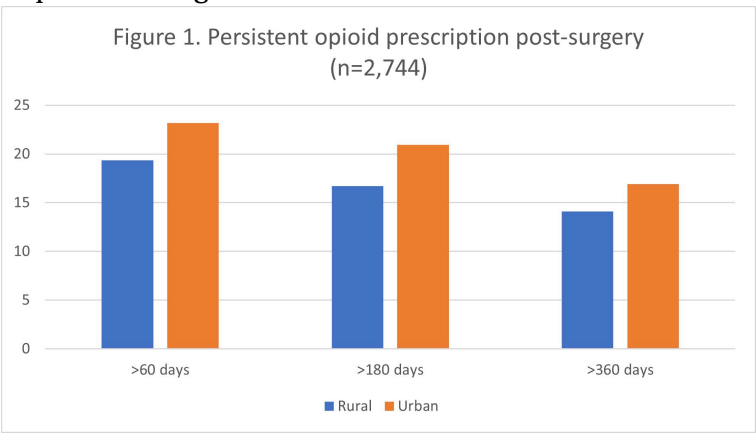

Figure 1. Persistent opioid prescription post-surgery

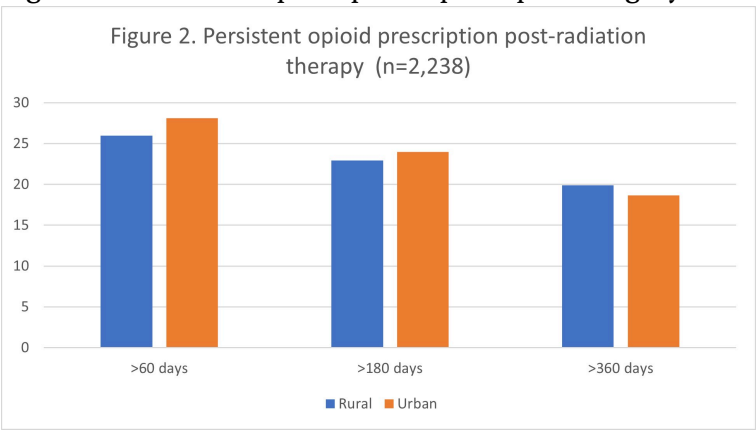

Figure 2. Persistent opioid prescription post radiation therapy

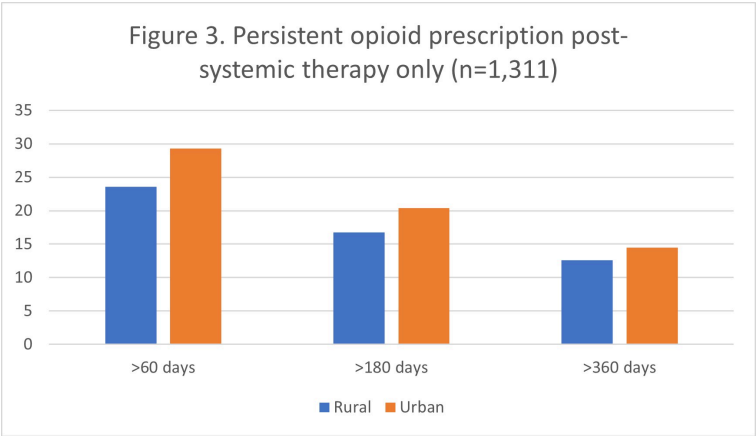

Figure 3. Persistent opioid prescription Post systemic therapy only

Bibliography

Centers for Disease Control and Prevention. (2017, August 29). *Prescription opioids*. Centers for Disease Control and Prevention. https://www.cdc.gov/opioids/basics/prescribed.html

Sullivan, M. D., & Howe, C. Q. (2013, December). *Opioid therapy for chronic pain in the United States: Promises and perils*. Pain. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4204477/

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59.

RESEARCH REFLECTION BY TASHIANNA GRAY

Tashianna Gray

Faculty Mentor: Brock O' Neil (Surgery, University of Utah)

My undergraduate research experience was an enriching and overall thrilling experience. I got to delve into cancer health disparities in rural and urban communities, more specifically in the prostate cancer sector. I also got to collaborate with a medical student cohort, be aware of their current research, and ask relevant questions. My mentor, Dr. Brock O'Neil was engaging and interactive during weekly meetings and while performing surgical procedures. Shadowing in clinical settings with actual patients was a privilege and an experience I will never

forget. Also, my workplace, the Huntsman Cancer Institute, was beautiful and filled with wonderful co-workers who were helpful in navigating Huntsman. I also got to get hands-on experience in the lab learning lab technique and conducting my very own PCR. Overall, my research during SPUR has leveled up my competitiveness for applying to medical school. Also, I have gained confidence in pursuing a medical degree as an African American woman because of the one on one interactions and timely research I participated in this summer. I am appreciative of all the staff, my mentor, and the Reach U2 Cohort coming together so that I may have a memorable experience here in Utah. Thank you.

About the Author

Tashianna Gray

60.

AUTOMATED CENTERLINE AND MESH GENERATION FOR CAROTID ARTERIES: A PYTHON-BASED APPROACH USING VMTK

Charlie Hayward; Xiaodong Ma; and Seyyedkazem Hashemizadehkolowri

Faculty Mentor: Xiaodong Ma (Radiology & Imaging Sciences, University of Utah)

Vessel wall imaging of carotid arteries is crucial in clinical evaluations due to their significant role in supplying oxygenated blood to the brain and their

susceptibility to atherosclerosis and other clinical events [1]. However, the current clinical practices often rely on manual qualitative assessments, which are time-consuming and subject to inter-rater variability. Hence, there is a pressing need to develop automated image processing tools that enable quantitative analysis of vessel wall imaging data. Techniques such as computational fluid dynamics (CFD) analysis, combined with precise thickness measurements, offer valuable insights into stenosis, plaque formation, and disease progression in carotid arteries [2].

This work aims to develop a Python-based pipeline leveraging the Vascular Modeling Toolkit (VMTK) library to generate centerlines and meshes from three-dimensional segmented carotid artery data [3], automatically and efficiently. Automation of this process streamlines workflow and reduces the chance of human error. By automating the centerline and mesh generation, we lay the foundation for extracting and reporting morphological features such as thickness measures and CFD simulations, which are critical for understanding carotid artery behavior and pathology [2]. The developed Python scripts demonstrate the capability for rapid and accurate centerline and mesh generation, streamlining the steps needed to set up CFD simulations as well as facilitation of vessel wall imaging quantitative analysis. In the future we aim to use these tools to evaluate longitudinal vessel wall imaging data on patients with Intraplaque hemorrhage (IPH) to achieve a better understanding of vascular disease progression in the carotid.

References

[1] Zhao X, Li R, Hippe DS, Hatsukami TS, Yuan C; CARE-II Investigators. Chinese Atherosclerosis Risk Evaluation (CARE II) study: a novel cross-sectional, multicentre study of the prevalence of high-risk atherosclerotic carotid plaque in Chinese patients with ischaemic cerebrovascular events-design and rationale. Stroke Vasc Neurol. 2017 Feb 24;2(1):15-20. doi: 10.1136/svn-2016-000053. PMID: 28959486; PMCID: PMC5435211.

[2] Giddens DP, Zarins CK, Glagov S. The role of fluid mechanics in the localization and detection of atherosclerosis. J Biomech Eng. 1993 Nov;115(4B):588-94. doi: 10.1115/1.2895545. PMID: 8302046.

[3] SK HashemizadehKolowri, Nadin Zanaty, Gador Canton, Niranjan Balu, Thomas S. Hatsukami, Chun Yuan. Automated localization of the extracranial carotid artery in black blood contrast MR images using a deep learning approach. In proceeding of ISMRM & ISMRT Annual Meeting & Exhibition, May 2023.

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61.

RESEARCH REFLECTION BY CHARLIE HAYWARD

Charlie Hayward

Faculty Mentor: Xiaodong Ma (Radiology & Imaging Sciences, University of Utah)

In my undergraduate research experience, I was able to broaden my horizons in the field of imaging. Having worked in the past with a PET system working with MRI was a good way to further learn in imaging. I hope to continue in the field of imaging research.

About the Author

Charlie Hayward

62.

CHARACTERIZING METABOLIC AND TRANSCRIPTIONAL CHANGES CAUSED BY AMINO ACID TOXICITY

Grace Makassa Agnes; Kylie Jacobs; and Adam Hughes

Faculty Mentor: Kylie Jacobs (Biochemistry, University of Utah)

Amino acids play an essential role in cell metabolism as the building block of proteins. It is known that amino acid deficiency in cells causes the cell to initiate autophagy, however it is not well understood how they react to

elevated amino acid conditions. Research suggests that elevated levels of amino acids are deleterious to the cell and organismal health, however there is little understanding of how this amino acid toxicity affects metabolic and transcriptional systems in the cell. Certain metabolic disorders such as diabetes and citrullinemia have been associated with elevated levels of amino acids; however many of these metabolic disorders do not have effective treatments beyond dietary restrictions which is why it is important that we understand how amino acid affects metabolic systems. The aim of this research is to investigate how amino acid toxicity affects the metabolic and transcriptional cell systems of budding yeast in order to create new therapies for metabolic disorders. In order to identify proteins involved in evading amino acid toxicity, we generated a library of suppressor strains that resist toxicity. Suppressors are cells that developed a mutation which allows them to grow in conditions that would otherwise be lethal such as high concentrations of amino acids. We generated this suppressor library by plating cells susceptible to amino acids onto high concentrations of each amino acid and selecting colonies that were able to survive those conditions. We then tested all of these strains on high concentrations of amino acids to determine their ability to resist toxic amino acid concentrations. Those that were able to resist the toxic effects of some amino acids, but not all amino acids were selected for further genetic, metabolic, and transcriptional analysis to identify pathways involved in ablating the toxicity of specific amino acids. From whole genome sequencing we were able to identify frameshift mutations in three genes: super histidine resistance 3

(Shr3), BI3, and Gap1. The Shr3 gene is required for the incorporation of amino acid permeases into the plasma membrane through ER chaperoning, a deletion of these gene results in amino acid permeases being stuck in the ER and unable to reach the plasma membrane. BI3 is a mitochondrial mRNA maturase that forms a complex with Mrs1 to mediate Cytochrome B (COB) splicing, a mutation in this gene results in the shortening of BI4 and the improper splicing of COB rendering the cell non-respiratory. Gap1 is an amino acid permease which is normally shuttled to and from the plasma membrane depending on the cell's necessity for amino acids. However, we have developed a Gap1 mutant that allows it to stay on the plasma membrane in order to sensitize the cell to amino acids. These Gap1 mutants in the suppressors are gaining a frameshift mutation which renders our mutant nonfunctional. In the future we plan to recreate these mutations in wild type yeast cells to test how amino acid toxicity affects organelle morphology, its effect on metabolic pathways, and observe localization of amino acid permeases. As this is an ongoing project, we do not yet fully understand how amino acid toxicity causes changes in metabolic and transcriptional functions, but we hope that
further testing will allow us to shed light on this mystery.

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63.

ANALYZING THE ROLE OF TOM70 IN SUPPORTING MDC FORMATION: A RESEARCH REFLECTION

Aryana Merritt-Johnson

Faculty Mentor: Zachary Wilson (Biochemistry, University of Utah)

A research reflection

Upon my acceptance into SPUR, the immediate excitement from family, friends, and even faculty was followed by a questioning look, all questioning the same

thing, "Have you ever even been to Utah?" This question made sense, after all, being born and raised in Washington State, there has been little to no time outside the state without my friends or family for comfort. So, each time my answer was a chuckle laced with nervousness, excitement, and even the tiniest bit of fear followed by a small "No." I had a small idea of what kind of research I was getting into, knowing I would be studying mitochondria in the model organism *S. Cerevisiae*, cool right? The powerhouse of the cell! That in and of itself was a change, having only studied Pacific Madrone genetics and the DNA repair pathway of *Tetrahymena* thermophila, switching to a different organism with research heavy in biochemistry (which I have to admit, I wasn't stellar at) was a little nerve wracking, but even more exciting.

So, I made my way here to Salt Lake City, curious what my three new roommates would be like, if we would get along, and the same about my mentor. I had heard good things about Zach from a professor I worked closely with back home, so I had an idea of what to expect, but as most people know, what you expect, and reality can be completely different. Luckily for me, what I heard was true! Cue the automatic relief. This relief

continued as I met the other members of the Hughes lab, everyone being genuinely friendly and open. The kindness balanced out my nerves, and the sudden weight of expectation that I was feeling seemed a little lighter. At least until I saw the lab. Now, being from a smaller university our labs are still amazing, but this was on a completely different level. About five times the size of my lab back home, and filled with tools and machines I didn't even know existed, the pressure started increasing. I doubted if my work would be up to the caliber of what was expected from this lab. So of course in response, my determination to be a welcome addition to the lab increased tenfold.

Zach and I spent the first couple of weeks just introducing me to the project, going into the background of what research the lab had done previously, and how my project would fit in and contribute to others projects. At first, this was information overload, papers upon papers, wrapping my head around the fact that yes, sometimes the incubation rooms *would* smell like bread, and learning to get the timing right for yeast and bacterial cultures. But eventually I got the hang of it, and even got all the way through my project!

Now, I've been mentioning "the project" but haven't actually explained what I

dedicated my summer to! The Hughes lab focuses around how the organization of cellular proteins and metabolites drives aging and disease. As I've said, my project was centered around the mitochondria, which perform an essential role in numerous metabolic pathways. Defects in mitochondrial function are associated with the progression of several age-related neurodegenerative diseases. The Hughes lab recently discovered a mitochondrial degradation pathway, called mitochondrial-derived-compartments (MDCs) that is induced in response to several cellular stressors, as well as in old-aged cells. The lab has shown that MDCs selectively remove a subset of membrane proteins from the outer mitochondrial membrane and that failure to form these structures exacerbates mitochondrial dysfunction, suggesting that the MDC pathway protects mitochondria in times of stress. The formation of MDCs requires the conserved import receptor Tom70, an outer mitochondrial membrane protein that facilitates the import of hydrophobic proteins into the mitochondria and acts as a cochaperone that assists in reducing the proteotoxicity of aggregation-prone proteins. Currently, the role that Tom70 plays in MDC formation is unknown. This is where my part came in. To analyze the function of Tom70 in MDC formation, we used the budding yeast, *Saccharomyces cerevisiae*, to create genetically mutated strains that expressed either truncated versions of the Tom70 protein, which systematically removed functional

domains, or expressed Tom70 mutations that removed binding to cytosolic chaperones. The results determined that the majority of Tom70 mutations analyzed were unable to rescue the temperature sensitivity of a *tom70*Δ strain and were also unable to support MDC formation. Likely, many of the HA-tagged truncations destabilized the Tom70 protein, and therefore disrupted MDC formation. The plasmids created were found to more stably express Tom70 mutants and the results suggest that Tom70 binding to chaperones is not required for MDC formation.

Overall my research this summer provided an important first step in elucidating key features of Tom70 that are required for MDC formation. Doing this work allowed me to get experience with things I've never done, western blots, sequencing samples to ensure truncations were being made, designing primers, doing Gibson Assemblies to create the plasmids with single point mutations and bigger mutations like taking out the whole chaperone binding domain of Tom70. This summer helped me grow both as a researcher, and in general. I learned how to be comfortable being uncomfortable, being in a different field of research this summer felt like one big learning curve. However not once did I feel like it was a bad thing, or that I wouldn't be able to complete the summer. If anything, being exposed to new research,

techniques, and other aspects helped me adapt more to what I was learning. I also learned a lot about my own love for doing research. It solidified my desire to pursue a Ph.D. and start doing my own projects, no matter how far in the future that may be.

Now, with less than a week left and my project wrapped up, leaving will be bittersweet. I will desperately miss doing research full time in this awesome lab, full of amazing people. People who I asked for advice and help with my project, but also went to the movies with, tried to walk a tightrope with, and commiserated about the heat with. I feel very fortunate to have gotten Zach as a mentor because he made sure that with every experiment or test I knew what the purpose was, and what the result meant. He checked in with me everyday, was patient with my repeated questions, and always made sure I was doing okay. The other lab members were just as fantastic, answering my random questions, giving me memes to hang up on my workbench, and generally just being friendly and approachable in a way I would not have expected from graduate students and postdocs. I will also miss my roommates, while we all worked hard we still made time for family dinners, trips to the water park and various lakes, pizza and movie nights, late

night drives, and lots of fashion shows. Overall, my time here in Salt Lake City has been amazing and while it somewhat hurts to leave so soon, and trips back will definitely be on the horizon, I am looking forward to going home. Thank you for this opportunity.

References for my research

Hughes, A. L., et al., (2016). Selective sorting and destruction of mitochondrial membrane proteins in aged yeast. Elife, 5, e13943.

Backes, S., et al., (2021). The chaperone-binding activity of the mitochondrial surface receptor Tom70 protects the cytosol against mitoprotein-induced stress. Cell reports, 35(1).

Schuler, M. H., et al., (2021). Mitochondrial-derived compartments facilitate cellular adaptation to amino acid stress. Molecular Cell, 81(18), 3786-3802.

English, A. M., et al., (2020). ER–mitochondria contacts promote mitochondrial-derived compartment biogenesis. Journal of Cell Biology, 219(12).

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Aryana Merritt-Johnson

64.

CARDIOVASCULAR DISEASE RISK AMONG RURAL AND URBAN BLACK BREAST CANCER SURVIVORS

Breanka Moore; Mia Hashibe; Esther Chun-Pin Chang; and Bayarmaa Mark

Faculty Mentor: Mia Hashibe (Family & Preventative Medicine, University of Utah)

Cancer is the overgrowth of cells in the body and tumor suppressor genes such as BRCA1 and BRCA2 prevent the development and growth of cancerous cells in the body.

There are more than 4 million breast cancer survivors in the US today. Comorbidities such as cardiovascular disease, diabetes, obesity, high blood pressure, and arthritis can negatively impact breast cancer survivorship. Women of color are 40% more likely to die from breast cancer than Non-Hispanic White women.

Having a comorbidity decreases 5-years relative survival rates and prevents the patient from receiving the full benefits of cancer therapy. The objective of our study is to investigate the risk of cardiovascular disease among rural Non-Hispanic Black (NHB), and Non-Hispanic Whites (NHW) breast cancer survivors compared to their counterparts in the SEER-Medicare data. This study was based on a retrospective population-based cohort of 1,108 rural NHB, 4,702 urban NHB, 23,280 rural NHW, and 75,987 urban NHW breast cancer survivors. Other eligibility criteria that were used to identify the cohort in this study were age at cancer diagnosis >65 years, and diagnosis years 2000- 2017. Rural NHW breast cancer survivors had a higher proportion without baseline comorbidities (56.7%) compared to rural NHB breast cancer survivors (35.5%). Rural NHB breast cancer patients were less likely to receive surgery and radiation therapy, but more likely to receive chemotherapy than rural NHW breast cancer patients. The risk of cardiovascular disease increased significantly among rural vs. urban patients among NHB breast cancer survivors (HR for heart failure NHW=1.20, 95%CI=1.16, 1.24). Cardiovascular disease prevention may thus be important for rural NHB breast cancer survivors. Living in certain populations can impact breast cancer survivorship.

People who live in rural areas lack many resources, are

less likely to be married, education is not higher than high school diploma, and make less than 35,000 a year. While people who stay in urban areas are more likely to be married, have a high school diploma or higher, have access to more resources, and access great insurance. Non-Hispanic blacks are more likely to have baseline comorbidities than non-Hispanic whites because of their fear of going to the doctor, cost of treatments, and lack of transportation, and because of these non-Hispanic blacks are more likely to be diagnosed at later stages than non-Hispanic whites. Non-Hispanic blacks are also more likely to be obese, physically inactive, and have diabetes, and hypertension before being diagnosis with breast cancer.

There are several types of treatment for breast cancer such as chemotherapy, radiation, and surgery. Radiation is more likely to cause heart disease because it must be done directly to the breast, and this can affect the heart's tissue. There are abnormalities found in BRCA1 and BRCA2 from anthracycline that can damage the heart over time. For early prevention, it is important women have their yearly mammograms. Mammograms use small doses of X-Rays to catch cancer early and normally mammograms will detect the breast cancer before a woman starts to notice symptoms such as a breast lump, tenderness, skin irritation, dimpling, nipple discharge, pain, and ulceration. With the assistance of mammograms, and undergoing a thorough physical and history examination, women can receive earlier detection if they are found with breast cancer, or cardiovascular disease. They have a higher chance of different treatment options which can save their lives.

References

Gulati M, Mulvagh SL. The connection between the breast and heart in a woman: Breast cancer and cardiovascular disease. Clin Cardiol. 2018 Feb;41(2):253-257. doi: 10.1002/clc.22886. Epub 2018 Feb 15.PMID: 29446841; PMCID: PMC6489752.

Williams, M.S., Beech, B.M., Griffith, D.M. *et al.* The Association between Hypertension and Race/Ethnicity among Breast Cancer Survivors. *J. Racial and Ethnic Health Disparities* **7**, 1172–1177 (2020). https://doi.org/10.1007/s40615-020-00741-7

Qingqing Hu, PhD and others, Disparities in Cardiovascular Disease Risk Among Hispanic Breast Cancer Survivors in a Population-Based Cohort, *JNCI Cancer Spectrum*, Volume 5, Issue 2, April 2021, pkab016, https://doi.org/10.1093/jncics/pkab016

Association, A. H. (2020, February 19). What women need to know about breast cancer and heart disease. *American Heart Association* . Retrieved from https://www.heart.org/en/news/2020/02/19/what-women-need-to-know-about-breast-cancer- and-heart-disease

Institute, U. o. (2023). Non-Modifiable Risk Factors. *University of Ottawa Heart Institute* . Retrieved from https://pwc.ottawaheart.ca/awareness/heart-health-portal/risk-factors/non-modifiable-risk- factors

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65.

RESEARCH REFLECTION BY BREANKA MOORE

Breanka Moore

Faculty Mentor: Mia Hashibe (Family & Preventative Medicine, University of Utah)

My undergraduate research experience was amazing. I was able to learn, make mistakes, and grow all in one summer. This research experience allowed me to make the right connections that will help open the right doors to get into the medical field in the near future.

About the Author

Breanka Moore

66.

KINETICS OF VIBRIO CHOLERAE ANTIBODY RESPONSES AMONG CHOLERA PATIENTS IN GOMA, THE DEMOCRATIC REPUBLIC OF CONGO

Carmen Nieznanski and Kilee Davis

Faculty Mentor: Daniel Leung (Internal Medicine, University of Utah)

Introduction

Cholera is a diarrheal disease that continues to burden

vulnerable populations globally, primarily due to inadequate water and sanitation infrastructure. Understanding the kinetics of antibody responses elicited by Vibrio cholerae infection will inform estimation of disease burden by serosurveillance methods and targeting and timing of future vaccination efforts.

Methods

Patients presenting to cholera treatment centers in Goma, the Democratic Republic of Congo (DRC), with acute watery diarrhea between August 2020 and Mar 2022 were enrolled in the study and blood samples were collected during follow-up home visits approximately one week, four weeks, and six months after symptom onset.

Results

Out of the 1057 total collected samples, we performed vibriocidal assays against O1 Inaba and O1 Ogawa on 84 serum samples from patients with culture-confirmed V. cholerae infection (n= 35; 46% Male; 54% Female, Median age 8 (IQR 3-14), for which two or more timepoints were available; 26 of those 84 samples had a month six timepoint. Preliminary data analysis indicates that vibriocidal antibody responses were highest at the first collected timepoint (Ogawa Geometric Mean titers 105, range 5-10240), with a non-significant decrease in titers by week four (GM 96, 5-5120) and significantly lower titers at six months (GM 12, 5- 160).

Conclusions

Our findings highlight the potential that cholera patients in different regions of the world may have differing kinetics of antibody response, and by extension, potential differences in duration of immunity after infection or vaccination. Further studies into the kinetics

of cholera antibody responses may inform the timing of vaccination campaigns and interpretation of serosurveillance results. Further analysis, including of additional serum samples, and stratification by vaccination status, age, and disease severity, are pending

About the Authors

Carmen Nieznanski

Kilee Davis

67.

RESEARCH REFLECTION BY CARMEN NIEZNANSKI

Carmen Nieznanski

Faculty Mentor: Daniel Leung (Internal Medicine, University of Utah)

My undergradute research experience has been extremely fulfilling. As I've worked on this project with fellow peers and colleagues in the lab under the mentorship and supervision of Dr. Daniel Leung, I've developed a love and a passion for research. Actively participating in this project has made me realize that my future career would lack fulfillment if research wasn't permanently a part of my life as a doctor and a professional. It is now my aspiration to apply to the University of Utah's MD/PHD program so that I can

continue to learn and apply scientific tools to answer important questions in the field of medicine with the help of other professionals in the field. Without this, I cannot imagine being a great and proficient doctor. During my time in the lab and as I've diligently applied myself to this project, I've gained invaluable experience and I've learned a crucial skill that will forever aid me in all future pursuits, especially in medicine: the skill of humbly and passionately ask questions. I've always wanted to be the kind of doctor who remains humble and curious no matter how much education I accumulate. Research is the ideal environment to exercise those skills. I'm extremely excited to pursue research for the rest of my career and I can thank my time as an undergraduate researcher for igniting that passion and excitement.

About the Author

Carmen Nieznanski

68.

STRUCTURAL MOTIFS OF EXCITATORY SYNAPSES IN THE MAMMALIAN RETINA

Taylor Otterness; Crystal Sigulinsky; James R. Anderson; and Bryan W. Jones

Faculty Mentor: Crystal L. Sigulinksy (Ophthalmology, University of Utah)

Purpose

Connectivity within the nervous system is precise and disruptions lead to degraded performance and disease, yet the rules that govern connectivity largely remain unknown. Recent efforts reveal that distinct types of cone bipolar cells in the neural retina show preferences in the selection and frequency of presynaptic structure types

used for signal transmission (Sigulinsky *et al*., 2020; Yu *et al*. 2023). However, it is not yet known how these differences are related to the quantity or type of postsynaptic partner. We used Retinal Connectome 1 (RC1) to analyze the synaptic output of rabbit CBb6 cells, a type of ON cone bipolar cell that forms excitatory synapses via diverse presynaptic structure types, to identify patterns in how these cells interact with their postsynaptic partners.

Methods

RC1 is a 0.25 mm diameter volume sampled from mid-peripheral retina of a 13-month-old female Dutch-Belted rabbit, serially sectioned at 70 nm, and imaged at ultrastructural resolution (2nm/px) using transmission electron microscopy (Anderson *et al*., 2011). Postsynaptic partners of CBb6 cell 6156's presynaptic structures were annotated using the Viking Viewer for Connectomics. Statistical analyses were conducted in Microsoft Excel and investigated further with 3D rendering and graph visualization of connectivity.

Results

The factors tracked for comparison included presynaptic structure type, target number, and postsynaptic partner type. Cone bipolar cells use 3 types of excitatory chemical synaptic structures: single ribbons, multiribbons, and ribbonless synapses (Figure 1A-C). Single ribbons have 1 ribbon, multiribbons have >1 ribbon, and ribbonless structures lack a ribbon but have ⩾2 synaptic vesicles tethered to the presynaptic membrane.

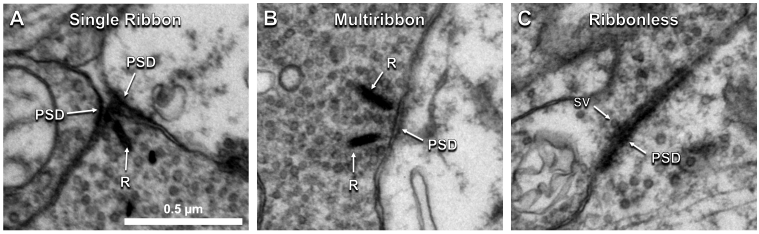

Figure 1. Cone bipolar cells form diverse presynaptic structure types. A) Single ribbon, B) multiribbon, and C) ribbonless presynaptic structure types observed at cone bipolar cell excitatory synapse sites in the rabbit retina. Abbr: R, ribbon; PSD, postsynaptic density; SV, synaptic vesicle.

The distribution of all excitatory presynaptic structures on CBb6 cell 6156 was modeled in 3D space and did not show a clear pattern in the distribution of presynaptic structure type based on depth or organization of the axonal arbor (Figure 2A-A'). Most presynaptic structures were located in the ON inner plexiform layer. The proportions of synapses of each presynaptic structure type with 1, 2, 3, or 4 postsynaptic partners were tracked and compared, which showed that multiribbon synapses of 6156 trended towards having a greater number of output partners (Figure 2B). Specifically, multiribbons overall had a greater proportion of 2 partner outputs (dyads) than 1 partner outputs (monads). Previous hypotheses proposed that presynaptic structure types may differ in the strength of neurotransmitter release (ribbonless < single ribbon < multiribbon). However, 3 partner and 4 partner outputs were only found opposing single ribbon presynaptic structure types (Figure 2C). These findings are inconsistent with scaling of output to the number of postsynaptic targets.

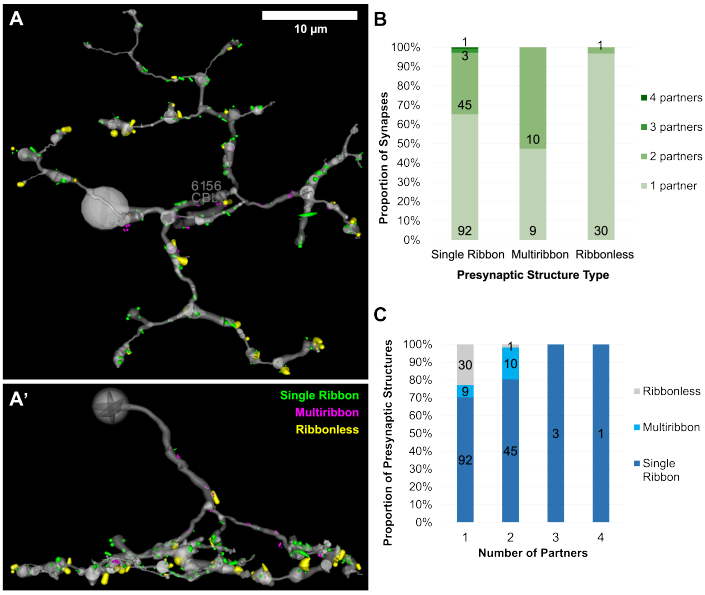

Figure 2. Distribution and relationships of presynaptic structure types of CBb6 6156. A) Top down (XY) view of the 3D rendered axonal arbor of CBb6 cell 6156 (gray) and presynaptic structures of its excitatory output synapses: single ribbon (green), multiribbon (magenta), and ribbonless (yellow). Structures scaled by a factor of 2 for visualization. A') Side (XZ) view. B-C) Proportion of synapses of each presynaptic structure type with 1, 2, 3, or 4 postsynaptic partners.

Both amacrine cells (AC) and ganglion cells (GC) are postsynaptic partners of CBb6 cell 6156. However, single ribbon and ribbonless structures appear biased towards AC only targets at individual synapses, while multiribbon synapses appear biased towards having mixed AC and GC targets at individual synapses (Figure 3). In one case, cell 6156 served as the presynaptic partner synapsing with

AC 5575 in five different locations. The fact that four of the five synapses in this partnership were multiribbons further supports the idea that postsynaptic partner type plays an important role in presynaptic structure selection with a high level of specificity.

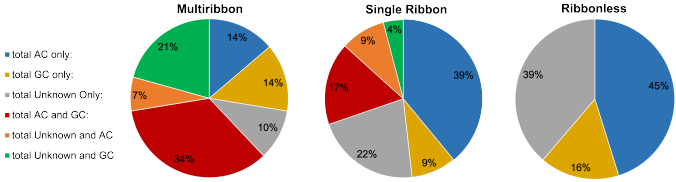

Figure 3: Partner classification proportions by presynaptic structure type. This figure does not account for quantity of output partners, therefore a presynaptic structure falling under the "AC only" output(s) category could have a single AC partner or multiple. Since ribbonless synapses did not form any dyads in this cell, they have fewer possible graphical categories.

Conclusion

It is hypothesized that presynaptic structure types may differ in the strength of neurotransmitter release (ribbonless < single ribbon < multiribbon), but the data collected for cell 6156 is inconsistent with such scaling of output to the number of postsynaptic targets. The data suggests that target type relationships may be more important than the number of targets in determining presynaptic structure type in CBb6 cells. This is consistent with recent work suggesting that cone bipolar cells in the mouse retina are also biased in their presynaptic structure type according to postsynaptic partner type (Yu *et al.*, 2023). Future efforts will incorporate size differences of

postsynaptic structures and presynaptic ribbon size, as well as compare across bipolar cell classes, in order to elucidate connectivity rules underlying excitatory synapses in retina.

Acknowledgements

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References

Anderson, J. R., Jones, B. W., Watt, C. B., Shaw, M. V., Yang, J. H., Demill, D., Lauritzen, J. S., Lin, Y., Rapp, K. D., Mastronarde, D., Koshevoy, P., Grimm, B., Tasdizen, T., Whitaker, R., & Marc, R. E. (2011). Exploring the retinal connectome. Molecular vision, 17, 355–379.

Sigulinsky, C., Anderson, J. R., Kerzner, E., Rapp, C., Pfeiffer, R. L., Rodman, T. M., Emrich, D., Rapp, K., Nelson, N. T., J. Scott Lauritzen, Meyer, M., Marc, R. E., & Jones, B. W. (2020). Network Architecture of Gap Junctional Coupling among Parallel Processing Channels in the Mammalian Retina. The Journal of Neuroscience, 40(23), 4483–4511.

Yu, W.-Q., Swanstrom, R., Sigulinsky, C., Ahlquist, R. M., Knecht, S., Jones, B. W., Berson, D. M., & Wong, R.

(2023). Distinctive synaptic structural motifs link excitatory retinal interneurons to diverse postsynaptic partner types. Cell Reports, 42(1), 112006–112006.

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69.

RESEARCH REFLECTION BY TAYLOR OTTERNESS

Taylor Otterness

Faculty Mentor: Crystal L. Sigulinksy (Ophthalmology, University of Utah)

I was fortunate to be warmly welcomed in to the Jones Laboratory (The MarcLab for Connectomics) at Moran Eye Center and provided the opportunity to explore retinal circuitry and neural plasticity in the context of retinal disease. This project and others I have completed through the Jones/Marc lab have deepened my knowledge of synaptology and neurological disease mechanisms. I had the opportunity to attend and present a poster on this project at the 2023 Association for Research in Vision and Ophthalmology (ARVO) Annual Conference and attend

lectures and poster presentations at the cutting edge of visual science. Doing Research at the Moran Eye Center has improved my ability to think flexibly and critically as well grown my skills in communicating nuanced information to generalized audiences, which will serve me as I pursue my education and career. I am so grateful to have been able to learn and grow alongside some of the most industrious, resilient individuals I have ever met, and I will strive to continue to learn from their example and knowledge.

About the Author

Taylor Otterness

70.

REFLECTION ON UNDERGRADUATE RESEARCH EXPERIENCE

Jonah Simmons

Faculty Mentor: Kanokwan Bunsawat (Internal Medicine, University of Utah)

During the summer of 2023 I participated in the Summer Program for Undergraduate Research (SPUR) under the mentorship of Dr. Kanokwan Bunsawat at the Utah Vascular Research Lab (UVRL). In the first three years of my undergraduate career, I worked in clinical research and the opportunity to continue broadening my experience in that field was what pulled me to join the team at the UVRL. Despite my familiarity with clinical

research, I broadened my scope of knowledge and skills beyond what I anticipated, even now I continue to learn new things in the lab every day. In my time at the UVRL I have learned various techniques, including the use of ultrasound, to measure and analyze vascular function. I have watched what goes on behind the scenes of a study from conception of the research question to publication in a journal. As an aspiring physician-researcher, I believe I gained useful knowledge that will benefit me as my career goes on.

About the Author

Jonah Simmons

71.

ADHERENT-INVASIVE E. COLI SIPHOVIRUS PROPHAGE EXCISION IS INDUCED DURING MURINE INTESTINAL COLONIZATION

Morgan Smoot; June Round; and Nicole Pershing

Faculty Mentor: Nicole Pershing (Pediatrics, University of Utah)

Background

Inflammatory Bowel Disease (IBD) is an autoimmune

disorder characterized by inflammation of the intestinal tract. Imbalance in the bacterial or viral microbiome has been associated with IBD. Bacteriophages are viruses that infect bacteria, and prior work has shown bacteriophages can stimulate intestinal immune responses even in the absence of their bacterial host. 1 Bacteriophages in the gut can be produced when bacteriophage integrated into bacterial genomes, or prophage, are induced to excise from the bacterial genome and produce viruses. Determinants of prophage induction remain unknown. We sought to characterize excision of three identified prophages in an IBD-associated E. coli pathotype, Adherent Invasive Escherichia coli (AIEC), in mouse models of intestinal colonization and colitis.2

Methods

We utilized polymerase chain reaction (PCR) to screen bacterial colonies for integration and excision of three possible prophages identified in the NC101 AIEC genome: a Myoviridae (MV), a Siphoviridae (SV), and an Inoviridae (Ino) type bacteriophage. Colonies were screened from fecal and tissue samples from (i) germ-free mice monoassociated with NC101 and (ii) specific pathogen-free mice colonized with NC101 followed by induced colitis.

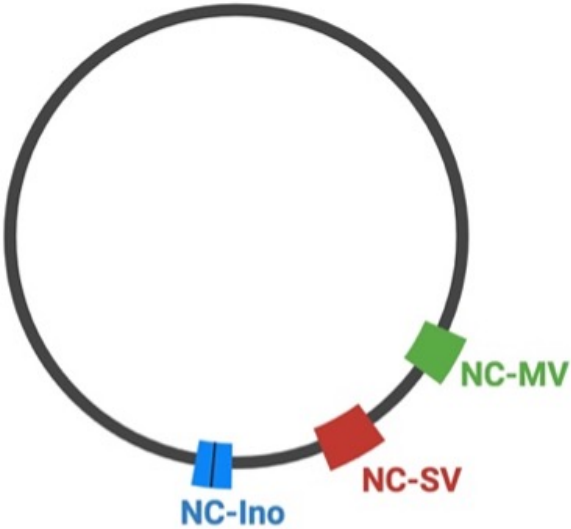

Figure 1 – Genomes of three intact putative prophage were identified in the E. coli NC101 bacterial genome.

Results

Following mouse gut colonization, we detected spontaneous excision of the SV prophage from the NC101 genome. No spontaneous excision of the NC-Ino or NC-MV prophages was identified. We did not observe significant differences in the rate of SV prophage excision between colonies screened during colonization versus colitis. To quantitatively assess prophage induction and identify bacteriophage abundance, we designed a quantitative polymerase chain reaction (qPCR) strategy to quantify bacterial genomes with integrated versus excised, and recirculated phage genomes for the Ino and MV phages; design of SV phage qPCRs is ongoing.

Conclusions

We have described spontaneous excision of the Siphovirus prophage from the AIEC strain NC101 during

in vivo gut colonization of mice. Future directions characterizing AIEC prophage excision dynamics will utilize qPCR to quantitatively assess prophage induction following macrophage infection in vitro, and in vivo during gut colonization and intestinal inflammation.

References

1. Gogokhia, L., Round, J. PMC 2021
2. Pamela, C. et al. BMJ 2018;67:574-578

About the Authors

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72.

RESEARCH REFLECTION BY MORGAN SMOOT

Morgan Smoot

Faculty Mentor: Nicole Pershing (Pediatrics, University of Utah)

My undergraduate research has been incredibly fulfilling and has helped me realize that science is not linear. There will be trials and errors that will require more time and attention. These principles are applicable to my future career and education as things may not always go as planned, but it is important to press forward.

About the Author

Morgan Smoot

73.

ROLE OF FAMILIES IN COMBUSTIBLE TOBACCO PRODUCT USE AMONG IMMIGRANT YOUTH FROM AFRICA AND THE MIDDLE EAST

Naomi Q. Thombs; Ola Onigbogi; and Kola Okuyemi

Faculty Mentor: Dr. Ola Onigbigi (Family & Preventative Medicine, University of Utah)

Abstract

Immigration can lead to environmental, social, and

economic disruptions in families. Immigrant families who arrive in the United States from Africa and the Middle East also experience these changes which can result in residency in low-income areas with experiences of health disparities. The separation of the family unit due to inability of some family members to obtain entry visas to the US and the expectation of integration into a new culture also pose challenges to members. There is also the possibility of disruptions in leadership structure due to a sudden attempt at replacing the extended family structure prevalent in many African and Middle Eastern cultures with the American nuclear family arrangement. We therefore sought to determine the role of the family in combustible tobacco product use among Immigrants from Africa and the Middle East who currently live in the Greater Salt Lake City area. We hypothesized by the use of the social learning theory of modeling, positive or negative reinforcement, and the experiential learning theory of experience that families play a role in the initiation, maintenance and cessation of smoking among immigrant youth.

Introduction

Immigrant families in the United States (US) experience social, cultural and economic disruptions which can lead to changes in health-related decision making. An understanding of the effect of these disruptions on health may help in planning effective interventions. We therefore sought to determine the role of the family in combustible tobacco product use among US immigrants from Africa and the Middle East.

Materials/Methods

Results/Discussion

There were 14 respondents from Somalia, five from Senegal, three from Ethiopia and one from Ghana who all identified as Muslims. Respondents understood the concept of family in four contexts namely, biological, national/cultural, religious, and racial relationships. Four themes were identified on the effect of families on initiation and cessation of tobacco smoking: (1) Family structures – breakdown of traditional headship of families due to loss of members; (2) Family role models – due to distrust of the official system and unfulfilled expectations; (3) Early financial independence of immigrant youth; (4) impulsiveness in decision making among immigrant youth. All participants agreed that Ramadan presented a good opportunity for introduction of tobacco cessation programs although the Islamic religion prescribes no particular
punishment for culprits.

Conclusion

Our study found out that with respect to tobacco smoking, the perception of family was in this order: biological; cultural; religious; racial relationships. These findings highlight potential roles for families in the understanding of and addressing tobacco use in this population.

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74.

RESEARCH REFLECTION BY NAOMI THOMBS

Naomi Q. Thombs

Faculty Mentor: Dr. Ola Onigbigi (Family & Preventative Medicine, University of Utah)

The Summer Program for Undergraduate research has been a great introduction to the world of Research. My experiences with my mentors provided me great direction and perspective for all possible future endeavors in the field of healthcare. I was able to participate hands-on in all dimensions of a research project and the experience was more insightful than I could have imagined. Leaving this program I feel confident displaying all of my newly earned skills, and enhancing them through other future opportunities.

About the Author

Naomi Thombs

SECTION VIII

COLLEGE OF MINES & EARTH SCIENCES

75.

OUTLINE OF LAST ICE AGE GLACIERS IN CENTRAL-WESTERN WYOMING

Marcus Tanner

Faculty Mentor: Dr. Leif Anderson (Geology and Geophysics, University of Utah)

During the last Ice Age, many of the mountain ranges in the western United States were covered with glacial ice in the form of glaciers and ice caps. These glaciers grew because, (probably put climate cooled first here) as the climate cooled, the elevation above which snow accumulation exceeds ablation, or the Equilibrium Line

Altitude (ELA), dropped below the topography as the climate cooled. When the climate warmed at the start of the current interglacial period, these glaciers began to retreat and eventually disappear because the ELA rose above the landscape and annual snow accumulation could no longer overcome the increasing ablation rate. The evidence of these glaciers' presence remains in the depositional and erosional landforms they left behind, the most notable of which are loose deposits of rock called moraines and "U-shaped" valleys. This study aims to find these features in the mountains of central-western Wyoming and use them to create outlines of glaciers as they appeared during the last Ice Age. Specifically, our region of interest (ROI) includes the full extents of the Wyoming and Salt River Ranges, as well as portions of the Salt River Range, the Tetons, and the Gros Ventre Range. These outlines are given a confidence rating based on how much evidence the glacier left behind, and the highest confidence outlines are used to create estimates for local ELAs using an assumed Accumulation Area Ratio of 60/40. Determining past glacial extent allows for more accurate estimates of paleoclimate during the last ice age based on glacier modeling. These models will provide a better understanding of how glaciers react to warming climates over longer timescales and more diverse ELA conditions than we can infer from the active glaciers of today. We observed evidence for 329 distinct paleoglaciers with a total area of 1387.96 km2, including indications of a previously undocumented ice cap across parts of the Wyoming Range. We also observed a preference for larger glaciers across ranges with more high-elevation topography. Studying where these glaciers were and what

they left behind will allow for more accurate predictions of how modern glaciers and the landscapes they inhabit might evolve in the face of ongoing anthropogenic climate change. These outlines will also be added to a living database that tracks glaciation from the last Ice Age across the western United States and will be used in future research to further investigate how different landscapes changed during the last glacial period and how they continue to evolve during the present interglacial period.

About the Author

Marcus Tanner

76.

RESEARCH REFLECTION BY MARCUS TANNER

Marcus Tanner

Faculty Mentor: Dr. Leif Anderson (Geology and Geophysics, University of Utah)

Undergraduate research has opened my eyes to the breadth of opportunities and experiences that exist in the world of academia. My experience has given me the chance to learn how to apply various computer programs and field methods to collect and analyze data, which are skills that will aid me in pursuing a career in science.

About the Author

Marcus Tanner

77.

USING AUTOMATED SEEPAGE METERS TO QUANTIFY SURFACE WATER INFLUENCE ON HIDDEN VALLEY SPRINGS

Tyler Yoklavich

Faculty Mentor: Kip Solomon (Geology and Geophysics, University of Utah)

Abstract

Springs in Hidden Valley adjacent to the Jordan River, Bluffdale Utah are used for

water supply but their source areas are not known. To quantify possible surface water influence on these springs, novel automatic seepage meters were deployed at regular intervals (15 m) throughout a 400 meter transect of the East Jordan irrigation canal located approximately 45 m to the east of the springs. 256 automatic seepage meter measurements were made in order to estimate a mean groundwater seepage flux (q) in cm/day for the canal. This value, in conjunction with geometric measurements of the canal and previous hydrogeologic evaluations of spring recharge zones, were used to estimate a volumetric seepage rate (Q) from the canal that may be a source of water to the springs. The mean seepage flux (q) for the canal is -0.87 ± 2.14 cm/day. Applying this seepage flux to a 3.4 km reach of the canal that lies within the spring's presumed recharge zone, and an average canal width of 6.1 ±0.9 m results in a maximum possible volumetric seepage rate of 181.3 ±444.4 m3/day (0.07 ±.18 CFS). The springs have a mean flow of 2,200 m3/day (0.9 CFS), a low flow of 11 m3/day (0.0045 CFS), and a high flow of 8560 m3/day (3.5 CFS). A maximum of 5% of annual spring flow may be accounted for by water loss from the nearby irrigation canal. Traditional differential flow

measurements at the site showed no statistically significant seepage from the canal. Thus, the lower resolution traditional measurements are consistent with the higher resolution seepage meter results.

1 – Introduction

Hidden Valley Springs are a collection of developed groundwater springs in the Jordan River Valley near Bluffdale, Utah. They lie approximately 200 m East of the Jordan River, and 45 m West of the East Jordan Irrigation Canal. The canal is approximately 20 m higher in elevation than the springs. The springs are used as a source of drinking water to a nearby Non- Transient Non-Community Water System. The purpose of this study is to investigate the East Jordan Irrigation Canal as a possible water source to Hidden Valley Springs.

The East Jordan Irrigation Canal's proximity to the springs and location upgradient identifies it as a possible source of spring water. To investigate potential seepage losses, a variety of traditional methods can be employed, the most common of which is differential flow gauging (DFG). DFG entails conducting stream flow measurements at multiple points along the canal's reach using an ultrasonic flow meter or similar instrument, and comparing measurements to estimate the volume of water being lost or gained due to groundwater interference between measurement points. This is the most commonly used method for measuring stream seepage.

However, these measurements have large associated uncertainties, low spatial resolution, and variations in stream flow that

are identified may be related to evapotranspiration or other factors unrelated to direct groundwater interactions. Ultrasonic flow measurements were conducted in line with the southern-most spring, and 1 km downstream, with assistance from Bert Stolp of the United States Geological Survey.

Flow measurements showed a differential of +1.5 CFS, with 55.45 CFS recorded at the upstream location and 56.96 CFS at the downstream location. Propagating the uncertainty reported for each measurement by the Ultrasonic Flow Meter produces an uncertainty of ±2.02 CFS, indicating that the reported difference in streamflow is within the uncertainty of the measurements. The uncertainty is also two times greater than the mean flow of the springs. Error reported by the meter itself is based on calibrations conducted in laboratory conditions during the development of the device. Further uncertainty can be attributed to potential human error during the measurement, relatively few measurements being conducted, and factors aside from direct groundwater influence that are captured by the technique such as evapotranspiration. Hydrologists typically attribute 3-5% error to Ultrasonic Flow measurements, with 3%

being the standard for optimal measurement conditions. Conditions for the measurements were not ideal, so attributing 5% error results in an uncertainty of ±2.8 CFS. Both the uncertainty reported by the instrument and that which would be subjectively attributed are much greater than the 0.9 CFS mean discharge of the springs of interest. Therefore, DFG results were considered inconclusive regarding the influence of canal seepage on the springs.

A novel method of quantifying groundwater seepage using automatic meters was developed by Dr. Kip Solomon and colleagues, as described in Solomon et al. (2020). The automatic seepage meters directly measure the vertical specific discharge (q) for soft bottom streams, rivers, and other surface water features. This method has lower associated uncertainties than DFG, since it can record stream stage measurements to a precision of ± .1mm, takes measurements over much larger time-scales, and allows for multiple measurements along a stream transect to be taken simultaneously. Taking a high number of measurements to assess repeatability of results is also feasible with the automatic meters. Since DFG was inconclusive for the East Jordan Irrigation

Canal, automatic seepage meters were deployed for greater precision.

2 – Site Description

2.1 – Bedrock and Structural Geology

The Traverse mountains in the vicinity of Hidden Valley Springs consist of Mississippian and Pennsylvanian age bedrock that was intensely fractured and folded by regional compression during the Sevier Orogeny 175 million years ago. The Laramide Orogeny followed, during which bedrock was thrusted eastward and mountains were uplifted in Western Utah. Concurrently, rising sea levels flooded interior North America and created an inland sea, which accumulated sediment eroded from uplifted mountains. The depositional environment transitioned from marine (salt water) to lacustrine (fresh water) to fluvial (river) by early Tertiary time (56 million years ago). Subsequent relaxation of mountain building forces created normal faults and other structural weaknesses in the earth's crust. The Wasatch Intrusive Belt formed 35- 50 million years ago, with magma rising into subsurface bedrock along structural weaknesses. Basin and Range east to west extension started about 15 million years ago, creating numerous north-south trending normal faults such as the Wasatch Fault. As a result of regional extension, basins formed where sedimentary deposits accumulated, and fault block

mountain ranges like the Wasatch and Oquirrh mountains were created. (Biek, 2005a, 2005b)

2.2 – Surficial Geology

The springs are located near the Traverse Mountains, which separates the south part of Salt Lake Valley from the north part of Utah valley. The Jordan Narrows is an incised river valley that bisects the Traverse mountains and contains the Jordan River. The Jordan River flows northward out of Utah lake in Utah Valley, through the Jordan Narrows into the Salt Lake Valley, and terminates at the Great Salt Lake. (Biek, 2005b) The East Jordan irrigation canal is a man- made diversion of the Jordan River that flows in parallel to the river. The canal is generally active from early spring to late fall, and flow is regulated by a series of pumps at the river diversion to maintain consistent levels.

Salt Lake and Utah Valley are composed of Quaternary and Tertiary age valley-fill sediments that were eroded from the surrounding mountains and deposited in the valley. The valley-fill sediments exhibit a wide range of grain sizes, with the coarsest sediments typically found near the mountain front and major drainages, and finer sediments such as clay and silt more prevalent toward the center of the valley. Throughout Quaternary time (the last 2.5

million years), regionally-extensive lakes such as lake Bonneville intermittently filled Salt Lake and Utah Valley. Generally, thick and extensive lacustrine clay and silt deposits accumulated during periods of lake expansion, and coarser deposits accumulated when the lakes contracted. The cycling of lake extent in response to climatic changes over Quaternary time resulted in the current valley stratigraphy of alternating and interfingering layers and lenses of sediment with differing grain sizes. Thus, the valley-fill sediments possess high horizontal and vertical heterogeneity in grain size and hydraulic conductivity. (Loughlin, 2021)

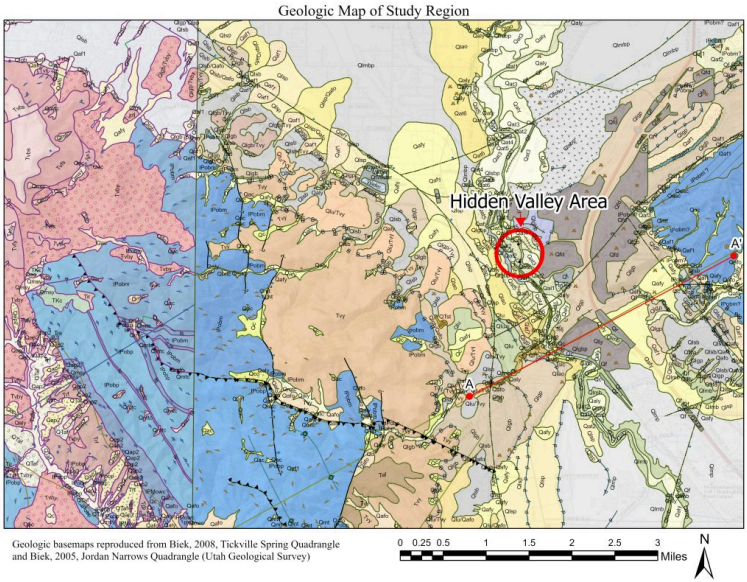


Figure 1. Geologic map of the study region. The springs

lie in the Jordan Narrows, Utah 7.5- minute quadrangle. The Jordan Narrows is a river valley that bisects the east and west Traverse Mountains. It is composed of unconsolidated Quaternary deposits of alluvial and lacustrine origin atop Carboniferous bedrock that was folded and fractured by the Sevier Orogeny. Geologic basemaps reproduced from Biek 2005a, and Biek 2008 (Utah Geological Survey).

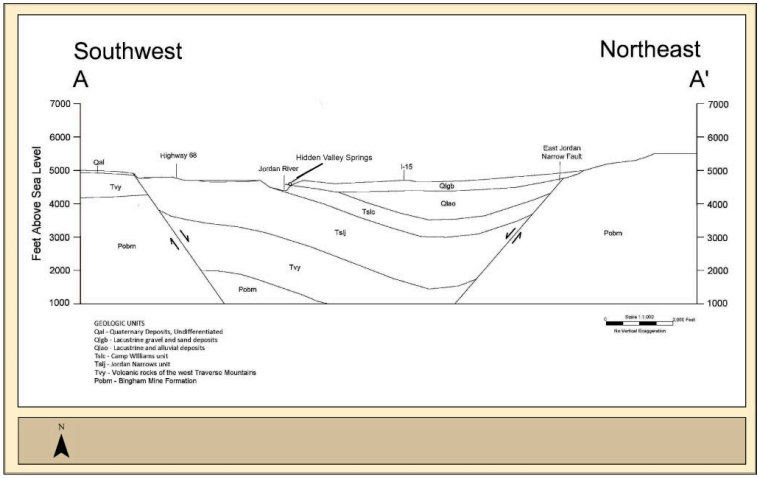


Figure 2. Geologic cross section A-A'. Illustrates the subsurface geology in the vicinity of the springs. The Jordan River Valley is bordered on each side by the Bingham Mine Formation and east-west trending normal faults. Interfingering lenses of lacustrine and alluvial deposits overlie the graben. Reproduced from Biek geologic cross-section, 2005a.

2.3 – Geochemistry

Hidden Valley contains 6 springs in total, with high geochemical variability throughout the system. Previous environmental tracer,

stable isotope, and major ion chemistry evaluations showed that Springs A-D possess the "youngest" water, having recharged less than 5 years ago. They also note that the stable isotope signature of water discharging from Springs A-D plots similarly to that of the Jordan River, with a highly evaporated signature. Springs E-F plot on the Local Meteoric Water Line, indicating that their water is derived from precipitation with little evaporation occurring (Solomon, 2021). In response, this study focuses on the irrigation canal as a potential source of water to springs A-D, and assumes that springs D-F have deeper flow paths, older recharge, and are recharged primarily by precipitation.

Solomon (2021) examined the geochemistry of springs A-D and concluded that a mixing of 24% irrigation water with 76% natural groundwater could explain the observed geochemical makeup. However, recent longitudinal sampling has shown that the Jordan River, and in turn the irrigation canal, have high seasonal variability in stable isotope composition and major dissolved ions. Springs A-D have a relatively consistent stable isotope signature that is intermediate among values observed in the Jordan River. This may suggest the river/canal as a primary source of water, with significant dispersion/mixing

occurring between recharge and discharge. Seepage analysis serves as a more direct assessment of whether the irrigation canal in the area directly adjacent to the springs is providing water to the springs.

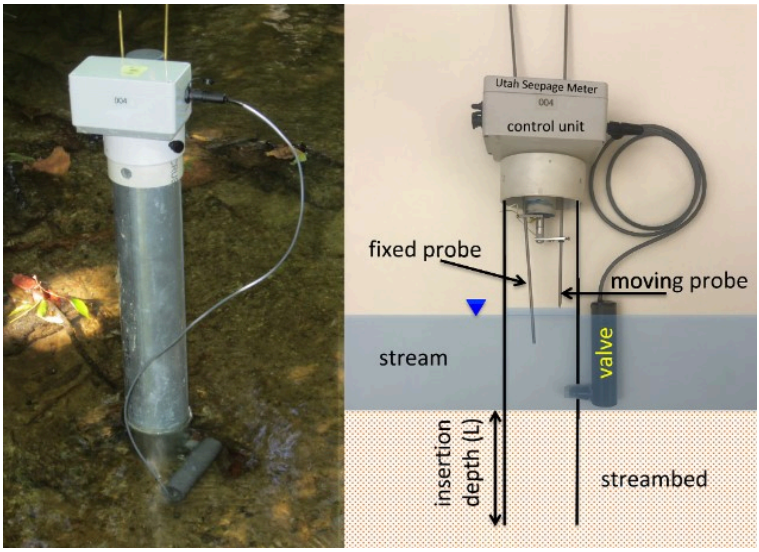
3 – Methods

3.1 – Theory

The automatic seepage meters measure the vertical specific discharge (q) of a surface water feature by measuring change in water level over time. A thin-walled tube is driven 30-50 cm into the streambed, and a control unit is affixed to the top of the tube. The tube has a hole below the stream level, where a valve is placed. Before seepage measurements are taken, the valve is set to open, allowing the water level in the tube to equilibrate with the stream stage. The height of the initial stream stage is measured 10 times and recorded. The valve then closes, and the water level in the tube changes (upwards for a gaining stream, downwards for a losing stream) over time. A linear actuator and metal probe within the control unit measures changes in the water level, and writes the data to an SD card within the control unit. Water level measurements are taken every 30 seconds. After a set number of measurements is taken (50 in this case), the valve reopens so that the final stream stage can be measured. The test is then automatically repeated until the meter is manually switched off, or runs out of battery.

Figure 3. Photo and diagram of the seepage meter. The control unit is affixed to the top of a thin-walled tube that is inserted 30-50cm into the streambed. The valve in the side of the tube is initially open, allowing the water level in the tube to match the stream stage. The valve then closes, and the water level in the tube changes (upwards

for a gaining stream, downwards for a losing stream) over time. A linear actuator and metal probe within the control unit measures these changes to the water level, and writes the data to an SD card within the control unit. Reproduced from Solomon et al. (2020).



Evaluating seepage rates is based on combining a water balance equation with Darcy's law. Once data is extracted from the SD card, a water level vs time graph is generated. Changes in stream stage outside the tubing during the duration of the test are accounted for based on the initial and final stream stage measurements taken by the meter when the valve is open. The slope of the water level vs time graph evaluated at time = 0 is a direct measure of the seepage rate in the stream, and is independent of the hydraulic conductivity of the streambed. A full description of the theoretical basis behind the seepage meter's design can be found in Solomon et al. (2020).

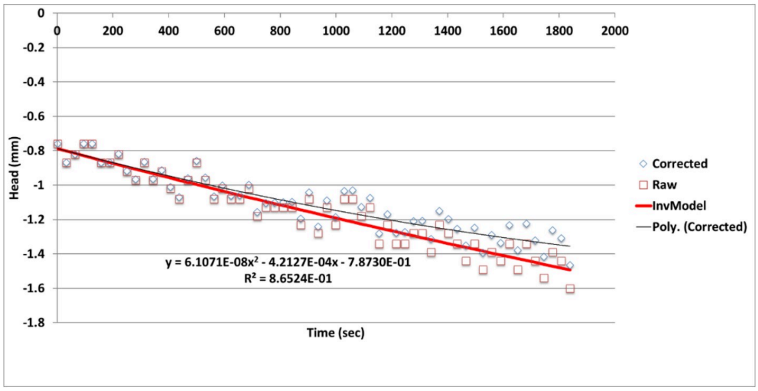


Figure 4. Example data recorded by a seepage meter during a measurement (R3-5). The water level in the tube in mm is plotted against time since the valve opened in seconds. Data points are corrected to account for fluctuations in stream stage throughout the measurement. A polynomial is fit to the data points obtained, and seepage flux (q) is estimated as the slope of the polynomial at t = 0 (-.035 m/day).

3.2 – Study Design

Seepage flux measurements were taken along a 400 m transect of the canal directly adjacent to the springs. A preliminary set of measurements were taken with one seepage meter in the center and one seepage meter near each bank to determine if seepage varied between the canal's center and edges. The preliminary run showed little variation between measurements, so for the full study all measurements were taken in the center of the canal, equidistant from both banks. For the full study, the first meter was placed directly in-line with spring 1, and subsequent meters were placed at 50 ft (15.24 m) intervals, beginning at the north end of the transect and moving southward. Measurements were taken over the

course of 4 non-consecutive field outings, with multiple meters being deployed simultaneously during each field outing. Measurements were taken for 3-12 hours, with some transects being measured continually overnight and others being deployed and collected within the same day. For data presentation, measurement points have been labeled based on the field outing ("run") they were a part of, and what number the meter was in relation to others. For example, R2-1 was a part of run 2 (the second field outing), and was the northern-most meter in the sequence during that run. Figure 6 presents a detailed map of measurement points in relation to the springs.

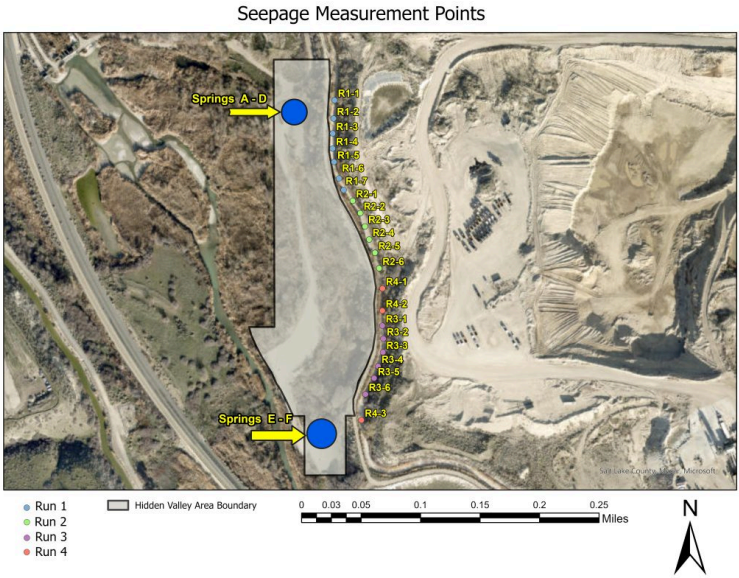


Figure 5. Map of canal measurement points and adjacent springs. Each color group represents points that were measured simultaneously during one field outing. Measurement points were situated in the center of the canal, around 15 meters apart from one another. Seepage

measurements were taken throughout the portion of the canal that lies within the Spring's 3 year time-of-transit zone identified by Horrocks engineers.

Figure 6. Seepage meters in operation at the field site on the first day of measurements. Measurements were taken over the course of four non- consecutive field outings, with one transect being measured during each outing. Measurements for each transect were taken simultaneously over the course of 2-12 hours.

4 – Results

4.1 – Mean Seepage Flux (q)

Seepage fluxes were recorded at each measurement point 5-20 times depending on the time available for each field outing. Each measurement point produced an average seepage flux (q), with attributed uncertainty taken as the standard error of all measurements made at that point. The total representative seepage flux for the canal is obtained by calculating the arithmetic mean of all measurement point fluxes. Overall uncertainty is obtained

by propagating the standard error of each measurement point average through the overall average calculation. The representative canal seepage rate was -0.87 ±2.1 cm/day, meaning that on average throughout the study area 0.87 cm of water height was lost per day to the ground. Spatial variability was greater than the mean seepage value, but was still quite small, with only 9.1 cm separating the highest and lowest seepage value recorded.

Table 1. The mean seepage flux obtained from each meter, and associated uncertainty values. Each meter performed multiple tests at the same measurement point. Mean seepage flux is the arithmetic mean of flux values recorded at that individual point over the measurement period (typically 5-7 hours). Uncertainty is calculated by taking the standard error of each measurement, and propagating that uncertainty through the averaging of fluxes at that point. *Note: R3-1 produced anomalous results, and has been omitted.* The overall representative seepage flux for the canal is obtained by calculating the arithmetic mean of all measurement point fluxes. Overall uncertainty is obtained by propagating the standard error of each measurement point average through the overall average calculation, and multiplying the standard error by 2.96 to produce a 95% confidence interval.

Meter/ Measurement Point	Mean Seepage Flux, q (cm/d)	Uncertainty +/- (Standard Error)
R1-1	-0.12	0.96
R1-2	-1.52	0.12
R1-3	-0.78	0.22
R1-4	-1.19	0.11
R1-5	-0.75	0.19
R1-6	3.63	0.51
R1-7	-1.47	0.29
R2-1	-1.15	0.93
R2-2	-0.28	0.51
R2-3	-0.35	0.27
R2-4	1.31	1.14
R2-5	-0.40	0.15
R2-6	-0.34	0.08
R3-2	-0.48	0.06
R3-3	-2.37	0.08
R3-4	-0.46	0.11
R3-5	-3.53	0.07
R3-6	-5.51	0.09
R4-1	0.15	0.19
R4-2	-0.15	0.48
R4-3	-2.62	0.77
Overall:	-0.87	2.08

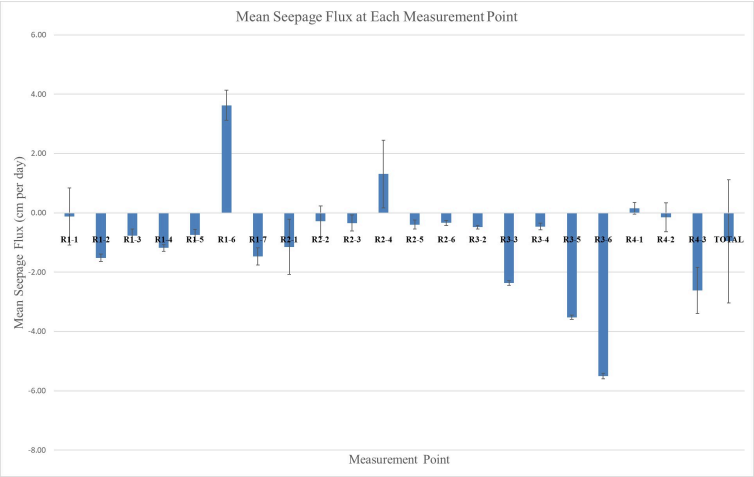


Figure 7. Mean seepage flux for each measurement point along the study reach. While some measurement points recorded a positive (gaining) seepage value, a majority of measurement points demonstrated a small amount of negative (downward) seepage. The two points with upward flow may be the result of hyporheic flow, wherein water that has seeped from the canal further upstream discharges back into the canal. Uncertainty, obtained from the standard error calculation above, is presented as error bars.

4.2 -Volumetric Seepage Rate(Q)

To estimate the volumetric seepage rate from the canal and into Hidden Valley Springs (Q), the area of canal within the springs presumed recharge zone is multiplied by the representative seepage flux (q). A spring delineation performed by Horrocks engineers in 2021 identified the recharge zone to extend several kilometers east into the Traverse

mountains, and a few kilometers south of the springs. ArcGIS was used to measure the length of canal within the recharge zone, 3400 m. 3% error (±102 m) was attributed to the length measurement. ArcGIS was used to measure the width of the canal, which was found to be 6.1 m on average. 15% error (±.92 m) was attributed to the width measurement to account for places in the canal's reach that were more wide or narrow than average. Multiplying the canal area by the representative seepage rate for the canal (.0087 ± .021 m/day) and propagating associated uncertainties yields a volumetric seepage rate of 181.3 ± 444.4 m3/day (0.07 ±.18 CFS). Assuming the irrigation canal is operational for 6 months per year produces an annual seepage volume of 3.32 X 104 m3/year.

4.3 – Estimating Proportion of Spring Flow due to Seepage

The proportion of flow through springs A-D that may be attributed to canal seepage is estimated by comparing the total annual flow through the springs in 2021 to the estimated annual seepage volume. Flow data from 2021 was utilized since it is the highest resolution annual flow data on record. Applying 181.3 m3/day as the volumetric seepage rate (Q)

and assuming the typical yearly canal runtime from April 15th to October 15th (183 days), yields an annual seepage volume of 3.32 X 104 m3/year. The 2021 total annual flow through Springs A-D was 6.38 X 105 m3/year. Dividing the seepage input by the total flow yields 5.2%. **This indicates that a maximum of 5% of spring flow can be accounted for by seepage losses from the nearby canal.** Several assumptions are made in this calculation regarding spring recharge, groundwater flow paths, and spatial/temporal uniformity, discussed below.

5 – Discussion

5.1 – Assumptions and Limitations

Estimating the proportion of spring flow that is due to seepage losses from the canal involves several assumptions. Firstly, the presumed recharge area identified by Horrocks engineers may be disparate from the true recharge zone due to subsurface heterogeneity and the presence of fractured bedrock in the vicinity of the Traverse mountains. It is also unlikely that all canal seepage within the recharge zone discharges at springs A-D, since some likely discharges at the Jordan River and other seeps in the area. Further subsurface characterization, such as the installation of groundwater monitoring wells to contour hydraulic head would be

necessary to determine more precise flow paths in the area. The canal also has relatively high spatial heterogeneity in seepage, and it is possible that locations further along the canal's course may have higher or lower seepage rates than that identified in this study. Assessing temporal variability in seepage was outside the scope of this study, but since the canal is dry for the winter, refilled in the spring, and fully saturated throughout the summer, it is possible that seepage rates vary throughout the irrigation season. The higher than typical statistical noise recorded during this study also increases the uncertainty associated with the estimates considerable. **Due to these assumptions and limitations, the 5% estimate is considered the maximum possible proportion of spring flow that may be attributed to the canal**

Data recorded by seepage meters during this study generally possessed higher uncertainty and statistical noise than in previous field applications. After noting the high uncertainty in data from the first few field outings, plastic hand screws were used to affix the meter's housing to the metal tubing more securely. This reduced statistical noise in future tests, but did not fully remediate the high uncertainty. Potential

sources of higher than typical variability include vibrations from the gravel mining operations and freeway nearby. Future seepage meter application in the area could emphasize reducing statistical noise to produce a lower uncertainty analysis.

The third transect of the canal that was measured (run 3) produced significantly lower uncertainty and statistical noise than runs 1, 2, and 4. The average seepage rate for run 3 was also larger than other runs, at -2.5 cm per day ±.18 cm. Applying this seepage rate to the full 3.4 km reach of the canal within the springs recharge zone, and propagating the associated uncertainty results in a volumetric seepage rate of 512.1 m3/day ±87.4 m3/day (0.21 ±.04 CFS). This discharge value is within with the uncertainty range of the discharge rate calculated for the whole canal (0.07 ±0.18 CFS), demonstrating parity between the higher certainty run and the overall study results. The canal reach measured in run 3 has the highest seepage rate of any transect in the study, and provides a snapshot of the upper end of seepage variability throughout the canal.

5.2 – Statistical Analysis

Simple statistical analysis was applied to study results to estimate the uncertainty attributed to the seepage data. Since a high

number of measurements were conducted at each measurement point, the standard error of seepage values recorded at each point was utilized as uncertainty. The standard error is appropriate, as it allows the repeatability of seepage values to determine how representative measurements were of the true mean seepage. Uncertainty was propagated through all calculations conducted including averaging to determine mean flux at each point, averaging to determine the total representative seepage rate, and multiplication to turn the mean specific discharge value into a volumetric seepage rate. The uncertainty in total mean seepage rate, calculated via the standard error, was multiplied by 1.96 to produce a 95% confidence interval, meaning there is a 95% chance that the value range presented includes the true mean seepage rate throughout the study area.

The goal of this study was to identify whether the canal is a primary source of water to Hidden Valley Springs. While these estimates contain inherent assumptions and uncertainties, it is very likely that true seepage is of similar magnitude to what this study estimates. Thus, it is unlikely that the canal is a primary source of water to the springs.

6 – Summary & Conclusions

Novel automatic seepage meters were applied to an irrigation canal in Bluffdale, Utah in order to evaluate canal seepage as a source of recharge to the Hidden Valley springs. The seepage meters provide: (1) An estimate of the representative seepage flux for the canal (q), (2) an estimate of the annual volumetric seepage flux (Q), and (3) quantify the potential influence of canal seepage losses on nearby springs.

The mean seepage flux for the canal was -0.87 ±2.1 cm/day. Applying this seepage flux to a 3.4 km reach of the canal that lies within the spring's recharge zone, and an average canal width of 6.1 ± 0.9 m, results in a maximum possible volumetric seepage rate of 181.3 ± 444.4 m3/day (0.07 ± 0.18CFS). Assuming 6 months of canal runtime (April 15th-October 15th), this would result in an annual volumetric seepage of 33,200 m3. Springs A-D have an annual flow of 638,000 m3, which indicates that a maximum of 5% of annual spring flow may be accounted for by seepage losses from the canal. It is unlikely that all canal seepage to groundwater in the 3.4 km transect enters the springs, so this estimate is considered an absolute maximum.

The 2021 Hidden Valley Springs Geochemistry study noted that the seasonal

uniformity in stable isotopes for Spring A, along with the high seasonal variability in Jordan River stable isotopes means that substantial dispersion may be occurring between recharge and discharge for spring A. This suggests that spring water may be taking a longer flow path than that necessary to discharge from the area evaluated in this study. In the future, it may be useful to take seepage measurements much further south along the canal's reach in order to determine if seepage is higher in those areas. High canal seepage further upstream may explain why the geochemical makeup of springs A-D suggests Jordan River water as a primary source despite low seepage occurring directly adjacent to the springs. Discussing this study with the East Jordan Canal Company may help determine whether the entire canal has been lined with clay to prevent seepage, or if some areas upstream have been left unsealed.

Although measurable seepage from the canal does occur in the study area, seepage losses are unlikely to be a primary contributor of flow to the springs. **These results imply that it is not necessary to make the irrigation canal a primary consideration in Drinking Water Source Protection plans for the springs. Rather, potential primary spring contamination vectors include**

subsurface pollution within the spring's recharge zone, which extends east of the springs, throughout the adjacent gravel/sand mining operations, and into the East traverse mountains.

Bibliography

[1] Biek, R.F., 2005a, Geologic Map of the Jordan Narrows Quadrangle, Salt Lake and Utah Counties, Utah: Utah Geological Survey Map 208, Map scale 1:24:000.

[2] Biek, R. F, 2005b, The Traverse Mountains; New Geologic Maps and Explosive Suburban Growth. *Utah Geol. Miner. Surv. Notes*, *37*(1), 1-5.

[3] Robert F. Biek, 2008, Geologic map of the Tickville Spring quadrangle, Salt Lake and Utah Counties, Utah. M-214dm. UGS. 1:24,000 scale.

[4] Bowen Collins and Associates, (2021) Camp Williams Water Source Report, Consultant's report prepared by BC&A for UTNG ERM

[5] Bowen Collins and Associates, (2021) Hidden Valley Springs Geochemistry Study, Consultant's report prepared by BC&A for UTNG ERM

[6] CH2MHill, (2003) Delineation Report associated with Drinking Water Source Protection Plan for Hidden Valley Springs: Consultant's report prepared by CH2MHill of Salt Lake City, UT for UTNG ERM

[7] Loughlin W., (2021) Updated Delineation Report for DWSP For Hidden Valley Springs Nos. 1 Through 6. PWS No. Utah18054, Consultant's report prepared by Loughlin Water Associates for UTNG ERM

[8] Solomon, D. K., Humphrey, E., Gilmore, T. E., Genereux, D. P., & Zlotnik, V. (2020). An automated

seepage meter for streams and lakes. Water Resources Research, 56(4), e2019WR026983.

[9] Solomon, D. K. (2016). Analysis of Environmental Tracers in Hidden Valley Springs, Letter report to Bowen Collins & Associates, Dec. 2016.

[10] Solomon, D. K. (2021). Continued Analysis of Environmental Tracers in Hidden Valley Springs, Letter report to Bowen Collins & Associates, Feb. 2022

Appendix A: Raw Data Recorded in Study

For future reference, the raw .txt files recorded by seepage meters during this study have been archived online. They can be accessed on the Harvard Dataverse online data repository with this link.

About the Author

Tyler Yoklavich

78.

RESEARCH REFLECTION TYLER YOKLAVICH

Tyler Yoklavich

Faculty Mentor: Kip Solomon (Geology and Geophysics, University of Utah)

My undergraduate research experience was a great opportunity to practice skills that will be useful in my academic and professional careers alike. It exposed me to field work, data analysis, and technical writing that I otherwise would not have been able to take part in. It will be an excellent resume builder and an experience that future work can be built on.

About the Author

Tyler Yoklavich

SECTION IX

COLLEGE OF NURSING

79.

"I'M AT THE MERCY OF THE PRICE OF FOOD": THE IMPACT OF INFLATION ON FINANCIAL TOXICITY IN CANCER IMMUNOTHERAPY PATIENTS

Irene Liang and Djin Tay

Faculty Mentor: Djin Tay (Nursing, University of Utah)

Immunotherapy treatments have become the standard of care in the treatment of advanced solid cancers including lung cancer and head and neck cancers.

Financial toxicity is well documented in cancer immunotherapy patients due to their high cost and the need for many cancer patients to continue on them long-term, even until the end-of-life. Immunotherapy patients' financial toxicity may be exacerbated by historic inflation in the past two years that has dramatically increased the cost of everyday items such as food and gas. No studies have yet examined the additional impact of recent inflation on cancer-related financial toxicity. As such, this study evaluated the additional impact of inflation on financial toxicity in cancer patients undergoing immunotherapy and their caregivers. Patient-caregiver dyads were recruited from the lung and head and neck cancer clinics at the Huntsman Cancer Institute. Eligible patients, who were 18 years of age or older, had advanced cancers and had received or were receiving immune checkpoint inhibitors, and their caregivers were recruited from the Total Cancer Care caregiver registry. Audio-recorded semi-structured interviews exploring broad areas of unmet need were conducted at baseline and at 6 months. Two researchers qualitatively coded transcriptions of interviews with a focus on financial toxicity by applying deductive codes based on Jones et al. (2020) Model of Financial burden After Cancer Diagnosis in NVIVO R1. Nineteen patient- caregiver dyads were recruited. Patients were 41-81 years old. Most were treated with Pembrolizumab, White and Non-Hispanic, and insured through Medicare or private insurance. The most commonly applied codes were a participant's receipt of support from the cancer center, insurance or cancer support organizations (n=37), dissatisfaction with their financial situation (23 counts), financial stress related to

medical costs (21 counts), and financial stress from non-medical costs (16 counts). Financial struggle was evident among those most impacted. . Inflation impacted psychological burdens associated with non-medical financial burden, with the rising cost of gas, housing, and food presenting significant challenges. Younger dyads, particularly those without Medicare, were observed to be more affected by financial toxicity, with lifestyle trade-offs and uncertainty about their future commonly identified. These findings have implications for financial toxicity as an unmet supportive care need of cancer patients and their families during this period of inflation.

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SECTION X

COLLEGE OF PHARMACY

80.

EFFECTS OF CARBON SOURCES ON SECONDARY METABOLITE PRODUCTION IN TEREDINIBACTER TURNERAE

Marina Gerton; Eric Schmidt; and Bailey Miller

Faculty Mentor: Eric Schmidt (Medicinal Chemistry, University of Utah)

Shipworms are wood-digesting marine bivalves that rely upon symbiotic bacteria for cellulose digestion. The symbiotic bacteria, which grow intracellularly in shipworm gill tissue, produce cellulases that are then

transported to the shipworm's cecum. It has also been hypothesized that the bacteria produce antibiotics, exported to the cecum with the cellulases, to prevent microbial glucose scavenging upon cellulose digestion, thus making the bacteria medicinally interesting. While various species of bacteria can form symbioses with shipworms, the most well-characterized is Teredinibacter turnerae, in part due to the success of in-lab culturing. Nonetheless, the lab growth conditions are significantly different from the in situ environment, as the physical conditions of intracellular growth are incredibly difficult to replicate with flask or fermenter culturing and the chemical conditions would require complex and potentially expensive media.

Since physical and chemical growth conditions both affect microbial metabolism, these conditions also affect growth patterns and secondary metabolite production. To investigate these effects, various growth conditions (such as presence of cytosolic compounds and carbon source, among others) were manipulated to study how they might impact secondary metabolite production of the bacteria. Compounds produced by the bacteria were isolated, purified via HPLC, and analyzed using NMR and mass spectrometry. By more closely replicating the growth conditions found in the bacteria's natural environment, and generally changing conditions known to impact metabolic activity, it may be possible to promote the production of antibiotics that are not seen under standard culture conditions.

Additionally, while T. turnerae has primarily been utilized in the natural products world, its cellulolytic properties ensure that its utility extends beyond

pharmaceuticals. As such, complex cellulose-containing carbon sources were tested, ranging from paper to corn husks, to determine, broadly, whether such sources could be digested and whether known high-value compounds would still be produced by the bacteria. The investigation thus holds implications not only for natural products, but also for sustainability and second-generation biofuel production efforts.

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81.

BIOCOMPATIBILITY OF MICELLAR AND LIPOSOMAL FORMULATIONS OF HYDROPHOBIC DRUGS FOR USE WITH EXTRACORPOREAL MEMBRANE OXYGENATION (ECMO) CIRCUITS

Jane Staples; Nitish Khurana; Kamiya Watkins; Debika Ghatak; Venkata Yellepeddi; Kevin Watt; and Hamidreza Ghandehari

Faculty Mentor: Nitish Khurana (Pharmaceutics & Pharmaceutical Chemistry, University of Utah)

Extracorporeal membrane oxygenation (ECMO) is a cardiopulmonary bypass device used for critically ill patients with refractory heart and lung failure. Although the technology is lifesaving, dosing information for ECMO supported patients is highly variable. Dosing can differ for ECMO patients because the ECMO circuit components can adsorb the drugs, resulting in suboptimal drug exposure. Hydrophobic drugs are extremely vulnerable to getting adsorbed on the ECMO circuits, due to interaction of hydrophobic drugs with hydrophobic surfaces of ECMO circuit components. Micellar or liposomal encapsulation of the drug can reduce adsorption. The hydrophobic drug is packaged within the hydrophilic shell so that hydrophobic interactions with ECMO circuit components are minimized. The goal of this study was to optimize micelle and liposomal formulations of the hydrophobic drugs propofol, a common anesthetic, and furosemide, a diuretic and test their biocompatibility. Propofol and furosemide were encapsulated in triblock copolymers forming micelles: Kolliphor® P 407 Geismar (P407 MP) or Kolliphor® P 188 Geismar (P188 MP), as well as the following lipids to form liposomes (LP): Dipalmitoylphosphatidylcholine(DPPC), cholesterol, and PEG 2000. Size and polydispersity (PDI) were characterized using Dynamic Light Scattering. Cytocompatibility and hemocompatibility of the formulations were analyzed in human macrophages and human plasma, respectively. Size and low PDI of P407

propofol (25nm; 0.007), P188 propofol (27nm; 0.243), liposomal propofol (141nm; 0.200), P407 furosemide (11nm; 0.020), P188 furosemide (4nm; 0.040), and liposomal furosemide (85nm; 0.200) demonstrated low polydispersity. All formulations were cytocompatible and hemocompatible. These formulations can be tested in an ex-vivo ECMO for their adsorption profile.

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SECTION XI

COLLEGE OF SCIENCE

82.

DEVELOPMENT OF NEW TOOLS FOR THE STUDY OF SUPERCONDUCTIVITY AT EXTREME CONDITIONS OF TEMPERATURE AND PRESSURE

Mason Burden; Audrey Glende; Willis Holle; Julia St. Andre; Jason Chang; and Shanti Deemyad

Faculty Mentor: Shanti Deemyad (Physics & Astronomy, University of Utah)

Introduction

Superconductors are materials with the unique properties of zero DC electrical resistance and perfect diamagnetism. However, the operating conditions of superconductors are currently limited to either very low temperatures or high pressures – conditions which obscure their wider application. The holy grail of condensed matter physics and material science is a superconductor that operates in ambient conditions. The realization of such a material would be revolutionary. Although we know of many superconducting materials, we do not have a universal theory for how they operate. To develop a theory of superconductivity, one path is to construct a form of dimensional phase space from known samples by analyzing their pressures, temperatures, currents, and unit cell parameters at the point they become superconductive. In doing so, we lay out a path to discovering novel materials to harness phenomena in increasingly ideal environments.

The goal of this research is to provide a comprehensive metric to analyze properties of superconductors, which allows for reliable measurements and helps develop and test for a universal theoretical model of superconductivity. One of the most important metrics modernly used to develop this understanding has been the modulation of a sample's pressure. Unfortunately, the apparatuses required for applying such immense pressure are bulky and consequently bring their own complications. To achieve the required pressures for some superconductive samples, a Diamond Anvil Cell (DAC) is used. This device takes advantage of the roughly inverse relationship between area and pressure by placing the

sample between the tips of two diamonds of low area to maximize pressure.

The problem arises when trying to take useful measurements while applying pressure. The DAC physically surrounds the sample and interferes with any mechanical interface used to operate with the sample. Common forms of measurement of superconducting properties such as Scanning Tunneling Microscope (STM) or Angle-resolved photoemission spectroscopy (ARPES) become impossible as they require physical interaction with the sample to be of use. Other techniques can be used – such as DC Four-Probe measurements and AC Magnetic Susceptibility – but they require very precise electronic circuits to be built in or around the DAC. Though these measurements are useful, they can be enhanced using complimentary measurements.

Fortunately, while diamonds are the hardest naturally occurring material, they also happen to have the immensely useful property of being completely transparent to light in and around the visible spectrum. The table of the diamond operates as an optical window pointing directly through the heart of the diamond anvil and onto the sample, even under immense pressure. Through this window, a plethora of optical measurements can be taken. For this work, Raman spectroscopy will be of greatest emphasis.

Raman spectroscopy can be used to measure the superconductive gap. This gap is essentially the energy disparity between electrons and cooper pairs [1]. At the critical temperature of superconductivity (TC), it becomes energetically favorable to form Cooper pairs as the energy gap is zero. Below TC, the energy gap increases in favor

of Cooper pairs [1]. This gap can be measured using electronic Raman spectroscopy [3], providing useful insights into superconductive samples.

Raman spectroscopy is a form of optical measurement used to analyze the low frequency vibrational mechanical or electrical oscillations of a system. This is done by firing a laser of a set frequency and measuring the offset of the wavelength of the light scattered from the sample. Three signature frequencies of light will be scattered from the sample, namely the Rayleigh scattering, Stokes Raman scattering, and anti-Stokes Raman Scattering [2]. Rayleigh scattering is simply the light of the same wavelength of our laser. Useful information is stored in the energies of the two other forms of scattering, but they occur at a far lower rate than that of Rayleigh scattering; an occurrence which makes readings much more difficult to achieve. Thus, the apparatus for measuring Raman must be of great precision to absorb enough light to make significant measurements. It is notable that for superconductors the anti-stokes scattering will not occur.

For most Raman setups, this is accomplished by designing systems with extremely short working distances (the distance the focal plane sits away from the last lens). Doing so increases the numerical aperture (the maximal angle a system will accept light from) which increases the percent of light available for collection. This short working distance does not integrate well with DACs, as the sample lies outside the working distance of most Raman spectroscopy systems. Incorporate the massive cryostat structure required for low temperature measurements, and conventional Raman becomes near impossible.

Methods

To address the current sizable disparities in working distance and the distance required by our removed focal plane. We spent time using parabolic mirrors as a solution, but encountered issues with alignment, so we devised n alternative solution. This work proposes a secondary lensing system to extend the working distance of the primary instruments. This solution unfortunately decreases the numerical aperture and proportionally the light received by the sample. To accommodate the extended working distance, a higher-powered laser and a bandpass filter of finer precision can theoretically be used to increase Stokes and Anti-Stokes scattering counts.

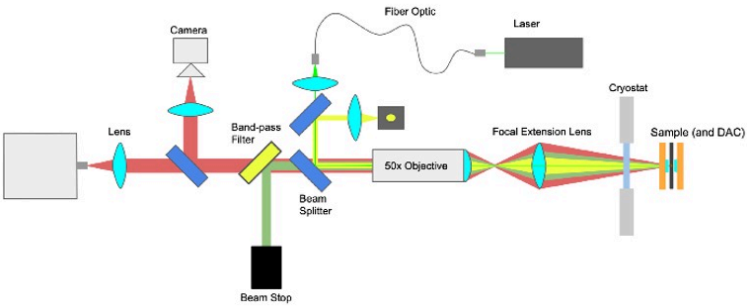

Figure 1. A model of a standard Raman system with modifications to allow for long-distance spectroscopy.

The “Focal Extension Lens” in Fig. 1 is the central focus of this project. By aligning the focus of the extension lens between the focal length of the fifty times objective and twice that same distance we can extend the working distance of our lens. Through careful alignment and construction, long distance microscopy can be realized. This level of clarity can be observed in figures 2 and 3 below.

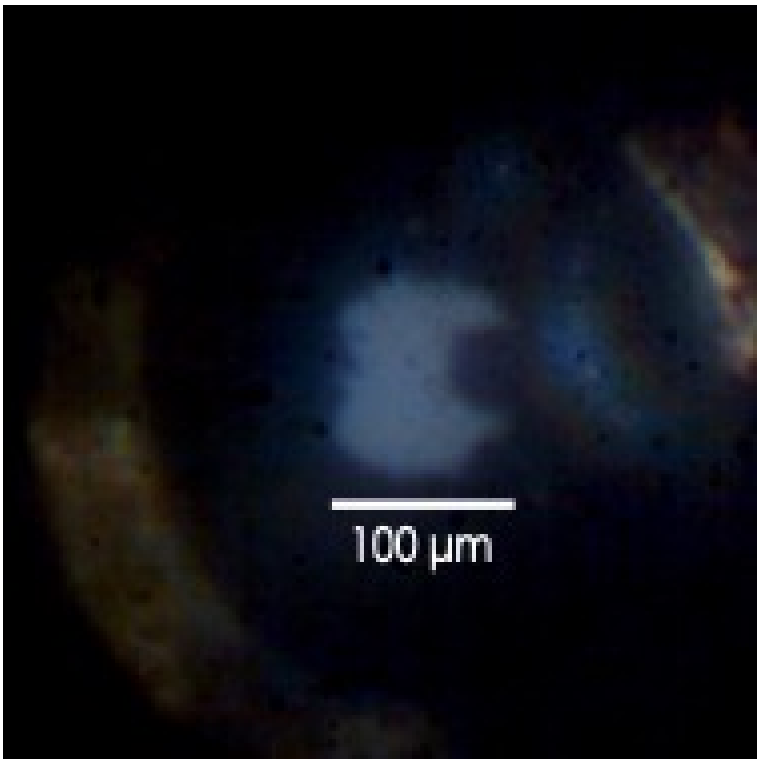

Figure 2. Image of a DAC loaded with ruby sample, taken with a working distance of around three inches.

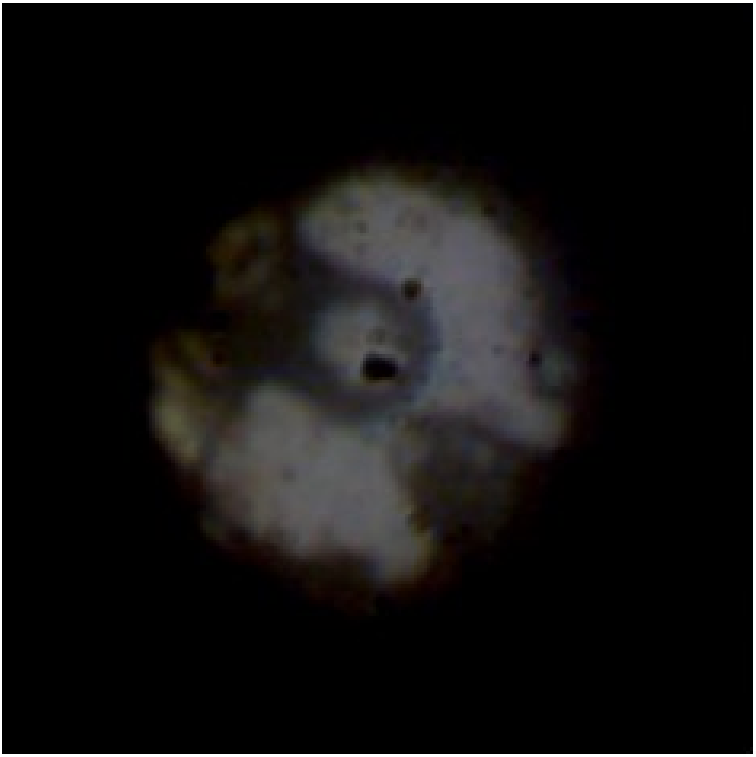

Figure 3. Image of a DAC loaded with a CeO2 sample, taken with a working distance of around three inches.

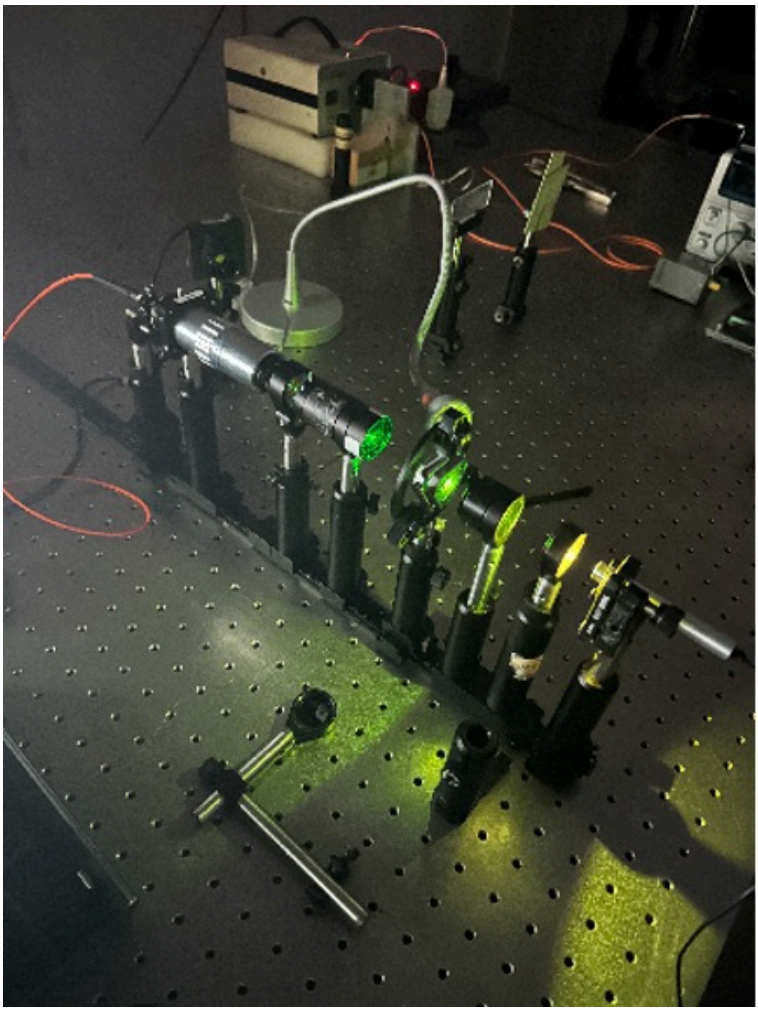

Figure 4. Image of the Raman system in an earlier prototype phase, taking an image of a DAC.

A preliminary test of the system's effectiveness and alignment was taken using the DAC featured in Fig. 2. A fluorescence reading was used for visual calibration and alignment, the results of which can be seen in Fig. 5.

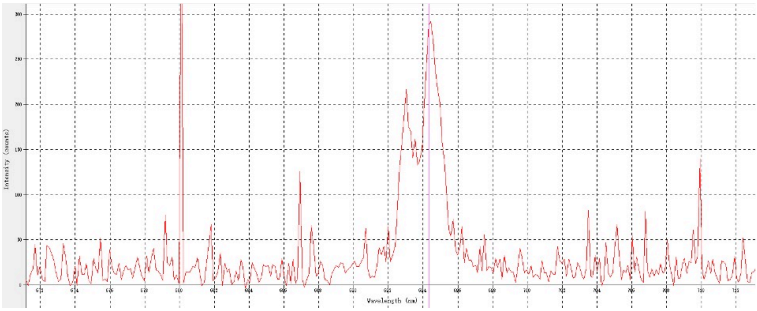

Figure 5. R1 and R2 peaks of ruby fluorescence in the Fig. 2 DAC

Conclusion

The results of this work reveal that the extension of the working distance of Raman Spectrometry using a secondary lensing system stand as a viable solution to the limitations of high-pressure low temperature experimentation. While continued work can be done to improve beyond this modification, it appears to already show great promise in terms of imagery and fluorescence. With further effort, it is reasonable to assume that long distance Raman measurements can be achieved and even applied in situations beyond the realm of low temperature high temperature measurements once thought impossible.

Acknowledgements

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References

[1] Cooper, Leon N, “Bound electron pairs in a degenerate Fermi gas”. Physical Review, vol. 104, no. 4, 1956.

[2] A. Lyon et al., “Raman spectroscopy,” Anal. Chem., vol. 70, no. 12, pp. 341–362, 1998.

[3] P. Devereau and D. Einzel, Physical Review, vol. 51, 1995.

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83.

CONTROLLING PHASE TRANSITIONS IN LEAD-FREE 2D METAL HALIDE PEROVSKITES

Emily Dalley

Faculty Mentor: Connor Bischak (Chemistry, University of Utah)

Introduction

Two-dimensional (2D) metal halide Ruddlesden-Popper (RP) perovskite crystals have been shown to have a number of optoelectronic properties, making them useful materials for a wide range of devices, such as light emitting diodes (LEDs), solar panels, and photodetectors

(1-3). Additionally, RP perovskites are efficient barocaloric materials, as they undergo reversible phase transition in response to changes in pressure or temperature (3-4). This phase transition is possible due to the structure of RP perovskites, where two inorganic layers sandwich an organic layer. As the organic layer "melts," the inorganic layer remains solid, allowing the crystal to undergo a solid-solid phase transition. These phase transitions can be used for room-temperature solid-state barocaloric cooling, which could allow perovskites to replace hydrofluorocarbon as more eco-friendly refrigerants (3-4). However, much of the research on RP perovskites to date has been on lead-based halide perovskites, which would be too toxic to be feasible for industrial level production (5). This is why our study specifically focuses on copper (II) bromide perovskites, which are much more environmentally friendly. We look into controlling the phase transitions in lead-free metal halide perovskites by altering the length of the organic cation. We did this by synthesizing copper (II) bromide with nonylammonium ((NA)2CuBr4), decylammonium ((DA)2CuBr4), and dodecylammonium ((DDA)2CuBr4), and then used a variety of methods including X-ray diffraction (XRD), temperature dependent grazing incident wide angle x-ray scattering (GIWAXS), bright field microscopy, scanning electron microscopy (SEM), and atomic force microscopy (AFM), to characterize and analyze the resulting perovskite crystals and their thin films.

Procedure

I. **Synthesis**

First, we brominated the alkylamines (nonylamine,

decylamine, and dodecylamine) by combining the amine with hydrobromic acid in a one-to-one ratio in ethanol to create white salts, using a procedure adapted from a previous study (5). We then combined these salts with copper (II) bromide in a solution of hydrobromic acid and recrystallizing the resulting solution overnight resulting in dark purple flake-like crystals, again following a similar procedure to the previous study (5). To create thin films, we dissolved the crystals in ethanol in ratios equivalent to 100 mg crystal to 1 mL solvent. We then syringe filtered this precursor solution and spin-coated 40 ⌦L of solution onto a clean substrate at 2000 rpm for 30 s, then annealed on a hotplate at 80 ℃ for 10 min. The substrates were cleaned in 1% alconox, DI water, acetone, and IPA sequentially for 10 min each. They were then dried using an N2 gun and then cleaned in a plasma cleaner for 15 min before being spin-coated.

II. **Analysis and Characterization**

To determine lattice spacing, the crystals were analyzed on the University of Utah's Crus Center's Rigaku Miniflex 600 X-ray Diffractometer (XRD). The thin films were analyzed on an Anton Paar SAX/WAXS/GISAXS/RheoSAXS laboratory beamline at the University of Utah's Nanofab using the GISAXS 2.0 stage with the GIWAXS Heating Module 2.0 attachment, to analyze their phase change and its effects on lattice spacing. A variety of microscopes were used to analyze the thin films. An Axioscope Zeiss inspection microscope, a Hitachi S-3000N scanning electron microscope, and a Molecular Vista PiFM, were all used to inspect the surfaces of the thin films. Results and Discussion We found that the larger the lattice spacing, the higher the transition temperature of

the perovskite was. The XRD showed that (DDA)2CuBr4 had the largest lattice spacing at 27.68 Å, followed by (DA)2CuBr4 with 24.07 Å and (NA)2CuBr4 with 22.41 Å. The XRD also showed that blending two cations in a crystal effect the lattice spacing, with a 50/50 blend of DA and NA resulting in a crystal with a lattice spacing of 23.65 Å. When we preformed temperature dependent GIWAXS on thin films of these samples, we found that (DDA)2CuBr4 had the highest phase transition around 60 ℃, while (DA)2CuBr4 had a phase transition around 45 ℃, and (NA)2CuBr4 having a phase transition somewhere below 30 ℃ and below the temperature limits of the heating stage. Further research into these phase transitions and how lattice spacing effects these transitions will include using differential scanning calorimetry (DSC) of all crystals and will also include the creation and characterization of crystals with different blends of cations.

Bibliography:

(1) Chen, Y.; Sun, Y.; Peng, J.; Tang, J.; Zheng, K.; Liang, Z. 2d Ruddlesden-Popper Perovskites for Optoelectronics. Adv. Mater. 2018, 30, No. 1703487.

(2) Dahod, Nabeel S.; Paritmongkol, Warcharaphol; Stollmann, Alexia; Settens, Charles; Cheng, Shao-Liang; Tisdale, William A. Melting Transitions of the Organic Subphase in Layered Two-Dimensional Halide Perovskites. J. Phys. Chem. Lett. 2019, 10, 2924-2930

(3) Kingsford, R. L.; Jackson, R. S.; Bloxham, L. C.; Bischak, C. G. Controlling Phase Transitions in Two-Dimensional Perovskites through Organic Cation Alloying." JACS Au. 2023, 145, 1177311780.

(4) Seo, J.; McGillicuddy, R. D.; Slavney, A. H.; Zhang,

S.; Ukani, R.; Yakovenko, A. A.; Zheng, S.L.; Mason, J. A. Colossal Barocaloric Effects with Ultralow Hysteresis in Two-Dimensional Metal–Halide Perovskites. Nat. Commun. 2022, 13, 2536.

(5) Li, X.; Li, B.; Chang, J.; Ding, B.; Zheng, S.; Wu, y.; Yang, J.; Yang, G.; Zhong, X.; Wang, J. (C6H5Ch2Nh3)2Cubr4: A Lead-Free, Highly Stable Two-Dimensional Perovskite for Solar Cell Applications." ACS Appl. Energy Mater. 2018, 1, 2709-2716.

About the Author

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84.

RESEARCH REFLECTION BY EMILY DALLEY

Emily Dalley

Faculty Mentor: Connor Bischak (Chemistry, University of Utah)

I thought that participating in the SPUR program this summer was very beneficial to me. I had tried to get involved in research last semester, but I was unable to really dedicate much time to it as my class schedule often clashed with when my graduate student I was working with was able to work, and so this summer has been nice to fully dedicate time to research in a lab. I really enjoyed working with my professor and with all the graduate students in the lab, and also being allowed to run experiments on my own with the guidance of my P.I. and

grad student was very beneficial to my time. I was fairly sure that I wanted to continue on to grad school before this summer, but my research experience this summer has further solidified that goal. I plan to continue work in this lab over the school year, and I really do look forward to that.

About the Author

Emily Dalley

85.

WORKER RESOURCE STORAGE AS AN OVERWINTERING STRATEGY IN THE WESTERN THATCH ANT, FORMICA OBSCURIPES

D. Christian Furness and John Longino

Faculty Mentor: John Longino (Biological Sciences, University of Utah)

In highly seasonal temperate habitats insects exhibit overwintering strategies. Perennial ant colonies must

overwinter as a functional colony. Formica obscuripes is a common ant in western North America that builds conspicuous thatch mounds and can be an ecologically dominant species in mountain habitats. In the winter, the colony descends to more than a meter deep, and it is known that they overwinter as the queen(s) and adult workers only, with no immatures (eggs, larvae, pupae). Yet in early Spring they seem to begin reproduction almost immediately. We hypothesized that workers were storing resources in their bodies, as fat or other storage compounds, which could be mobilized in early Spring to begin feeding larvae. These resource dynamics would be reflected in winter workers hav ing greater size-adjusted dry weight thansummer-active workers. On average, summer foragers collected on the nest were 50% lighter than winter workers. Further research should track colony phenology at greater temporal resolution, to see if larvae begin to grow and workers lose weight prior to foraging in the Spring, and the nature of weight gain in the Fall.

About the Authors

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86.

RESEARCH REFLECTION BY D. CHRISTIAN FURNESS

D. Christian Furness

Faculty Mentor: John Longino (Biological Sciences, University of Utah)

I found my undergraduate research experience to be very enlightening as it aided me in fostering my passion for research. It gave me opportunities to explore what topics I may be interested in and develop skills that I can advertise and use for the job market and graduate school. I plan on applying for graduate programs soon and plan on bringing the skills I developed in my research experience here with me into graduate school.

About the Author

D. Christian Furness

87.

UNCOVERING THE PRO-REGENERATIVE CARDIAC RESPONSE TO BACTERIAL INFECTION

Hailey L. Hollins; James A. Gagnon; Clayton M. Carey; and Alexis V. Schmid

Faculty Mentor: James A. Gagnon (School of Biological Sciences, University of Utah)

Humans lack robust mechanisms to resolve scarring caused by damage to the heart. After cardiac injury caused by events such as a myocardial infarction, humans form a non-contractile scar that chronically impairs heart function. In contrast, some species can regenerate

damaged heart tissues allowing for full recovery after injury. Zebrafish, a species with robust cardiac regenerative capabilities, have been recognized as a crucial model to help us understand the regenerative response. Significant zebrafish regeneration research has been completed using various models of cardiac injury, but we still have not adequately explored the response to damage caused by a bacterial infection of the heart muscle (bacterial myocarditis). Bacterial myocarditis is known to cause fibrosis in non-regenerating hearts; however, we do not know whether regenerating hearts have the same response or whether they are able to resist damage. Injection of bacterial cell wall proteins has been used as a way to model systemic infections and, as is seen in bacterial myocarditis, injection has been found to cause cardiac fibrosis in mice. Interestingly, when zebrafish are injected with the same proteins, they turn on pro-regenerative pathways. I hypothesize that this ability to turn on this regenerative cascade protects zebrafish from significant fibrosis. To explore this hypothesis, I injected zebrafish and Japanese medaka, a similar teleost species that cannot regenerate its heart, with a bacteria lipoprotein and used various tools to understand the cardiac response. By continuing this work, I can begin to explore cardioprotective features that could also protect humans from scar formation.

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88.

THE EFFECT OF SCHOOL FUNDING DECISIONS ON INCOME INEQUALITY: AN EXPLORATION OF MACHINE LEARNING FOR CAUSAL ANALYSIS

Benvin Lozada

Faculty Mentors: Jing Yi Zhu (Mathematics, University of Utah)

The effects of public K-12 education funding disparities on student outcomes remain one of the most contentious

issues in the realm of education. While many studies approach this problem through the analysis of discrepancies in short-term results such as test scores, no study has yet attempted to analyze the effect of discrepancies on long-run economic outcomes; this study attempts to fill this divide. To do so, we investigate the long-run economic health of children born from 1978-1983 and draw comparisons with school funding statistics from the 1991-1992 school year. We conduct this analysis using an instrumental variable approach combined with the deployment of machine learning regression algorithms in hopes to accurately model the causal impact of disparities in school funding. We find that machine learning models are more effective at modeling the causal relationship between school funding and income at age 35 than a standard linear regression model, using state fiscal neutrality scores as an instrument. We conclude that increases in school funding in the school district where a child grew up are causally linked to that child's outcome at age 35 and demonstrate that increasing school funding could be one potential solution to help remedy income inequality in the United States.

About the Author

Benvin Lozada

89.

HOW STUDENTS DESCRIBE THEIR BELONGING UNCERTAINTY IN GENERAL CHEMISTRY 1

Rebecca MacGillvray and Regina Frey

Faculty Mentor: Regina Frey (Chemistry, University of Utah)

This study seeks to understand how undergraduates describe their social belonging within General Chemistry 1, specifically, students' belonging uncertainty within the course. While social belonging envelopes the terms belonging uncertainty and sense of belonging, belonging uncertainty refers to the lack of a robust feeling of

acceptance within a specific group. Previous findings led by the Frey group discovered high belonging uncertainty can not only negatively affect students' performance but may also influence them to not pursue future STEM courses. For this study in particular, belonging uncertainty relates to the question: Do people like me belong in this course?

We seek to uncover the reason behind students' levels of belonging uncertainty by utilizing a Likert scale survey that was previously distributed to students taking General Chemistry 1 at the University of Utah. The survey is sent to students twice in the semester where they can rate their social belonging based on how much they agree with the different survey questions. Within the Frey group, we are currently looking at question five which allows students to also elaborate on their response to the statement: I feel uncertain about my belonging in CHEM 1210. To understand the dominating topics affecting belonging uncertainty, hundreds of student responses have been separated into categories created with specific definitions. The categories that have been created for question five include course environment, course structure, student-student relationship, student-instructor relationship, identity, perceived ability, quality of performance, chemistry value, nonspecific, and non- codable. In time, these overarching themes can be used to develop interventions that harbor high social belonging in the classroom.

About the Authors

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90.

RESEARCH REFLECTION BY REBECCA MACGILLVRAY

Rebecca MacGillvray

Faculty Mentor: Regina Frey (Chemistry, University of Utah)

This undergraduate research experience opened me up to the field of Chemical Education which I knew little about before. Although I am unsure if this will be my future field, it made me passionate about helping students feel welcome in the sciences and the research process in general. It has given me a greater confidence to seek out different types of research and helpful skills that are required as an undergraduate researcher.

About the Author

Rebecca MacGillvray

91.

SECONDARY METABOLITE-ASSISTED PROTECTION OF AN AEROBIC BACTERIUM DURING ANOXIC STRESS

Victoria Medvedeva; Aaron Puri; and Rachel Hurrell

Faculty Mentor: Aaron Puri (Chemistry, University of Utah)

All bacteria must overcome nutrient limitation in their environment; a consequence of natural variability and fluctuations within their specific niche. Despite the commonality of this challenge, the strategies bacteria use

to survive nutrient limitation are understudied. This applies to methane-oxidizing bacteria (methanotrophs), which use methane as their only source of carbon and energy. Methanotrophs are obligate aerobes, meaning they require oxygen to survive. However, they must also survive periods of low oxygen to obtain methane created by anaerobic communities found deeper in sediments. Rising methane emissions are fueling the rapid warming of our planet, and it is critical that we identify ways to remove methane from our atmosphere. Methanotrophs are useful tools in bioremediation because they serve as methane sinks to sequester this potent greenhouse gas. We recently discovered that a methanotroph, Methylobacter tundripaludum strain 21/22 (21/22), produces a new secondary metabolite called tundrenone. This project investigates the role that tundrenone plays in the survival of 21/22 under anoxic stress. After subjecting cultures of 21/22 to periods of oxygen deprivation, we can assess the viability of the cultures. We found that wild-type 21/22 has increased cell viability when compared with a mutant strain that does not produce tundrenone. We now hypothesize that tundrenone acts as an ionophore or extracellular electron shuttle to support 21/22's survival in hypoxia. Understanding the mechanism by which 21/22 survives low-oxygen conditions may enable optimization of this organism, and others, as methane-sinks and other useful environmental tools.

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92.

UNDERSTANDING THE RADIAL DISTRIBUTION OF DWARF SATELLITE GALAXIES BEYOND THE VIRIAL RADII

Emily Sageser and Yao-Yuan Mao

Faculty Mentor: Yao-Yuan Mao (Physics and Astronomy, University of Utah)

Dark matter has been theorized to exist for over 80 years based on astronomical observations but has yet to be found in terrestrial experiments. Named for its lack of interaction with the electromagnetic field, dark matter

does not absorb, reflect, or emit electromagnetic radiation making it undetectable to us. As such, it is considered one of the greatest unsolved mysteries in astronomy. However, visible galaxies are believed to live inside dark matter halos, which are high-density regions of dark matter that have disassociated themselves from the cosmological constant and contain matter bound together through gravity. Studies of these visible galaxies can hence reveal the distribution of dark matter within these halos. Smaller galaxies that hold fewer stars and mass, commonly known as dwarf galaxies, are of particular interest as they are rich in dark matter. These dwarf galaxies are sometimes close enough to another galaxy to be pulled into the gravity of the larger "host" galaxy which then makes them a satellite in the host's system.

My work uses cosmological simulations to study the spatial distribution of dwarf galaxies within and outside of their individual host systems to better understand the underlying dynamics within the structure of dark matter halos. The existing body of observational studies predominantly concentrates on host galaxy systems up to the virial radius, as exemplified in studies of our own Milky Way satellites and research such as "The Satellites Around Galactic Analogs Survey II" (Mao et al.,2021). We use the Very Small MultiDark Planck Simulation (VSMDPL) to make predictions of the expected number of dwarf galaxies one could find in the outskirts of the halo, and to study its correlation with the number of satellite galaxies (within virial radius) and other host halo properties.

We have found that the number of satellite galaxies within our selected inner and outer regions is not as

strongly correlated as expected. We also found that the number of galaxies (halos) as a function of radial distance to the host, known as the radial profile, correlates differently with different host properties. In particular, by calculating the correlation strength at multiple radii, we found that the number of subhalos within the virial radius does not always correlate the strongest with a host property. Our finding also demonstrates the halo assembly bias effect becomes significant at approximately 1 Mpc away from the host galaxies. Our analysis will help connect the study of satellite systems to studies about the outskirts of host halos (e.g., splashback radii and assembly bias) and will be influential in predicting the next stage of observational data that will be conducted in the future.

References

Mao, Y.-Y., (2021) The SAGA Survey. II. Building a statistical sample of satellite systems around Milky Way-like galaxies, The Astrophysical Journal, vol. 907, no. 2. doi:10.3847/1538-4357/abce58.

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SECTION XII

COLLEGE OF SOCIAL AND BEHAVIORAL SCIENCES

93.

SOCIAL MEDIA PERPETUATING HATE SPEECH, RACISM, AND RACIAL BIAS

Pierce Christoffersen

Faculty Mentor: Phillip Singer (Social & Behavioral Science, University of Utah)

Abstract

The research investigated in this paper examines the correlation between racism and hate speech, and how the Internet and social media have perpetuated both. Subsequently, my research delves into why we see racist ideologies and hate speech persist and thrive on social

media platforms. Then, I further elaborate by analyzing the harms of hate speech, and racist ideologies—primarily domestic terrorism. Ergo, after showing the harmful effects of social media—particularly through a racial-political lens—I investigate the current regulatory state of the internet and social media companies, and how social media companies' various interests prevent them from acting appropriately as a self-regulating force. Accordingly, my research concludes by arguing there is a need for a regulatory agency (at the federal level) tasked with overseeing the Internet and social media. The solution I argue for is for a new commission—referred to in my paper as the Internet Communication Commission—to be implemented based on the precedence of the 1927 Radio Act which created the Federal Communications Commission. A solution based on the work of Melody Fisher, Darvelle Hutchins, and Mark Goodman in "*Regulating Social Media and the Internet of Everything.*"

Introduction

The topic I investigate in this research paper is the new age media's impact on racial politics and public policy's role in helping to mediate this new democratic forum that has emerged from social media. This topic is relevant and important to research because a pressing question in contemporary political science is how media consumption, especially social media, impacts societal discourse. In the case of racial and social politics, it appears that contemporary media has had *mixed* effects. The increased ease and flow of information through social media has led to heightened levels of coalition building, and a simultaneous furthering of the phenomena of filter

bubbles. Historically, the media has been referred to as the "fourth estate" of our government with the task of acting as the government's watchdog. Thus, if we are to discuss governmental operations, we would be leaving out a key aspect of our society by choosing to not discuss the media, particularly social media contemporarily.

My research paper seeks to analyze how social media is perpetuating racism and hate speech, which in some instances has led to harmful outcomes. The problem for social media companies is they are unable to effectively address this issue themselves—given differing interests and limited resources. Consequently, the goal of my paper is to show that negative discourse in social media *is* a social policy issue, and why the internet and social media as a means of discourse ought to be taken seriously. A task of contemporary scholars is to *determine agency* in the context of this new online environment, an environment that is tremendously different than that of traditional news outlets for two primary reasons. First, given the blurred lines of user's involvement—where consumers can be producers or informants, and vice-versa—anonymity is a key aspect of these platforms. Second, there are the roles and responsibilities of social media companies since they themselves are not creating, posting, and sharing problematic content on their platforms. "[T]he Internet developed without any regulation. Now, the world is moving towards "the Internet of Everything lawmakers and regulators are trying to cope with worldwide havoc created through social media and viral content" (Fisher, Hutchins & Goodman, 2020). The "Internet of Everything" is a term that is meant to broadly describe the various software, technologies, data, and devices

associated with the Internet. Therefore, the goal of this paper is to discover how agency should be determined in this new media world and what regulatory practices should be instituted (if any) for the Internet and social media.

I argue (that despite its differences) there are several similarities between the early uses of radio and our current social media state. Various problems that were addressed on how to properly regulate radio have re-emerged regarding the Internet and social media. Consequently, I (along with a couple of scholars) argue that the Radio Act of 1927 can be utilized as a precedent in creating a baseline regulatory body for the Internet and social media in hopes of further, more robust, and expansive institutions and policies to follow. Hence, I am employing the use of the concept of *incrementalism* which states institutional change occurs gradually, in increments over time—usually after an initial policy or institution occurs (Peters, 2019).

Racism, Hate Speech, & Social Media

To begin, a paramount problem in the current scholarly work regarding social media is proving whether social media is being employed as a medium to perpetuate racist ideologies, hate speech, and racial prejudice. Part of this difficulty lies in two primary issues. First, (which mirrors a problem with society as a whole) is a lack of consensus regarding what constitutes dangerous or racist speech and what is an acceptable benchmark to distinguish harmful content from appropriate content (ElSherif et al., 2018). Some companies, like Facebook, take a post-racial approach, thus denying the existence of racism, contemporarily (Siapera & Viejo-Otero, 2021). Second,

once a benchmark *is* determined, you have to address the issue of semantics, since a lot of incendiary content possesses typos, or does not contain verbiage that is *explicitly* racist (ElSherif et al., 2018).

Despite these obstacles, there is substantial evidence to show that hate speech, racism, and stereotyping are perpetuated by social media (Cook et al., 1983; Dobson & Knezevic 2018; ElSherif et al., 2018; Siapera & Viejo-Otero, 2021). Moreover, hate speech across scholarly and legal works I examined all closely followed the definition by Caitlin Carlson, defining hate speech as "[an] expression that seeks to promote, spread or justify misogyny, racism, anti-Semitism, religious bigotry, homophobia, bigotry against the disabled" (Carlson, 2018). For example, in a Pew Research Center study, "60% of Internet users said they had witnessed offensive name-calling, 25% had seen someone physically threatened, and 24% witnessed someone being harassed for a sustained period of time" (ElSherif et al., 2018). Even more startling, however, is that a study in 2016, found that "95 percent of adolescents witnessed hate speech (directed against a minority group) on the internet" (Soral, Liu & Bilewicz, 2020). Social media has become a primary communication medium that is "deeply ingrained in people's everyday socialization and a site where issues of race and power persists" (Fisher, Hutchins & Goodman, 2020). Moreover, "popular social media websites, such as Facebook, Instagram, Twitter, Pinterest, and LinkedIn, are all owned by white Americans and businesses, social media is a public space where Blacks continue to experience erasure and invisibility of race by dominant social groups" (Fisher, Hutchins, Goodman, 2020).

A case study that exemplifies social media's role in perpetuating racism and racist stereotypes is that of Kimberly Wilkins. A massive fire destroyed a building, leaving over 100 residents homeless—including Wilkins herself. When local news outlets arrived at the scene, they began interviewing residents affected by the incident and Kimberly Wilkins was asked about her experience during the fire. Wilkins explained that as she was grabbing a soda from a vending machine, she suddenly realized there was a fire. Wilkins stated, "Oh Lord, Oh Jesus, it's a fire. I ran out, I didn't grab no shoes or nothing. Jesus! I ran for my life and then the smoke got me. I got bronchitis. Ain't nobody got time for that." This colorful statement was picked up by a Reddit user and quickly became an internet sensation. The quote eventually led to several racist memes of Wilkins being plastered around social media platforms overnight.

Unfortunately, the sensation of Wilkins' statement not only motivated racial commentary but after Wilkins became an internet and media celebrity, the case study researchers had a difficult time finding any reports on the actual aftermath of the fire or on the various other individuals affected by the tragic accident (Dobson & Knezevic 2018). They were only able to find stories related to Wilkins' short time as an internet celebrity, with no news regarding the over 100 people left homeless from the fire and their whereabouts. The "Kimberly Wilkins" Case Study tragically shows how social media changed the framing of a legitimate news topic about residents being left homeless due to a massive fire to a parody about a "funny black woman."

This is because "social media has become a gauge for

what [news] stories are deemed "news-worthy" as research by Dobson & Knezevic has shown (Dobson & Knezevic 2018.) Not only does this carelessly move the definition of newsworthy into the court of public opinion, but it is also exceptionally problematic because of the historic role of the media. Scholars that discuss the media's role, describe its job as government and society's "watchdog," and as the United States' "fourth estate" (Tumber, 2001). Yet, what contemporary sources argue is that this role has been shifting given the introduction of the internet and consequently social media. Going a step further, I argue that this is not just isolated to the internet but rather a societal shift towards "scandal" media that began around the time of the internet's inception. Over the past few decades, there has been a viewership power struggle that has resulted in a media sea change where the objective shifted from providing factual unbiased information to obtaining and maintaining a large core audience through shock pieces and opinion news shows (Tumber, 2001). This phenomenon has been further exemplified by social media, and its attention-based economic model that *prioritizes* preserving and growing an audience, and its consumer base (A consumer base that is simultaneously aiding in producing content). "[U]sers…are no longer passive consumers of media content, but active producers and distributors of it" (Dobson & Knezevic, 2018). Social media is unique because individuals who were previously *only* consumers of media have become active producers or participants in it as well (Tumber, 2001; Dobson & Knezevic, 2018). This fundamental shift threatens the original practice of journalism where "traditional" media forums are required

to follow FCC acts and regulations while still attempting to maintain an audience that is being seduced and bombarded by social media platforms that are not hindered by the same laws and further benefits from an excessive saturation of producer-consumers.

The Harms of Social Media

"The presence of hate speech in one's environment can produce a sense of a social norm by suggesting that using such language about immigrants or minority groups is common rather than exceptional" (ElSherif et al., 2018). This can cause individuals to become more complacent in tolerating hate speech given their conditioning that it is a commonplace norm. This phenomenon may then be exemplified and cause individuals to be more willing to condone or even commit violent acts against minorities.

"[T]he widespread adoption of racial and ethnic slurs has historically been associated with acts of violence, ranging from hate crimes targeted at individuals to mass genocide…the casual use of racial slurs can create a climate that will tolerate crimes against humanity such as slavery or the Holocaust…Throughout history, hate speech has been used to dehumanize various religious, ethnic, or racial groups in order to make military action or physical violence against them more palatable" (Soral, Liu & Bilewicz, 2020).

"It is undisputed that social media has played a key role in the expansion of domestic terrorism" (Berryman, 2020). Social media's commonplace hate speech, anonymity, and expedited ability to connect and communicate with others have meant that bad actors have had their biases reinforced as perceived norms and have had an easier time connecting with others who have similar

biases—potentially harmful tendencies. Thus, social media has become a breeding ground for domestic terrorist groups, and bad actors.

Annoyingly, "[t]he existing case law seems to condemn holding social media providers liable for acts of terrorism, particularly in light of the existing evidence that focuses on the radicalization process" (Berryman, 2020). However, even with existing case law, when referencing Crosby v. Twitter—the case involving the "Pulse Night Club Shooter"— "the court…did not preclude liability completely, noting that one should not interpret its holding to mean that "[d]efendants could never proximately cause a terrorist attack through their social media platforms" (Berryman, 2020). Unfortunately, prosecutors have a near-to-impossible task to prove"proximate cause" when charging social media companies with liability relating to terrorism, and thus, to date, none have been cited (Berryman, 2020). Accordingly, it is only with considerable modifications to current legal statutes that social media companies could be legitimately charged—including being held accountable for the coordination and disinformation that took place on social media platforms—like Twitter, that helped to incite the January 6th Insurrection on the Capital.

At the end of her analysis, Berryman provides a couple of suggestions that she argues (if done correctly) could solve this problem. First, Berryman argues that it is essential for the Anti-Terrorism Act of 1990 (ATA) to include acts of domestic terrorism. While this would not directly address social media companies, it would regulate domestic terrorism as a whole and allow it to be part of the Act's stipulations and penalties. Second, Berryman

furthers a claim made by other legal scholars that the Communications Decency Act of 1996 (CDA) should be amended to include Internet Service Providers (ISPs). This would hold social media platforms liable if they were involved in providing materials that supported terrorists and their terrorist actions. Finally, Berryman states that a paramount issue with the current case law is its condemnation of charging social media companies and the overtly onerous task to show proximate cause. Therefore, Berryman contends these practices should be amended so the agency of social media companies can be properly addressed—especially as technologies are constantly improving and companies have a greater ability to filter potentially dangerous content (Berryman, 2020).

Current Social Media Regulation

Currently, the task of regulation falls upon the social media companies themselves. Consequently, social media companies (including Facebook) claim they are *appropriately* regulating the content that flows through their platforms. Currently, Facebook's (like a lot of other platforms) model for regulating inflammatory content is a "hands-off approach" (Oates, 2020). This approach tries to maintain a free environment where every voice, ideology, and opinion can co-exist. Additionally, Facebook's model is heavily reliant on users themselves reporting or blocking content that they find inappropriate (Siapera & Viejo-Otero, 2021). Due to the unreliability of self-reporting, it is important to examine these regulatory practices. Moreover, Facebook's approach to controversial content is color-blind and post-racialized (as stated in the first section) meaning that if content is posted about a group that has historically been oppressed and

marginalized the content is regarded with the same weight as a group that has not had the same oppressive history and were potentially themselves the oppressors (Siapera & Viejo-Otero, 2021). Consequently, "hate speech…is not seen as an ethical or political problem [for Facebook]. Rather hate speech is just another category of problematic content, one of about twenty" thereby amplifying and reproducing (white) supremacist positions (Siapera & Viejo-Otero, 2021). Accordingly, the internet and social media have become the ideal places for terrorist organizations because of the minimal censorship and regulation, along with previously mentioned factors like anonymity. The ease of accessing social media platforms, and the disapprobation of companies to ban such content have allowed individuals with similar, extreme, ideologies to connect and create a collective identity otherwise difficult or impossible (Berryman, 2020). "[With the internet] [n]ew citizenship linkages and virtual communities are emerging in which participation, whether around political affiliation, social issues or local community interests, suggest[ing] a move away from a unified public sphere to a series of separate public spheres. A single public sphere becomes obsolete as groups maintain their own deliberative democratic forums." (Tumber, 2001).

Therefore, without comprehensive regulation, racist ideologies are sure to persist as more people become a part of "algorithmic enclaves" that reinforce their ideologies and biases (Dobson & Knezevic 2018). The paramount interest of social media companies is preserving as diverse and large of a user base as possible. Thus, *instead* of removing all potentially inflammatory

content, social media companies rely upon the individual user's ability to *manually* censor harmful content from themselves—manually meaning the user must select an option to block or report negative or harmful content on their feeds. Of course, as your sphere of information grows smaller and less diversified, *manual* censorship becomes less and less likely—until a time in which algorithms are able to stop showing the individual content that they find odious. A social media company's interest is not in the user's well-being, but rather the user's time and information. As a former Facebook employee Frances Haugen stated, "the company [Facebook] systematically and repeatedly prioritized profits over the safety of its users" (Zakrzewski, 2021). Time, activity, and personal information are what fuel the attention economy of social media and the internet as a whole, not in maintaining a civil forum of collective discourse.

Furthermore, it is important to remember that social media companies openly admit engaging in this practice that prioritizes customizing content feeds to each individual's interests, needs, and desires. As an example, in Facebook's (Meta's) terms of service, they state that they want to "[p]rovide a personalized experience for you" (Facebook, *Terms of Service,* 2022*)*.

"Your experience on Facebook is unlike anyone else's: from the posts, stories, events, ads, and other content you see in News Feed or our video platform to the Facebook Pages you follow and other features you might use, such as Trending, Facebook Marketplace, and search. We use the data we have – for example, about the connections you make, the choices and settings you select, and what you share and do on and off our Products – to personalize

your experience" (Facebook, *Terms of Service,* 2022*)*. This extends far beyond the user's feed, however. Subsequently, they state they want to help "[c]onnect you with people and organizations you care about" (Facebook, *Terms of Service,* 2022*)*. So, their algorithms try to: "help you find and connect with people, groups, businesses, organizations, and others that matter to you across the Meta Products you use. We use the data we have to make suggestions for you and others – for example, groups to join, events to attend, Facebook Pages to follow or send a message to, shows to watch, and people you may want to become friends with. Stronger ties make for better communities, and we believe our services are most useful when people are connected to people, groups, and organizations they care about" (Facebook, Terms of Service, 2022).

This is done all while ensuring their user's individual right to say or do whatever online is protected. As stated by their additional mission to "[e]mpower you to express yourself and communicate about what matters to you" and "show you ads, offers, and other sponsored content to help you discover content, products, and services that are offered by the many businesses and organizations that use Facebook and other Meta Products" (Facebook, *Terms of Service,* 2022*)*. Thus, the goals in some cases directly conflict with regulating hate speech and actors prone to engage in racist or hateful behavior. Rather, the interests of (in this case) Facebook, are to create a personalized content feed for each user that also connects them with other users who share similar content interests. The mission is to essentially help create specific groupings of individuals to help limit the amount at which actors with

two contrasting (and in some cases harmful) viewpoints implicitly interact—while still providing the user with an option to manually search for certain users or content types. However, this is not to suggest that social media companies do not believe hate speech is an issue (i.e., Facebook, Twitter, Instagram, Youtube, Snapchat, Tiktok, Reddit). Nor that these companies are inherently at fault for the harmful actions that occur on their platforms. Across the several social media platforms' community guidelines and terms of service I read, hate speech—along with bullying and harassment—were consistently highlighted as "violations" and not condoned or prohibited on their platforms.

Unfortunately, the ability to actually enforce a firm stance against "hate speech" is onerous and resource-intensive for various reasons. First, social media companies see hate speech as one of the *many* issues that occur on their platforms. Accordingly, they are (arguably so) willing to allocate so much money, time, and resources to address the issue. For instance, Facebook averages some 5 billion posts every single day circulating throughout their servers ("Facebook's Hate Speech Problem," 2020). Second, if social media companies begin striking down all the content several individuals classify as "harmful," "obscene," or "inappropriate" they risk disturbing the peace, causing individuals to feel as though their right to free speech is violated, and creating a hostile environment to the free exchange of ideas—which in some instances can be seen as hypocritical or targeting certain groups or ideologies. This causes a comprehensive and extensive regulatory body on social media platforms to be a net loss for companies, and against their best

interests—most stating their goal is to allow for a free exchange of (authentic) content and ideas. Third, while social media companies have a vast number of resources because of their monopoly over the industry, there are limits to what their resources can achieve. A common problem for social media companies attempting to regulate harmful and illicit content is language barriers and differentiation in syntax and language between users of various groups, races, and nationalities (such as typos, abbreviations, slang, etc.).

Lastly, there is no legal reason as to why social media companies should care to strictly enforce anti-hate speech sentiments and actions on their platforms. "In the United States, most hate speech is protected by the First Amendment…in *Snyder v. Phelps* (2011), the U.S. Supreme Court held that picketing fallen soldier's funerals with signs that said, "[G]od hates fags" did not meet the threshold for intentional infliction of emotional distress" (Carlson, 2018). So, regarding social media, (most) hate speech occurring on social media platforms is protected by the United States Bill of Rights. "Unless expression falls into the categories of fighting words, incitement to illegal advocacy, true threats, or the rarely invoked notion of group libel, it is considered protected" (Carlson, 2018). Yet, as we have seen with instances of domestic terrorism—which should fall under "true threats" or "fighting words" under freedom of expression—social media's anonymity and fabricated distancing means that legal actions still do not occur in instances where serious physical danger and harm can and does occur.

The Solution for Accountability & Regulation

Consequently, I maintain that social media companies

themselves are not equipped to regulate hate speech on their platforms and that there is no serious legal action taken against bad actors (and social media companies themselves) for running afoul when engaging in hate speech. I argue that the solution is a defined set of parameters regarding government oversight and regulations. I recognize and previously indicated that this may be seen as problematic due to the current perception that social media prioritizes individual freedom above all else. Fortunately, by utilizing the work of Fisher, Hutchins, and Goodman we understand that the Radio Act of 1927 led to the creation of the Federal Communications Commission (FCC) as a regulatory body of technocrats. The FCC determined the best way to manage and regulate the medium of radio and to identify what ran afoul. By employing the

Radio Act of 1927, and identifying the similarities between social media and radio, we can show why regulations—particularly at the Congressional level— are necessary and required and consequently that an Internet Communications Commission (ICC) (of sorts) should be instituted to regulate social media and the internet (Fisher, Hutchins & Goodman, 2020). The rudimentary similarities between radio and the internet are that upon each of their inceptions, the expansion of public discourse increased due to lack of regulations and oversight and that "Congress does not understand the technology" (Fisher, Hutchins, Goodman, 2020). Hence, many of the issues and questions raised in the Radio Act of 1927 mirror problems being discussed contemporaneously—such as monopolies, who should be producing content, free speech, hate speech, obscenity, and censorship.

Therefore, if we investigate the arguments, problems, and logical solutions that led to the creation of the Radio Act of 1927 the same should and can be done (to a degree) for the Internet and social media.

First, at its inception, there was a collective fear that the radio industry would become a monopoly dominated by capitalist and corporate interests. Consequently, the creation of the FCC was meant to act as a regulatory body to limit the power and influence of corporations on the radio industry (Fisher, Hutchins & Goodman, 2020). Comparatively, "[t]he communication network monopolies of 2019 dwarf the radio monopoly of 1926", the digital platforms hold so much economic power that "Apple, Google, Amazon, and Facebook have more impact on the world econom[y] than all countries except the U.S. and China" (Fisher, Hutchins, Goodman, 2020). Even if one believes it is foolhardy to have a so-called "Internet Communications Commission" break up the massive monopolies of the social media industries; it should still be acknowledged that the collective power of these corporations is too great for there to be no tangible government oversight. Moreover, as Galloway states: "These markets are no longer competitive. They can no longer resist abusing their market power" (Fisher, Hutchins & Goodman, 2020). It is ignorant and naive to merely allow these social media giants to act in the best interest of public discourse and to trust them to remain objective in their actions and regulatory principles—something that the Congress of 1927 understood and that the Congress of 2022 should inherently acknowledge as well.

Second, regarding a radio broadcaster's responsibilities

and its relation to free speech and hate speech in 1924, individuals at the time argued those with a voice on the radio should be upheld to a more stringent moral standard than is commonly applied in other uses referencing the right to free speech and expression. Clarence Dill (a Washington Senator) argued, that "[b]roadcasters should be businessmen of the highest class…The right to broadcast is to be based not upon the right of the individual, not upon the selfish desire of the individual, but upon a public interest to be served by the granting of these licenses" (Fisher, Hutchins & Goodman, 2020). This philosophy is one that is nonexistent in the realm of social media and the internet. For example, a man by the name of Christopher Blair, who was unemployed, "earned $17,000 weekly by making up ridiculous stories and posting them on Facebook during the 2016 presidential election" Blair stated, "The more extreme we become, the more people believe it" (Fisher, Hutchins & Goodman, 2020). This is why the issue of accountability and agency needs to be addressed on social media and the internet. The interest of individuals on social media is not to uphold a higher ethical and moral standard by ensuring the content they are producing is in the best interests of society, their interest in this unregulated entity lies only with themselves (Fisher, Hutchins & Goodman, 2020).

Ergo, while creating a regulatory body may seem intrusive, what the framers of the 1927 Radio Act believed was someone with the power to have their voice heard on the radio should be held to a higher level of accountability given their higher level of power. These same standards ought to be applied to the internet, social media, and digital platforms. As individual users, we have wide

discretion in the content we post and given the fact our power of voice is immensely amplified by the internet and social media, our accountability should be as well.

The best way to establish a standard by which accountability and agency should be most equitably determined is by instituting a Federal Communications Commission whose sole task is to decide the most appropriate manner to regulate social media and internet content—and what actions should be taken against bad actors or companies (Fisher, Hutchins & Goodman, 2020). Similar to the FCC, the Internet Communications Commission would have technocratic experts appointed ranging from the owners of social media companies to scholars on communications law, veteran government officials in communications regulations, and even specialists in the realms of social media and the internet. While this may not directly address the paramount problems behind hate speech and racism online, it would at the very least instill a regulatory baseline for future, more robust policies. Arguably, it would be most agreeable to implement a law that banned all hate speech, but this, of course, creates its own problems regarding the right to free speech, etcetera. Therefore, the best alternative is to establish a regulatory framework (in the form of a commission) to help decide how social media and the internet should be navigated. If we endorse the concept of incrementalism, an initial implementation of policy would over time lead to better, more direct policies, institutions, and regulations in the future.

Conclusion

In summary, my findings have shown the following. First, racism, hate speech, and extremist ideologies *are*

perpetuated through social media. Second, the media as a medium and a place for discourse has drastically changed. Third, social media companies are apathetic in regulating and mediating said racism and hate speech or holding their *users* accountable—in part because of economic and external interests. Fourth, current laws and regulations *do not* hold social media companies or users accountable. Thus, what my findings indicate is a need for some form of regulation, which I argue should take a form similar to that of the Radio Act of 1927. This would create an Internet Communication Commission tasked with determining the appropriate response to regulating social media and the Internet. Once this commission is created, I argue that we follow the concept of incrementalism, we can assume more robust and expansive regulations and policies surrounding the internet and social media will be instituted.

Bibliography

Berryman, Chloe. "Holding Social Media Providers Liable for Acts of Domestic Terrorism " Florida Law Review." *Florida Law Review*, 25 Feb. 2021, http://www.floridalawreview.com/2021/holding-social-media-providers-liable-for-acts-of-domestic-terrorism/.

Carlson, Caitlin. "Censoring Hate Speech in Social Media Content: Understanding the User's Perspective." *Communication Law Review*, vol. 17, no. 1, Nov. 2018.

Cook, Fay Lomax, et al. "Media and Agenda Setting: Effects on the Public, Interest Group Leaders, Policy Makers, and Policy." *JSTOR*, Oxford University Press, 1983, https://www.jstor.org/stable/2748703.

Dobson, Kathy, and Irena Knezevic. "'Ain't Nobody Got Time for That!': Framing and Stereotyping in Legacy and

Social Media." *Canadian Journal of Communication*, vol. 43, no. 3, 2018, https://doi.org/10.22230/cjc.2019v44n3a3378.

ElSherief, Mai, et al. *View of Hate Lingo: A Target-Based Linguistic Analysis of Hate Speech in Social Media*, University of California, Santa Barbara, 15 June 2015, https://ojs.aaai.org/index.php/ICWSM/article/view/15041/14891.

"Facebook's Hate Speech Problem Is Even Bigger Than We Thought." *Anti-Defamation League*, 23 Dec. 2020, https://www.adl.org/blog/facebooks-hate-speech-problem-is-even-bigger-than-we-thought.

Facebook. (2022, January 4). *Terms of Service*. Facebook. Retrieved April 16, 2022, from https://www.facebook.com/terms.php.

Fisher, Melody, et al. "Regulating Social Media and the Internet of Everything: The Precedent of the Radio Act of 1927." *Communication Law Review*, vol. 19, no. 1, 2020, https://doi.org/https://commlawreview.org/Archives/CLRv19/Regulating_Social_Media_and_the_Internet_of_Everything_Fisher_Hutchkins_Goodman.pdf.

Oates, Sarah. "The Easy Weaponization of Social Media: Why Profit Has Trumped Security for U.S. Companies." *Digital War*, Springer International Publishing, 2020, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7212244/.

Jaishankar, K, and Imran Awan. "Islamophobia on Social Media: A Qualitative Analysis of the Facebook's Walls of Hate." *Zenodo*, 24 July 2016, https://zenodo.org/record/58517.

Peters, B. Guy. *American Public Policy: Promise and Performance*. 11th ed., SAGE Publications, Inc., 2019.

Terms of Service. Help center. (2022, January 4). Retrieved April 16, 2022, from https://help.instagram.com/581066165581870.

Terms of service | Tiktok. Legal Terms of Service. (2019, February). Retrieved May 10, 2022, from https://www.tiktok.com/legal/terms-of-service?lang=en.

Tumber, Howard. "Democracy in the Information Age." *Culture and Politics in the Information Age*, 2002, pp. 31–45., https://doi.org/10.4324/9780203183250-7.

Twitter. (2021, August 19). *Twitter terms of service*. Twitter. Retrieved April 16, 2022, from https://twitter.com/en/to.

Siapera, Eugenia, and Paloma Viejo-Otero. "Governing Hate: Facebook and Digital Racism." *Television & New Media*, vol. 22, no. 2, 2021, pp. 112–130., https://doi.org/10.1177/1527476420982232.

Snap inc.. terms of service. Snap Inc. (2021, November 15). Retrieved April 16, 2022, from https://snap.com/en-US/terms.

Soral, W., Liu, J. H., & Bilewicz, M. (2020). Media of contempt: Social media consumption predicts normative acceptance of anti-Muslim hate speech and Islamoprejudice. International Journal of Conflict and Violence, 14(1), 1-13. doi: 10.4119/ijcv-3774 Harvard: Soral, Wiktor, Liu, James H., Bilewicz, Michał. 2020. Media of Contempt: Social Media Consumption Predicts Normative Acceptance of Anti-Muslim Hate Speech and Islamoprejudice. International Journal of Conflict and Violence 14(1): 1-13. doi:10.4119/ijcv-3774

User agreement – September 12, 2021. Reddit. (2021,

September 12). Retrieved May 9, 2022, from https://www.redditinc.com/policies/user-agreement-september-12-2021.

Wu, P. (2015). Impossible to Regulate: Social Media, Terrorists, and the Role for the U.N. Chicago Journal of International Law, 16(1), 281-311.

YouTube. (2022, January 5). *Terms of Service*. YouTube. Retrieved April 16, 2022, from https://www.youtube.com/static?template=terms.

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Pierce Christoffersen

94.

RESEARCH REFLECTION BY PIERCE CHRISTOFFERSEN

Pierce Christoffersen

Faculty Mentor: Phillip Singer (Political Science University of Utah)

My undergraduate research experience has had a tremendous impact on my education and future goals, as it is the projects and experiences I have had as an undergraduate researcher that have led me to apply to graduate school, specifically a Ph.D. in Political Science. Moreover, the research I have been fortunate enough to participate in here at the University of Utah has informed the types of research and work I would like to continue to do in and beyond graduate school. I can say without a doubt that my undergraduate research opportunities have

had the biggest impact on my education, future goals, and me as an individual when compared to the other opportunities and experiences I have had at the University of Utah.

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Pierce Christoffersen

95.

EXPLORING THE SUBJECTIVE WELL-BEING OF INTERNATIONAL AND DOMESTIC PHD STUDENTS IN STEM FIELDS

Hailee Davis; Jacqueline Chen; and Becky Neufeld

Faculty Mentor: Jacqueline Chen (Psychology, University of Utah)

Introduction

Science, technology, engineering, and mathematics (STEM) fields are critical to a nation's success, so it is vital to have highly skilled individuals in these fields (Kayan-

Fadlelmula et al., 2022). There is a common misconception that leaving a graduate program is tied to ability, but many students leave their graduate program for reasons such as emotional exhaustion, lack of support, and/or conflict between institutional values, expectations, or life goals (Devine & Hunter, 2017). I was interested in researching how well-being differs between international and domestic PhD students in STEM fields. Graduate students are under a lot of stress and this relates to their well-being. Graduate students are evaluated often, have paper deadlines, high workload, lack of permanent employment, pressure to publish and participate in the scholarly environment, etc. (Schmidt & Hansson, 2018). International and domestic students both experience academic stress, but there are additional stressors that are unique for international students, such as studying in a second language, being far from support networks, and navigating visa issues (Suh et al., 2021). Consistent with these differences, past research suggests that international graduate students experience higher anxiety, work-home interference, and have lower social-support than domestic students (Van Der Heijde et al., 2019).

Method

I analyzed data from an ongoing study sponsored by the National Science Foundation. The participants are students enrolled in science, technology, engineering, and mathematics (STEM) PhD programs at two large research universities in the U.S. Each participant took an intake survey when they first enrolled in the study, which was during the Fall 2020, Spring 2021, Fall 2021, or Spring 2022 semester. Recruitment spanned several years in

order to obtain a large sample size. There are 267 total participants and 87 of them are international students. The majority of participants are between the ages of 22 and 30 with the youngest being 20 and the oldest being 44 (M = 25.68, SD = 3.42).

To explore the well-being of international graduate students in STEM programs, I calculated their score on the Subjective Well-Being scale (SWB; Diener et al., 1985). SWB was measured with five questions (e.g., "In most ways my life is close to my ideal") using a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree). A mean score was taken from the five SWB questions asked on the intake survey. Then, I ran an independent samples t-test comparing the SWB scores between international students (n = 87) and domestic students (n = 180) using the software environment, R.

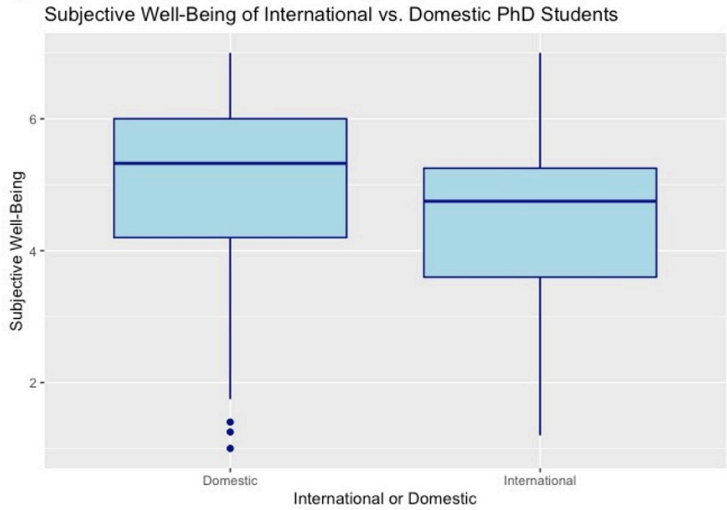
Results

Table 1 lists the descriptive statistics for the Subjective Well-Being (SWB) of International and Domestic STEM PhD Students. Of the 87 International PhD students (M = 4.45, SD = 1.28) and 180 Domestic PhD students (M = 5.01, SD = 1.32), there was a significant difference between their SWB scores, $t(174.92) = -3.36$, $p = 0.001$, $d = 0.44$. This indicates that international students had significantly lower SWB scores than domestic students, and the effect size was moderate. Figure 1 shows that the median SWB scores for international students are lower than the median for domestic students. It also shows more outliers for domestic students on the lower end of the scale.

Table 1
Descriptive Statistics

	n	mean	median	SD	min	max
International PhD Students	87	4.45	4.75	1.28	1.2	7
Domestic PhD Students	180	5.01	5.32	1.32	1	7

Figure 1



Conclusion

International students in STEM reported lower subjective well-being than domestic students in STEM programs. This result is consistent with previous research. Our findings suggest that additional support is needed for international students in STEM PhD programs.

References

Devine, K., & Hunter, K. H. (2017). PhD student emotional exhaustion: The role of supportive supervision and self-presentation behaviours. *Innovations in Education and Teaching International, 54*(4), 335, https://doi.org/10.1080/14703297.2016.1174143

Diener, E., Emmons, R. A., Larsen, R. J., & Griffin, S.

(1985). The satisfaction with life scale. *Journal of Personality Assessment, 49*(1), 71-75. https://doi.org/10.1207/s15327752jpa4901_13

Kayan-Fadlelmula, F., Sellami, A., Abdelkader, N., & Umer, S. (2022). A systematic review of STEM education research in the GCC countries: Trends, gaps and barriers. *International Journal of STEM Education, 9*(1), 1–24. https://doi.org/10.1186/s40594-021-00319-7

Schmidt, M., & Hansson, E. (2018). Doctoral students' well-being: A literature review. International *Journal of Qualitative Studies on Health and Well-Being, 13*(1), 1508171–14. https://doi.org/10.1080/17482631.2018.1508171

Suh, H., Hong, J., Rice, K., & Kelly, V. (2021). International and domestic graduate student satisfaction with life. *Journal of International Students, 12*(1). https://doi.org/10.32674/jis.v12i1.2679

Van Der Heijde, C.M., Douwes, L., & Vonk, P. (2019). Mental health problems and support needs of PhD students: Bottlenecks of the PhD trajectory. *European Journal of Public Health, 29*(Supplement_4). https://doi.org/10.1093/eurpub/ckz186.588

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96.

UNDERSTANDING THE IMPACT OF WATER CONTAMINATION ON INDIGENOUS LAND AND HEALTH: A CASE STUDY ON THE DUCK VALLEY RESERVATION

Cindy Diaz Rey; Tabitha Benney; Michael Komigi; Jordan Giese; and Brett Clark

Faculty Mentor: Tabitha Benney (Political Science, University of Utah)

Indigenous communities face disproportionate environmental-related health risks compared with the average North American population due to greater exposure to contamination (Hoover et al., 2012). Gaps in federal and state policy, in addition to weak governance in tribal settings, allow extractive and polluting enterprises greater access to tribal lands. This weakens effective regulation, which threatens the health and welfare efforts of tribal citizens (Grijalva, 2011). To understand this further, this study focuses on the Duck Valley Reservation, located on the Nevada-Idaho border, which is home to Shoshone-Paiute Tribes. Despite its small population of 1200 to 1500 people, there has been a growing concern regarding rising health issues over the last few decades due to water contamination from fossil fuels and pesticide-related chemicals. This research project examines (1) the social conditions and management practices that determined how toxic chemicals were handled on the Duck Valley Reservation and (2) contaminants in groundwater and drinking water, as well as the potential health and environmental consequences resulting from these. To investigate these issues, we conducted a historical case study of the reservation that involved collecting and examining historical records and data from newspapers, tribal documents, the Environmental Protection Agency (EPA), and other public sources. The team created a timeline of events, identified contaminants present on the reservation, and researched the concentration of these chemicals and their potential

impacts on human health. Based on a study undertaken by the EPA, the Bureau of Indian Affairs (BIA) was found to be responsible for the release of diesel, gasoline, and naphthalene directly into the ground of the reservation from 1950 until the mid-1990s. This procedure may be responsible for the formation of two hydrocarbon plumes that contaminated the main water supply of the reservation's most densely populated area. The location of the plumes has raised concerns over the long-term impacts of contamination due to its well-established connection to health (Levallois & Villanueva, 2019), education (Bondy & Campbell, 2017), and environmental issues (Madhav et al., 2019). Further research is needed to assess the impact of water contamination on community health and the environment to prevent exposure of future generations from existing contamination.

Bibliography

Bondy, S., & Campbell, A. (2017). Water quality and brain function. International Journal of Environmental Research and Public Health, 15(1), 2. https://doi.org/10.3390/ijerph15010002

Grijalva, J. M. (2011). Self-determining environmental justice for Native America. Environmental Justice, 4(4). https://doi.org/10.1089/env.2010.0033

Hoover, E., Cook, K., Plain, R., Sanchez, K., Waghiyi, V., Miller, P., Dufault, R., Sislin, C., & Carpenter, D. O. (2012). Indigenous peoples of North America: Environmental exposures and reproductive justice. Environmental Health Perspectives, 120(12), 1645–1649. https://doi.org/10.1289/ehp.1205422

Levallois, P., & Villanueva, C. (2019). Drinking water quality and human health: An Editorial. International

Journal of Environmental Research and Public Health, 16(4), 631. https://doi.org/10.3390/ijerph16040631

Madhav, S., Ahamad, A., Singh, A. K., Kushawaha, J., Chauhan, J. S., Sharma, S., & Singh, P. (2019). Water pollutants: Sources and impact on the environment and human health. Sensors in Water Pollutants Monitoring: Role of Material, 43–62. https://doi.org/10.1007/978-981-150671-0_4

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97.

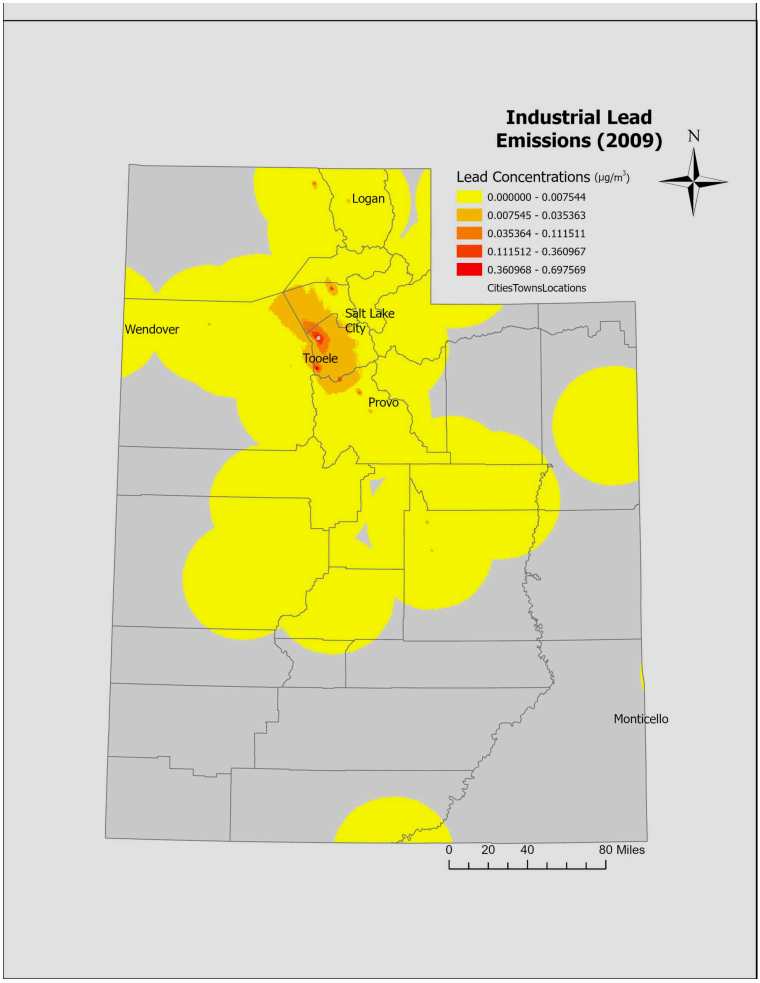
USING US EPA RSEI DATA TO CHARACTERIZE INDUSTRIAL HEAVY METAL EMISSIONS: AN APPLICATION TO INTELLECTUAL DISABILITY IN UTAH

Jacqueline Gomez; Sara Grineski; Timothy W. Collins; Roger Renteria; Kevin Ramos; Joemy Ramsay; and James Vanderslice

Faculty Mentor: Sara Grineski (Sociology, University of Utah)

Research has documented how exposure to heavy metals, e.g., lead, leads to an increased risk of neurodevelopmental disorders like autism spectrum disorder (ASD) and intellectual disability (ID). Our team has demonstrated that birth year exposures to industrial pollution are associated with ID in Utah. ID impacts one percent of the population and has serious implications for people's intellectual and adaptive functioning. In this project, we use industrial emissions data from the US Environmental Protection Agency's Risk Screening Environmental Indicators (RSEI) from 2000 through 2009. We focus on those years as this is when the children in our study were born. RSEI data summarize air concentrations of 770 chemicals within 50 kilometers of each reporting facility; these facilities are mandated to report emissions to the Toxics Release Inventory (TRI). TRI tracks the management of toxic chemicals. Here, we focus on eleven heavy metals and their compounds, i.e., lead, manganese, mercury, nickel, silver, zinc, cadmium, cobalt, chromium, copper, and arsenic. This poster shows temporal trends in emissions and spatial distribution of those emissions (Figures 1, 2, 3). Emissions remained constant throughout 2000 through 2009, with the exceptions of nickel and copper having spikes (Figure 4). While RSEI data have many strengths, important limitations include that emissions are self-reported by facilities and only annually, making it impossible to link emissions to birth month. The next step is to examine if specific industrial heavy metal exposures during the birth year increase odds of ID

for children with and without ASD relative to neurotypical children. We will also investigate synergies in these exposures and if the child's sex or mother's age modifies associations. We will link these RSEI data with birth certificate information from the Utah Population Database. We will next assign heavy metal exposure values to each child based on birth year and maternal residential address using ArcPro and then conduct statistical analyses. Examining these relationships will help us better understand how exposures impact children's development.


Industrial Lead Emissions (2009)
N
Lead Concentrations (μg/m³)
0.000000 - 0.007544
0.007545 - 0.035363
0.035364 - 0.111511
0.111512 - 0.360967
0.360968 - 0.697569
CitiesTownsLocations
Logan
Salt Lake City
Wendover
Tooele
Provo
Monticello
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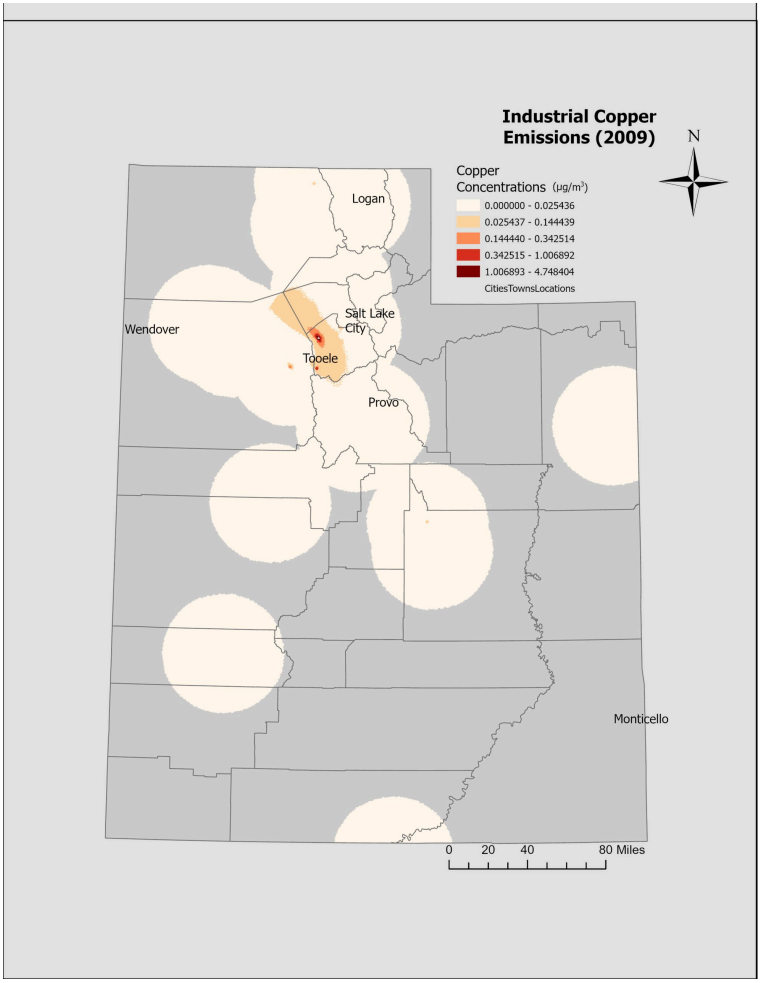
Industrial Copper Emissions (2009)
N
Copper Concentrations (µg/m³)
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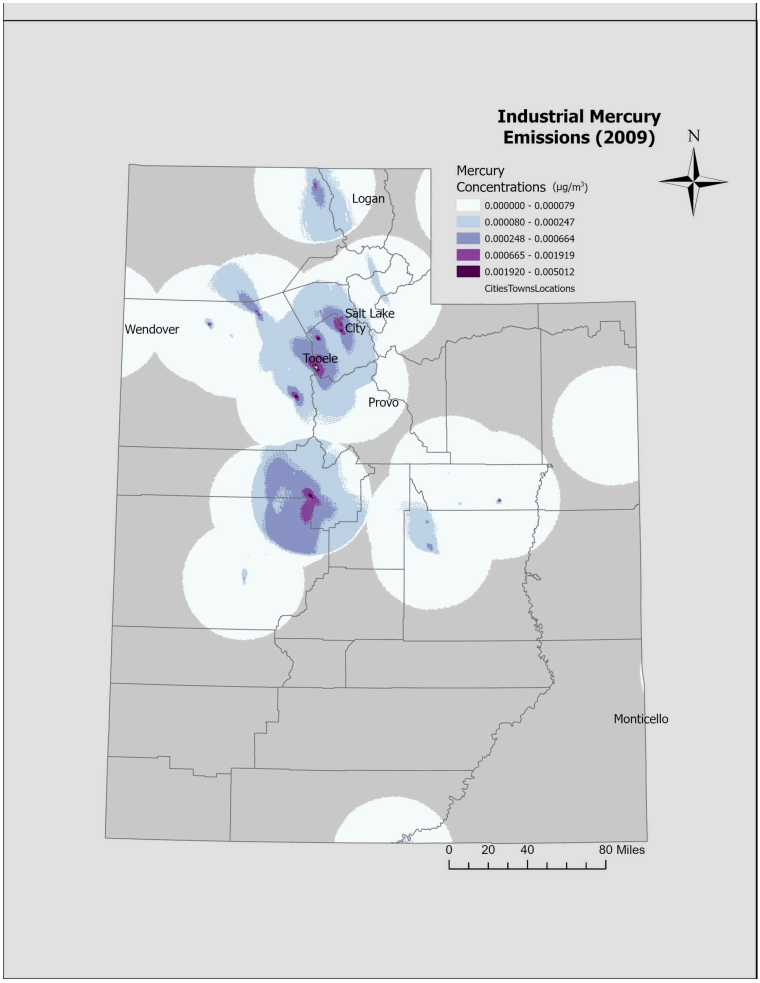
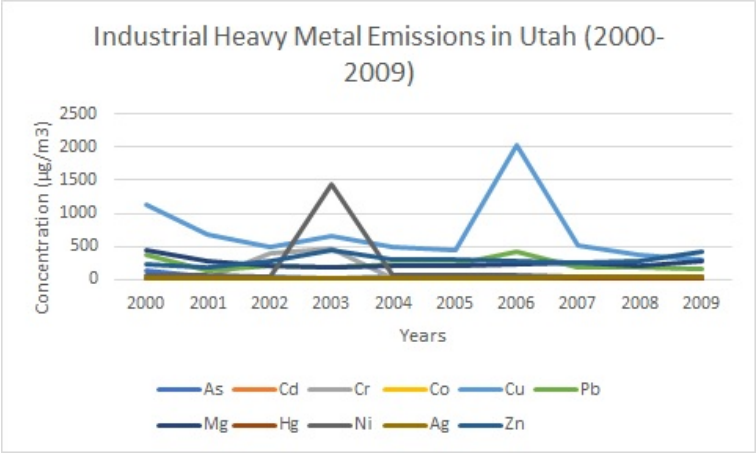
0.025437 - 0.144439
0.144440 - 0.342514
0.342515 - 1.006892
1.006893 - 4.748404
CitiesTownsLocations
Logan
Salt Lake City
Wendover
Tooele
Provo
Monticello
0 20 40 80 Miles


Industrial Mercury
Emissions (2009)
N
Mercury
Concentrations (µg/m³)
0.000000 - 0.000079
0.000080 - 0.000247
0.000248 - 0.000664
0.000665 - 0.001919
0.001920 - 0.005012
CitiesTownsLocations
Logan
Salt Lake
City
Wendover
Tooele
Provo
Monticello
0 20 40 80 Miles



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98.

RESEARCH REFLECTION BY JACQUELINE GOMEZ

Jacqueline Gomez

Faculty Mentor: Sara Grineski (Sociology, University of Utah)

My undergraduate research experience has been completely enriching and has made me gain a passion for doing research, both wet lab and dry lab. Research has impacted my education and future goals by pushing me to continue research after I graduate and decide to do grad school.

About the Author

Jacqueline Gomez

99.

THE SILENT MAJORITY(?): THE INSURGENT RIGHT IN THE SOUTHERN CONE, 2019-2023

Mauro A. Gonzalez

Faculty Mentor: David De Micheli (Political Science, University of Utah)

Introduction

While pundits have started to claim that Latin America is entering a "second pink tide" (Kirk 2022), there is more nuance than socialists triumphantly re-entering executive office after being exiled to the political wilderness during the 2010s A new, insurgent right has cropped up at the

same time: being more conservative, populist, antagonistic, and even authoritarian than their center-right forebearers. This paper examines three recently established right-wing populist parties in the Southern Cone: Chile's Partido Republicano (PR), Paraguay's Cruzada Nacional (CN) and Uruguay's Cabildo Abierto (CA).

Each of the three were newly created for their country's most recent election cycle and saw strong performances. The Chilean PR has quickly overtaken the center-right Chile Vamos (ChV) coalition, beating them more than 2-to-1 in the first round of the 2021 presidential race (28% to 13%), and garnering 44% of the vote in the runoff. The PR won another stunning victory in the 2023 Constitutional Council elections, totaling 34% of the vote to the center-right's 20% (SERVEL 2023). The Uruguayan CA got 11% in the 2019 general elections, outperforming the nearly two hundred year-old Colorado party in eight of nineteen departments (Corte Electoral 2019). Finally, the Paraguayan CN got nearly 23% in 2023, right on the heels of the center-left's 27% (ABC Color 2023b). What's remarkable is the previous performance of right-wing anti-system parties. Jose Antonio Kast's (founder of the PR) independent 2017 run for president saw him score nearly 8% of the vote (SERVEL 2017). In Paraguay, an assortment of right-wing protest parties got less than 4% of the vote in 2018 (TSJE 2018). Meanwhile Uruguay did not have a right-wing anti-establishment party compete in 2014. This electoral surge is noteworthy given that the three above-mentioned Southern Cone countries have some of the oldest and most stable party systems in the region. Such a momentous jump in vote shares is rare

(Roberts 2014), especially one that so quickly displaces traditional coalitions.

This article seeks to investigate how these parties have managed to find a foothold in well-established party systems. While the parties may differ in certain policy and rhetoric, all three have used appeals to tough-on-crime policies to highlight the failures of the state, romantic nationalism for an antelapsarian past, and the activation of domestic center-periphery tensions to create new coalitions that disrupt the traditional party system. The right-wing insurgents have particularly relied on disenchanted voters on the margins of mainstream politics. These voters tend to be less ideological and more willing to vote for protest candidates, thus taking votes from both left- and right-wing parties. Even if the individual parties don't survive, the rise in electoral volatility caused by the effective activation of both old (center-periphery) and new (tough-on-crime) divisions perhaps spells future party dealignment.

I. Punitive Populism & Romantic Nationalism

Latin America is "by far, the world's most violent region," with one-third of all global violent deaths annually taking place there, while only holding 8% of the total global population. Latin America also hosts forty-three of the fifty most violent cities in the world and seventeen of twenty of the most violent countries (Albarracín and Barnes 2020, 398). Given these conditions, it's no surprise that violence and citizen security has become one of the most salient issues in the region's domestic politics, even in locations where there may be lower crime rates (Altamirano, Berens, and Ley 2020; 2022).

In tandem, political entrepreneurs have begun to use the fear of crime in their electoral strategies, leading to the coining of the term "punitive populism." Populism in this context is to be understood as a type of strategy or rhetorical style. The concerns of "the people" may be disparate, but discontent energy is channeled into a single leader who is able to tie heterogenous demands together to "evoke this chain of commands as the 'will of the people'" (Bonner 2019, 9). Punitive populism refers to the coalescence of citizen security concerns, banding together the "silent majority" who wish to protect their ordered way of life versus violence, disorder, and those in power who intensify those issues. Punitive populist solutions are broad, ranging from harsher sentencing laws to increased funding of security forces, or even in some cases tacit welfare expansion (Fairfield and Garay 2017; Hathazy 2013) and decriminalization of certain drugs (Caballero 2023). No matter the solution, punitive measures are grounded in anti-establishment politics, pointing to the failure of the state to do its most basic task: protect its citizens. The rhetoric may even take on a certain paternalistic or technocratic demeanor with the presence of military officials within some of the insurgent parties, forming an alliance between the military (the experts who know what to do) and the people (the silent majority who want order) against the politicians (criminals who refuse to follow through with common sense solutions).

With figures like Bolsonaro in Brazil and Bukele in El Salvador having been elected to high office, it's clear that there is a large voter base in Latin American countries who are willing to engage with authoritarian candidates if it means increasing security. This is no different in the

Southern Cone countries, with apologism and nostalgia for previous military regimes being tied to cracking down on crime.

In Chile, the center-right under Sebastian Piñera distanced itself from military dictator Pinochet's legacy in the 2000s, favoring a modern, pragmatic conservatism that embraced certain welfare reform and deemphasized law-and-order policies. While this won Piñera a wide electoral coalition that saw him serve two terms as President, it sacrificed the Chilean right's political identity. The center-right and center-left coalitions began converging on political issues, leaving a vacuum for the significant number of Chileans who supported the old regime and its policies. It was Kast and his PR that reasserted this connection to the old right while homing in on contemporary issues, particularly that of crime and insecurity (Campos Campos 2021). While establishing itself during the political upheaval of 2019, the PR's communications during this time emphasized a "defense of the Republic" both morally (i.e., promoting traditional values) and politically (i.e., with force against criminals and violent individuals). The left is presented as not just the opposition, but as a destructive, violent force that must be stopped. While communications may have lambasted Piñera's lack of action during the 2019 demonstrations, the Carabineros (Chile's national police) were spoken in highly positive terms (Campos Campos 2021; Durán and Rojas 2021). Polling data demonstrates that an overwhelming majority of first-round Kast voters in 2021 favored tough-on-crime policies and most had a neutral-to-positive opinion of Pinochet, effectively mobilizing a demographic that had been on the political

margins for the better part of two decades (Argote and Visconti 2021a).

In Uruguay, the CA was founded by the sacked Commander-in-Chief of the Army, Guido Manini Ríos in 2019, with an initial coalition of older military men who had supported the dictatorship and a number of smaller right-wing groups that had been established in the earlier part of the decade (Caetano 2022). Embracing a militaristic, caudillo rhetoric, the party anchors itself around the image of Uruguayan Founding Father, General José Gervasio Artigas. An empty vessel by which the CA can construct their own vision, 21st century artiguismo plays on familiar themes of paternalism and militarism, all in the name of defending The Republic against the enemies of societal order, a well-used punitive populist trope (Barrenche 2021; Bonner 2019). The CA's identification with a romanticized image of the military and its leaders is coming at a time where confidence in the government and its institutions are falling, save for the Armed Forces, which have only become more popular (Caetano 2022). As such, the image of the steward that rises above partisan politics and can re-establish order efficiently can be particularly attractive.

As opposed to the romantic approaches to punitive populism, Payo Cubas in Paraguay has embraced a rough-and-tumble dialogue. He has openly questioned the efficiency of Paraguayan democracy, has called for instituting a state of emergency, establishing the death penalty for patricide, femicide, corruption, and bribery (Décima 2023; Infobae 2023), supports merging and increasing funding for the military and police (La Nacion 2023), and to end drug trafficking in the border region

of Pedro Juan Caballero (Caballero 2023). Like the PR in Chile, the opposition is presented as an existential threat, with Cubas stating that "Paraguay has lost" while "the mafia, the narcotraficantes, and the millions of public officials on payroll" have won after conservative technocrat Santiago Peña ascended to the presidency (Última Hora 2023).

The loss of the right's identity throughout much of Latin America since the 2000s left the doors wide open for new actors to establish a niche where a cautious center-right had refused to. Combining an older, paternal stewardship approach to governance with a modern "politically incorrect" rhetoric regarding pertinent issues such as citizen security, the insurgent right has been able to find a core constituency among those left at the political margins while also making inroads into other, traditionally non-conservative voting blocs.

II. Peripheral Populism

As populist movements see continuing success in both Western and Eastern Hemispheres, scholarly focus has been put on what causes individuals to support populist candidates. One proposal is the "peripheral resentment thesis," which suggests that the salience of a "periphery-metropole cleavage" drives up resentment among marginalized political groups, leading to the support of anti-establishment candidates (Blatter and Hartmann 2021). I suggest that this "periphery" can be both geographic and political, with any individuals cut off from the centers of power being folded into large anti-incumbent coalitions. This has typically been the case with Latin American populism, where diverse class interests converge against a common foe in the form of

the established national government (see for example Drake 1978; Roberts 2002).

In all three cases, there is a strong geographical element to where the insurgent populists managed to establish themselves. In Chile, there has been long-standing tensions between the economic and cultural center of the Central Valley versus the outer provinces. In the early- and mid-20th century, leftist and populist candidates effectively brought together multi-class coalitions composed of urban laborers from the center along with the working- and middle-classes from the frontiers, particularly in the north (Drake 1978). Recent elections have continued this pattern of center-periphery tensions, with the watershed 2021 presidential race seeing right-wing populists establish strongholds north and south of the Valley. During the first round, Kast and "no labels" populist Franco Parisi won three of the five northern regions, and either one of the candidates got second place in all five. Kast also managed to win every province south of Santiago besides Magallanes, with his stronghold in the central-south. The second round kept this pattern up. Leftist Gabriel Boric managed to pick up most of the northern and southern extremes of Chile as center-left and Parisi voters broke for the left, while Kast still dominated the central-south (Argote and Visconti 2021c, Pauta 2021). However, after two years of an unpopular left-wing government and the failure to ratify a new constitution, the 2023 Constitutional Council election saw the PR win a plurality in every province except Atacama, Coquimbo, and Metro Santiago in the center-north and Los Ríos in the south (SERVEL 2023).

Similar (though not as dramatic) patterns can be seen

in Uruguay and Paraguay. While the well-established Uruguayan parties dominated most of the country, the CA saw its strength in the linguistically and culturally distinct northern frontier (Larrouqué 2020) which elected four of eleven CA deputies in 2019 (Corte Electoral 2019). Similarly, Paraguay's CN won a plurality of votes in the eastern department of Alto Paraná in 2023's presidential contest, while nearly tying for second place in the frontier departments of Amambay, Canindeyú, and Presidente Hayes (ABC Color 2023b). Cubas went out of his way to appeal to voters on the periphery, specifically acknowledging the presence of drug traffickers among the border regions with Brazil (Caballero 2023), and regularly spoke in Guarani while on the stump in the countryside and among working-class audiences (Carneri 2023).

Paraguay has been dominated by the Colorados since the late 1940s – before, during, and after the Stroessner regime. Their only non-Colorado President, leftist Fernando Lugo was impeached in what was widely considered a parliamentary coup in 2012 (Roberts 2014). Chile meanwhile has had a heavy top-down technocratic political culture inherited from the Pinochet regime. Simultaneously, there has been a large-scale ideological convergence among the mainstream parties. Due to this, both Paraguayans and Chileans have extremely low party identification and high mistrust of parties (Morales Quiroga 2014; Villaga 2011). With the popular sectors vastly unswayed by any party, what counts as the periphery could potentially be expanded by political entrepreneurs who manage to capture the popular imagination against highly centralized, unpopular systems of governance, bringing together new and

disruptive coalitions as uncommitted voters turn against the parties they previously voted for.

III. Multi-Sector Coalitions

One of the most intriguing factors in the right-wing insurgency is the crossover appeal of the new populists, having taken votes from both right- and left-wing parties. In the 2019 Uruguayan elections, the CA attracted a significant portion of rural voters from the Frente Abierto (FA), Uruguay's main leftist coalition (Caetano 2022, Larrouqué 2020). In one election-day poll, 38% of CA voters said they voted for the Blancos in the previous election (2014), another 24% said they voted for the FA, and 21% for the Colorados, much more heterogeneous than either the Blancos or the FA. Ideological identification was also more split: 59% of CA voters identified themselves as being right-wing, 35% as centrist, and 6% as leftist, with only Colorado voters being more evened out at 46-44-10 (El Observador).

In Paraguay, Cubas was himself arrested as a youth for participating in anti-Stroessner demonstrations and was a founding member of the center-left Encuentro Nacional party that was part of Lugo's Concertación coalition (ABC Color 2023a). In an AtlasIntel poll taken a week before the elections, over one-third of previous non-voters (38.8%) and those who spoiled their 2018 ballots (35.4%) indicated they were going to vote for Cubas. Third-party voters were similarly attracted to Cubas, along with nearly 20% of both Colorado (19.6%) and Concertación (17.7%) voters, indicating a highly heterodox coalition (AtlasIntel 2023).

Chile may be a partial exception. In 2021, first round Kast voters were overwhelmingly conservative and pro-Pinochet, showing that the PR were unable to capture

a large ideological net at the time (Argote and Visconti 2021a). The candidate able to bring together an "anti-party" coalition was economist Franco Parisi, with his Partido de la Gente (PDG). In one survey, 45% of Parisi voters did not identify with any part of the political spectrum. Of the 55% who did, most identified with the center. A vast majority of Parisi voters agreed that they preferred independent politicians, with their political views scattered between being more liberal on social issues like abortion and gay marriage than the general public, but also were more in favor of immigration restrictions, tough-on-crime policies, and reducing the size of the state (Argote and Visconti 2021b). The Parisi vote split relatively evenly between leftist Boric (42%), rightist Kast (23%), and abstention (35%) in the second round (Argote and Visconti 2021b). Following this pattern, Boric's second-round victory relied on picking up moderate voters who were more likely to want immigration restrictions and penal policies (Argote and Visconti 2021c). However, as previously mentioned, this coalition quickly collapsed. The 2023 Constitutional Council election saw the PR ride a wave of discontent from everywhere outside the Santiago axis, earning 34.34% of the vote. A now-united left coalition only got a dismal 28% to the combined left's 49.4% in the 2021 convention elections (SERVEL 2021a; 2023), pointing to Boric's second round voters jumping ship to a newly invigorated PR.

The realignment between the 2021 and 2023 elections in Chile are a good demonstration of the ideological diversity that can sprout within insurgent populist coalitions in a short time. While the core voters of the

insurgent right parties may be right-wing (with the PDG being the exception), it's necessary to win over uncommitted centrist and leftist voters in order to bring in high electoral shares. The fact that this seems to be occurring in all three countries demonstrates the potency of the insurgent populists, and that it is well within the realm of possibility for them to expand beyond traditional right-wing sectors.

Conclusion

The Southern Cone countries have been well known for their stable, institutionalized, and nationalized party systems. For Paraguay and Uruguay, their party system has lasted for well over a century (close to two for Uruguay), while scholars have argued that the Chilean party system has remained relatively intact even through the Pinochet dictatorship (Bonilla et al. 2011; Roberts 2014). The rise of right-wing insurgents brings these assumptions into question and reflects a more nuanced analysis of said party systems. In particular, examining low identification, lack of party nationalization, and high levels of mistrust (Morgenstern, Polga-Hecimovich, Siavelis 2012; 2014). It raises questions of how much longer the centuries' old party systems of Paraguay and Uruguay can last: whether there'll be a shift away from traditional party dominance, or if the insurgents will be swallowed into the traditional coalitions (as has happened in the past). For Chile, it raises the question of whether the country's party system is a glass cannon, seemingly invincible from the outside but cracks when put through the wringer of societal crisis.

As the populist phenomenon digs its heels in, it's necessary to investigate the profile of the populist voter.

Having a fuller profile of the swing voter in the above-mentioned elections will be useful in seeing where the establishment parties have lost the most ground, and if there's a correlation to the types of anti-establishment insurgencies occurring in Western Europe, especially in relation to class. The periphery resentment thesis also offers a rich line of inquiry into understanding the evolution of party systems and requires further application in both contemporary environments in either hemisphere, along with in-depth historical analysis with specific case studies. Further inquiry into the role of the Latin American right within the "Reactionary Internationale" (Caetano 2022) is also critical. To what extent are political entrepreneurs (and their voters) explicitly relying on the mold set up in other countries? See for example Larrouqué (2020) who suggests this occurred with the Brazilian-descended CA voters in rural Uruguay, looking towards Bolsonaro. Or are these movements more "home-grown," relying on the signs and symbols of their country's own history and culture to create a unique populist movement (e.g., artiguismo in Uruguay, bolivarianismo in Venezuela)?

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Fig. 1. First Round Parisi (PDG) vote vs. Boric (CS) and Kast (PR) swing in the second round, 2021.

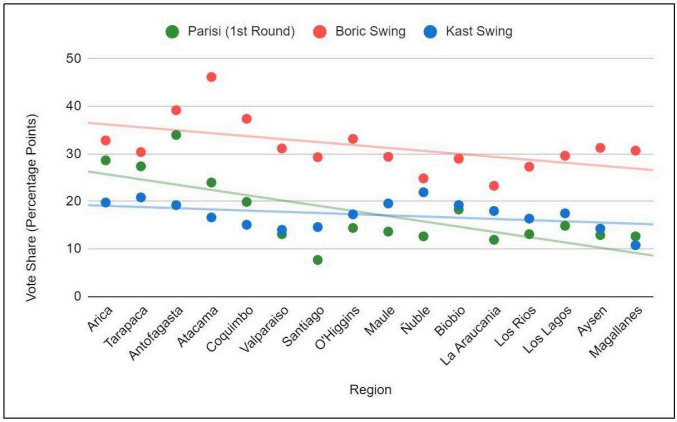


Fig. 2. First round non-Boric left and Parisi vote vs. Boric swing in the second round, 2021.

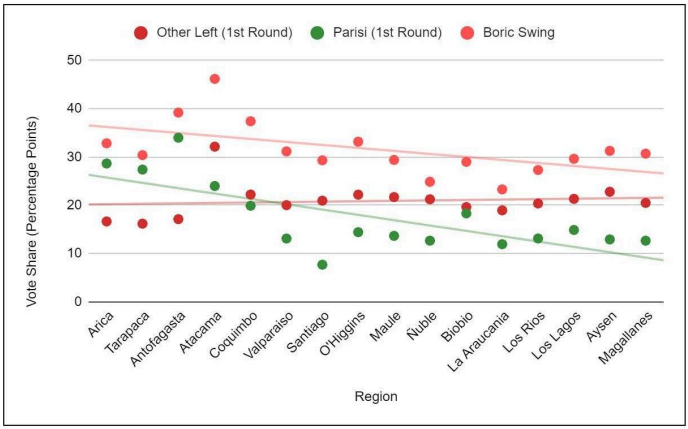


Fig 3. First round Sichel (ChV) and Parisi vote vs. Kast swing in the second round, 2021.

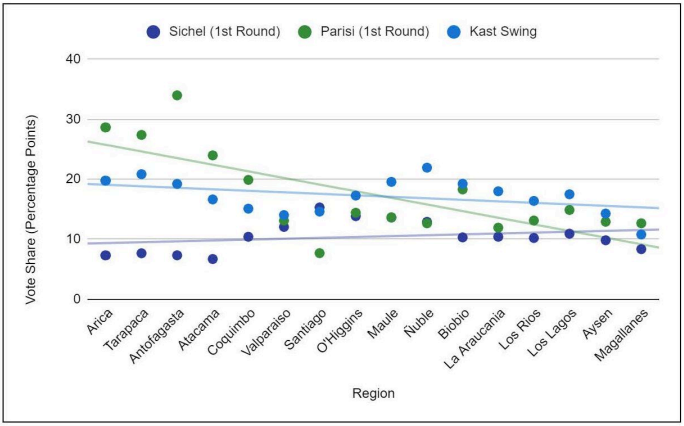


Fig 4. First round Manini (CA) vs. Martinez (FA) and Lacalle Pou (Blancos) swing in the second round, 2019.

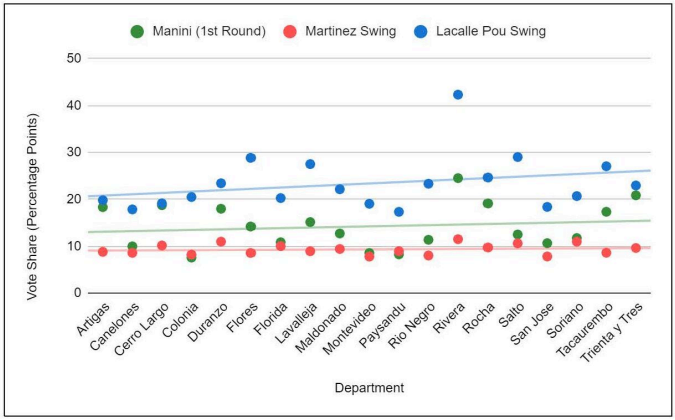


Fig. 5. First round Manini and non-Martinez left vote vs. Martinez swing in the second round, 2019.

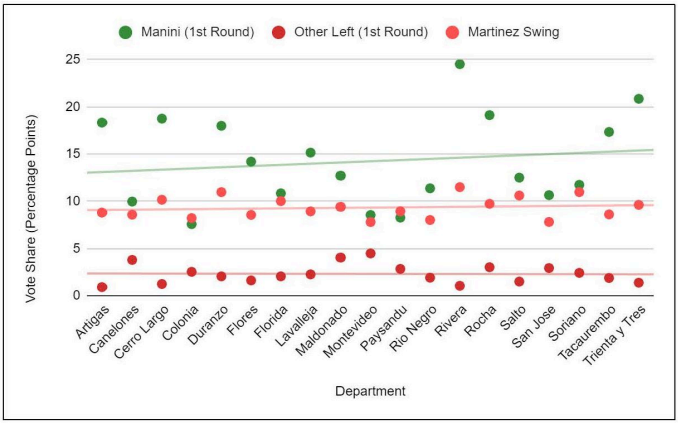
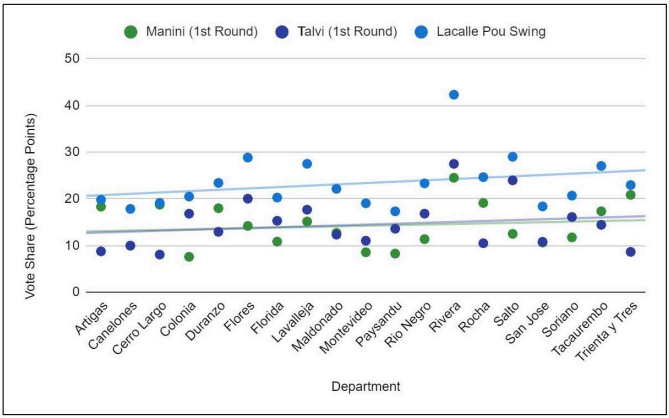


Fig. 6. First round Manini and Talvi (Colorados) vote vs. Lacalle Pou swing in the second round, 2019.



Bibliography

ABC Color. 2023a. "Paraguayo Cubas: ¿Quién Es El Candidato a Presidente Por El Partido Cruzada Nacional?" 29 April. https://www.abc.com.py/politica/2023/04/29/

paraguayo-cubas-quien-es-elcandidato-a-presidente-por-el-partido-cruzada-nacional/ (July 20, 2023).

———. 2023b "Los Números Definitivos de Las Elecciones: Así Quedaron Los Votos." 26 May. https://www.abc.com.py/politica/2023/05/26/los-numeros-definitivos-de-las-elecciones-asi-quedaronlos-votos/ (July 20, 2023).

Albarracín, Juan, and Nicholas Barnes. 2020. "Criminal Violence in Latin America." Latin American Research Review 55(2): 397–406. Altamirano, Melina, Sarah Berens, and Sandra Ley. 2020. "The Welfare State amid Crime: How Victimization and Perceptions of Insecurity Affect Social Policy Preferences in Latin America and the Caribbean." Politics & Society 48(3): 389–422.

———. 2022. "Security or Social Spending? Perceptions of Insecurity, Victimization, and Policy Priorities in Mexico and Brazil." Political Studies.

Argote, Pablo, and Giancarlo Visconti. 2021a. "Entendiendo al Votante de Kast." TerceraDosis. https://terceradosis.cl/2021/11/23/entendiendo-al-votante-de-kast/ (July 20, 2023).

———. 2021b. "Entendiendo al Votante de Parisi." TerceraDosis. https://terceradosis.cl/2021/11/24/entendiendo-al-votante-de-parisi/ (July 20, 2023).

———. 2021c. "¿Quiénes Son y Qué Piensan Los Nuevos Votantes de Boric?" TerceraDosis. https://terceradosis.cl/2021/12/22/quienes-son-y-que-piensan-los-nuevos-votantes-de-boric/ (July 20, 2023).

AtlasIntel. "Encuesta Atlas – Elecciones Paraguay 2023." 2023. https://cdn.atlasintel.org/92d996fd-c8624067-8b91-a7ea2e327fc5.pdf (July 20, 2023).

Barreneche, Sebastián Moreno. 2021. "Artiguismo,

restauración y usos estratégicos del pasado: La construcción discursiva de la identidad colectiva asociada al partido Cabildo Abierto." Cuadernos del CLAEH 40(113): 11–34.

Blatter, Joachim, and Martin Hartmaan. 2021. "Populism as Peripheral Resentment? Emotions, Narratives and Sliding Processes." Politikwissenschaftliches Seminar, Kultur- und Sozialwissenschaftliche Fakultät, Universität Luzern. https://www.unilu.ch/fileadmin/fakultaeten/ksf/institute/polsem/Dok/Projekte_Blatter/Populism_as_peripheral_resentment/Populism_as_Peripheral_Resentment_Summary.pdf (July 20, 2023).

Bonilla, Claudio A., Ryan E. Carlin, Gregory J. Love, and Ernesto Silva Méndez. 2011. "Social or Political Cleavages? A Spatial Analysis of the Party System in Post-Authoritarian Chile." Public Choice 146(1): 9–21.

Bonner, Michelle D. 2019. Tough on Crime: The Rise of Punitive Populism in Latin America. Pittsburgh, PA: University of Pittsburgh Press.

Caballero, Esteban. 2023. "Payo Cubas Phenomenon in Paraguay." LatinoAmerica21, 12 May. https://latinoamerica21.com/en/payo-cubas-phenomenon-in-paraguay/ (July 20, 2023).

Caetano, Gerardo. 2022. "Novedades y radicalidad de las «derechas alternativas» en el Uruguay reciente. El caso de Cabildo Abierto." Estudios: Revista del Centro De Estudios Avanzados (49): 29–54.

Campos Campos, Consuelo. 2021. "El Partido Republicano: el proyecto populista de la derecha radical

chilena.” Revista Uruguaya de Ciencia Política 30(1): 105–34.

Carneri, Santi. 2023. “Detenido En Paraguay ‘Payo’ Cubas, El Opositor Que Llama a Movilizarse Contra Un Supuesto Fraude Electoral.” El País, 5 May. https://elpais.com/internacional/2023-05-06/detenido-enparaguay-payo-cubas-el-opositor-que-llama-a-movilizarse-contra-un-supuesto-fraude-electoral.html (July 20, 2023).

Corte Electoral. “Elecciones Nacionales 2019.” 2019. https://eleccionesnacionales.corteelectoral.gub.uy/ResumenResultados.htm (July 20, 2023).

Drake, Paul W. 1978. Socialism and Populism in Chile, 1932-52. Urbana, IL: University of Illinois Press.

Durán, Carlos, and Gabriel Rojas. 2021. “El Partido Republicano chileno frente al ‘estallido social’: discurso político, identidad y antagonismo.” Revista Temas Sociológicos (29): 223–57.

Décima, Juan. 2023. “Elecciones En Paraguay: Payo Cubas, El ‘Milei Paraguayo’, Que Apuesta al Voto Bronca y Propone Pena de Muerte Para Los Corruptos.” Clarin, 27 April. https://www.clarin.com/mundo/elecciones-paraguay-payo-cubas-milei-paraguayo-apuesta-votobronca-propone-pena-muerte-corruptos_0_aUmA5kM7qR.html (July 20, 2023).

El Observador. 2019. “El 24% del electorado de Manini Ríos votó al FA en 2014, según Cifra”. 31 October. https://www.elobservador.com.uy/nota/el-24-del-electorado-de-manini-rios-voto-al-fa-en-2014-seguncifra-201910312150 (July 27, 2023)

Fairfield, Tasha, and Candelaria Garay. 2017. “Redistribution Under the Right in Latin America:

Electoral Competition and Organized Actors in Policymaking." Comparative Political Studies 50(14): 18711906.

Hathazy, Paul. 2013. (Re)Shaping the Neoliberal Leviathans: the Politics of Penality and Welfare in Argentina, Chile and Peru. Revista Europea de Estudios Latinoamericanos y Del Caribe / European Review of Latin American and Caribbean Studies, 95: 5–25.

Infobae. 2023. "Quién Es Cubas, El Candidato Sorpresa En Paraguay Obtuvo El Tercer Puesto." 30 April. https://www.infobae.com/america/america-latina/2023/04/30/quien-es-cubas-el-candidato-sorpresaen-paraguay-que-se-consolida-en-el-tercer-puesto (July 20, 2023).

La Nación. 2023. "'Payo' Cubas Prevé Realizar Una Fuerte Reforma Constitucional Para El 2024." 6 April. https://www.lanacion.com.py/politica_edicion_impresa/2023/04/06/payo-cubas-preve-realizar-unafuerte-reforma-constitucional-para-el-2024/ (July 20, 2023).

Larrouqué, Damien. 2020. "Elecciones en Uruguay: derrota del Frente Amplio y autonomización de la extrema-derecha." Les Études du CERI, (245-246): 80-82

Morales Quiroga, Mauricio. 2014. "Congruencia programática entre partidos y votantes en Chile." Perfiles latinoamericanos 22(44): 59–90.

Morgenstern, Scott, John Polga-Hecimovich, and Peter M Siavelis. 2012. "Ni Chicha Ni Limoná: Party Nationalization in Pre- and Post-Authoritarian Chile." Party Politics 20(5): 751–66. doi: 10.1177/1354068812453370.

———. 2014. "Seven Imperatives for Improving the Measurement of Party Nationalization with Evidence from

Chile." Electoral Studies 33: 186–99. doi: 10.1016/j.electstud.2013.07.002.

Pauta. 2021. "¿A Dónde Se Fueron Los Votos de Franco Parisi En Segunda Vuelta?" 19 December. https://www.pauta.cl/politica/a-donde-se-fueron-los-votos-de-franco-parisi-en-segunda-vuelta (July 20, 2023).

Roberts, Kenneth M. 2002. "Social Inequalities without Class Cleavages in Latin America's Neoliberal Era." Studies in Comparative International Development 36(4): 3–33.

———. 2014. Changing Course in Latin America: Party Systems in the Neoliberal Era. New York, NY: Cambridge University Press.

SERVEL. "Elección de Presidente 2017." 2017. https://historico.servel.cl/servel/app/index.php?r=EleccionesGenerico&id=187 (July 26, 2023).

———. "Convencional Constituyente 2021." 2021a. https://historico.servel.cl/servel/app/index.php?r=EleccionesGenerico&id=223 (July 20, 2023).

———. 2021b. "Elección de Presidente 2021." https://historico.servel.cl/servel/app/index.php?r=EleccionesGenerico&id=232 (July 26, 2023).

———.

2021c. Elección de Presidente 2021.". https://historico.servel.cl/servel/app/index.php?r=EleccionesGenerico&id=236 (July 26, 2023).

———. 2023. "Resultados Preliminares: Elección de Consejo Constitucional." https://www.servel.cl/eleccion-de-consejo-constitucional-2/resultados-preliminares-eleccion-consejoconstitucional-2023/ (July 20, 2023).

TSJE. "Resultados de Cómputo Definitivo – Elecciones

Generales 2018." 2018. https://tsje.gov.py/resultadosde-computo-definitivo—elecciones-generales-2018.html

Última Hora. 2023."Paraguayo Cubas: 'Han Ganado La Mafia, Los Narcotraficantes, Los Planilleros.'" 1 May. https://www.ultimahora.com/paraguayo-cubas-han-ganado-la-mafia-los-narcotraficantes-losplanilleros-n3060471 (July 20, 2023).

Villaga, Sarah Cerna. 2011. La senda del outsider: factores que explican la emergencia de candidatos exógenos al sistema de partidos en Perú y Paraguay. Estudios Paraguayos 29/30 (1/2): 117-145

About the Author

Mauro A. Gonzalez

100.

THE EFFECT OF TASK-RELEVANT SALIENT SIGNAL ON VISUAL SEARCH TASKS

Eunseo Han; Maiko Okamura; Brennan Payne; and Jeff Moher

Faculty Mentor: Brennan Payne (Psychology, University of Utah)

Purpose

Visual search is a common activity we do in our daily lives. It is a type of search that requires attention and typically involves scanning for a particular object. However, attention is a limited resource; we cannot pay

attention to every detail of our lives so we subconsciously select which element is important and worth paying attention to. This selection process can be hindered by distraction; Moher(2020) investigated the effect of target irrelevant salient signals (distractors) on visual search tasks. Target-relevant signals are the stimuli that convey no useful information for tasks, compared to the task-relevant stimuli that are sometimes helpful in completing tasks. Moher suggested that the target irrelevant salient signals cause early quitting effect: when salient distractors were present, observers quit tasks earlier and thus missed the target which they otherwise would not have.

Missing the target in daily life cannot be too dangerous; it can be as minimal as missing the celebrity you walked past on the street because you were too focused on responding to your friend on the phone. But for some others, it may be more detrimental. Radiologists, for example, have to go through a myriad of medical scans looking for possible abnormalities. Any distractions during their readings of the medical scans are unfavorable since they can lead to misdiagnosis or mistreatment of the patients. In order to assist radiologists in minimizing the risks of missed lesions, computer-aided detection, CAD was designed to highlight the potential abnormalities to encourage additional evaluation from the radiologists. Though previous studies have suggested that CAD increases the accuracy, however, CAD is not always accurate and thus causes false alarms CAD (2, 3).

The present study investigates the effect of task-relevant salient signals on visual search tasks; we utilize task-relevant salient signals since CAD is a task-relevant

salient signal. More specifically, we will observe if the early quitting effect can also be seen in visual search tasks with task-relevant salient signals. The observations from this study may ultimately help answer the question of whether the benefit of CAD outweighs the cost of it.

Method

Stimulus Design Stimuli used for this study were created by mimicking the medical scans radiologists read; rotated Ls and Ts in a noisy background represented the object on those medical scans, and the red circle around one of the letters Ls and Ts represented the CAD.

Study Design A between-subject design is employed; half of the participants are assigned to a salient signal present condition, in which red circles sometimes appear around a letter and the other half of the participants are assigned to a no salient signal present condition. Our salient signal is inspired by CAD, therefore, for the purpose of this paper, the salient signal is going to be referred to as CAD. For the first group of subjects when the target is present, CAD would highlight the target 75% of the time. 25% of the time, it would highlight non-target which makes CAD task-relevant. Both CAD and no-CAD groups completed 300 trials: 100 targets present and 200 target-absent trials. Participants would go through an additional 50 practice trials at the beginning of the experiment, therefore, 350 trials in total. Each trial has 12 objects in total, and only one rotated T is present in target-present trials.

Task Participants were asked to search for a rotated letter T among rotated letter Ls and give a simple

yes(target present) or no(target absent) response while our eye tracker recorded their eye movements.

Eye-tracking data There are key variables that are being measured through each trial. First is response time, recorded from the moment the participants start each trial until they give a response using response keys. As well as accuracy, from participants' keypress responses; represents how accurately participants performed the visual search tasks. Third would be the number and location of fixation. Objects on the screen (letters Ls and Ts and CAD) were considered fixated if their pupils fell within a 5 ° angle from them. Search coverage is another key variable. It is an estimate of the total area of the display viewed by the participants on any given trial. Additionally, dwell time: the amount of time participants spent fixating on a particular object. Lastly, oculomotor capture; identify which objects they most paid attention to, and how many total objects on the screen were fixated.

Result

We analyzed the data from four piloting participants. Based on these data, when CAD highlighted the target, higher accuracy was observed compared to both trials when CAD did not highlight the target, as well as the trials with no CAD at all. The accuracy of trials with CAD highlighting the target was over 90 percent and the accuracy of trials where CAD is not highlighting the target was around 65 percent, lastly, the accuracy of trials with no CAD was around 60 percent.

The average reaction time in target-present trials was shorter when CAD highlighted the target in targetpresent trials (=2.5 secs) compared to that of trials where CAD highlighted the nontarget(=4.3 secs), and reaction time of

trials with no CAD (= 3.5 secs). Additionally, in target-absent trials, the average reaction time in the trials where CAD was absent was slightly longer (= 4.6 secs) than in trials where CAD was absent(=4.5 secs), and also than trials in no CAD condition (=4.5 secs).

Conclusion

Moher (2020) research showed that task-irrelevant salient signals cause early quitting and lower accuracy in visual search experiments. This summer, we are testing out if task-relevant salient signals also cause the same effect. We observed this effect in within-subject comparison; the average reaction time on CAD present trials was shorter compared to the average reaction time on CAD absent trials. However, this effect is yet to be observed in between-subject comparison; the average reaction time between CAD present trials compared to no CAD trials was similar. This result may change as we collect more data.

References

1. Moher, J. (2020). Distracting objects induce early quitting in visual search. Psychol Sci, 31(1), 31-42. doi:10.1177/0956797619886809\

2. Birdwell, R. L. (2009). The preponderance of evidence supports computer-aided detection for screening mammography. Radiology, 253(1), 9-16. doi:10.1148/radiol.2531090611

3. Philpotts, L. E. (2009). Can computer-aided detection be detrimental to mammographic interpretation? Radiology, 253(1), 17-22. doi:10.1148/radiol.2531090689

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101.

THE WISHBONE CORE: IDENTIFYING SEDIMENT COMPONENTS TO DETERMINE THE PALEOCLIMATE OF LAKE BONNEVILLE

Kylee Haslam; Lauren Isom; and Andrea Brunelle

Faculty Mentor: Andrea Brunelle (Geography, University of Utah)

Abstract

Climate reconstructions of the Great Basin region has

led to unique discoveries during the Pleistocene-Holocene Transition, ~ 11,000 years ago (Palacios-Fest et al., 2021). The timeline of Lake Bonneville, a prehistoric pluvial lake, has largely been established, yet there are many unknowns about the specific timing of events and climatic conditions throughout each stage. For this study, we present lake sediment core data that expands the existing literature on the climate variability of the Bonneville Basin within the last 30,000 years. The Wishbone Core (WB19B), extracted from the Utah Test and Training Range in the West Desert of Utah, was sampled and analyzed using charcoal counts (CHAR), loss on ignition (LOI), and magnetic susceptibility (MAG SUS). These data were used to evaluate the variability of climate throughout the Late Pleistocene and Early Holocene. Our findings show an increase in charcoal abundance during the Stansbury Oscillation (SO) (~ 24,000 cal yr. B.P). Our working hypothesis for the high charcoal during the SO focuses on two components. First, an increase in fire activity may be attributed to dryer conditions during the oscillation, allowing existing fuel to burn. Additionally, lower lake levels expanded the exposed area which may have permitted more vegetation to grow, therefore, increasing fuel during the dry period.

Another distinct interval, known as the black mat, is found at the 80-84 cm mark of the core. The abundance of organic material in the black mat, dated to be ~ 12,000 cal yr., B.P, indicates a moist and wetland-like environment. The increase in organic material concurs with the Younger Dryas Event, a global return to near-glacial conditions. As suggested by Haynes (2008), it is possible the colder climate during the Younger Dryas reduced evaporation

which allowed incoming precipitation to raise water tables in the hydrographically closed Bonneville Basin. The findings from our analysis of the black mat are consistent with other geoarchaeological sites in the Western United States, which have similarly identified this dark organic layer (Haynes, 2008). The information collected for this study through the paleoclimate reconstruction of Lake Bonneville may be relevant to archaeologists, climate scientists, and policymakers in the Great Basin region.

References

Palacios-Fest, M. R., Duke, D., Young, D. C., Kirk, J. D., & Oviatt, C. G. (2021). A paleo-lake and wetland paleoecology associated with human use of the distal old river bed delta at the pleistocene-holocene transition in the Bonneville Basin, Utah, USA. Quaternary Research, 106, 75–93. https://doi.org/10.1017/qua.2021.49

Haynes CV Jr (2008). Younger Dryas "black mats" and the Rancholabrean termination in North America. Proceedings of the National Academy of Sciences of the United States of America 105(18): 6520–6525.

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102.

RESEARCH REFLECTION BY KYLEE HASLAM

Kylee Haslam

Faculty Mentor: Andrea Brunelle (Geography, University of Utah)

Working in a research lab as an undergraduate has been an amazing experience for me. I recognize the opportunities it has opened up for me and I have been extremely appreciative for the connections I have been able to make throughout my journey. Having a great team and being able to be excited about my work has led to making the project work out to its full potential. Without the support and enthusiasm from my mentor, Andrea Brunelle, and my lab partner, Lauren Isom, the research would have felt much more strenuous and less exciting.

I was ecstatic about the idea of working with sediment that was tens of thousands of years old, I knew that I was holding history in my hand and it was oftentimes difficult to fathom this information. I was also excited about the chance to carry out research that very few people my age are fortunate enough to experience. It has opened up a whole new realm of opportunities in education and future career aspects. If I were to do it all over again differently, I would have taken more time to get to know more about the background of the Wishbone Site. I felt as though I understood the background to a certain extent, however if I had conducted more research about the site, I might have been able to understand my findings on a more enhanced level.

About the Author

Kylee Haslam

103.

RESEARCH REFLECTION BY LAUREN ISOM

Lauren Isom

Faculty Mentor: Andrea Brunelle (Geography, University of Utah)

My undergraduate research experience exposed me to the intricacies of the scientific process, expanded my critical thinking skills, and strengthened my understanding of climatology and geography. I can proudly say that the experience has positively impacted my educational and career pursuits and I intend to continue my research in the field of paleoclimatology and paleoecology in graduate school. My long term career goal is to utilize my knowledge of paleoecology to contribute to

effective land management in the Western United States. Without my undergraduate research experience, I would have not recognized this as a possible option for my future career. My advisor, Dr. Andrea Brunelle, played a large role in the success of my undergraduate research and I am very grateful for her support throughout this journey. I highly recommend any undergraduate at the University of Utah getting involved in research through the Undergraduate Research Opportunity Program.

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Lauren Isom

104.

PERCEPTIONS OF CAREGIVING AND FAMILY CAREGIVERS' DESIRES TO INSTITUTIONALIZE

Anna Hsu; Rebecca Utz; Amber Thompson; and Catharine Sparks

Faculty Mentor: Rebecca Utz (Sociology, University of Utah)

Introduction

Family caregivers provide unpaid care and support for older adults or chronically ill or disabled family members. With limitations of long-term health services including a lack of healthcare workers, caregivers prevent the

healthcare system from being overburdened. Due to an aging population with overall worse health, caregivers are increasingly crucial to the healthcare system (Hoffman and Zucker, 2016 & Centers for Disease Control and Prevention [CDC], 2019). For instance, one of the largest groups provide care to those with Alzheimer's Disease and Related Dementias, with over 16 million family caregivers providing more than 17 billion hours of unpaid care (CDC, 2023).

Although family caregivers often express positive perceptions of caregiving, such as meaning, satisfaction, and closer interpersonal relationships with the care recipient, caregivers also face immense burden and stress, which can lead to worsened mental and physical health compared to non-caregivers of the same age (CDC, 2019 & Schulz and Sherwood, 2008). Furthermore, there is a lack of financial, mental, and physical support for caregivers (Schulz and Sherwood, 2008). When caregiving becomes too overwhelming or demanding, families may desire to institutionalize the care recipient in nursing homes or assisted living homes. Previous research on dementia family caregivers has found that caregiver burden is positively associated with the desire to institutionalize, whereas positive aspects of caregiving are negatively associated (Vandepitte et al., 2018 & Fields, Xu, and Miller, 2019). Other cultural or personal factors, such as religion or race/ethnicity, may also influence a caregiver's desire to institutionalize (Fields, Xu, and Miller, 2019 & Cho, Ory, and Stevens, 2016).

For example, when comparing the caregiving experience by sex, it was found that while there is no significant relationship between caregiver burden and

positive aspects of caregiving, there were different effects of each variable on the desire to institutionalize by each sex (Wong, Ng, and Zhuang, 2019). The purpose of this project is to understand how characteristics of dementia family caregivers', particularly perceived aspects of caregiving, caregiver burden, and sex, influence their desire to institutionalize.

Methods

163 dementia family caregivers enrolled in the Time for Living and Caring study, a 16-week intervention aimed to improve respite time-use satisfaction funded by the National Institutes of Aging. At baseline, participants completed surveys including those used to measure positive aspects of caregiving, caregiver burden, desire to institutionalize, and other demographic variables.

Caregiver burden was measured using the Caregiver Burden Inventory, which consists of 24 statements measured on a 0-4 scale. The five dimensions of caregiver burden are time-dependence, developmental, physical, social, and emotional burden. For each participant, the scores for all items were averaged and multiplied by 24 for a final score ranging from 0-96, with a higher score indicating greater burden. Desire to institutionalize was measured six yes/no questions, which were scored from 1-2. For each participant, the scores for all items were averaged and multiplied by 6 for a final score ranging from 6-12, and the data was recoded so a higher score would indicate less desire to institutionalize. Lastly, positive aspects of caregiving was measured using the Positive Aspects of Caregiving scale, which consists of 9 statements measured on a 1-5 scale about a caregiver's mental and emotional perception of the caregiving

experience. For each participant, the scores for all items were averaged and multiplied by 9 for a final score ranging from 1-45, with a higher score representing a more positive appraisal of caregiving.

Four regression models were used to understand the relationship between these variables on the desire to institutionalize. Model 1 was a bivariate regression comparing caregiver burden and desire to institutionalize, model 2 comparing positive aspects of caregiving and desire to institutionalize, and model 3 used both caregiver burden and positive aspects of caregiving to predict desire to institutionalize. Model 4 was a multivariate regression that also controlled for age, sex, race/ethnicity, caregiver health, caregiver employment, adequacy of income, relationship between caregiver and care recipient, and number of children in the household. Independent t-tests were also used to compare the average caregiver burden, positive aspects of caregiving, and desire to institutionalize scores between males and females.

Results

Positive aspects of caregiving and caregiver burden have a moderately weak negative relationship (r=-0.44). As shown in Figure 1, there is a moderately weak, positive

association between caregiver burden and the desire to institutionalize (r=0.43). On the other hand, as shown in Figure 2, there is a very weak, negative association between positive aspects of caregiving and the desire to institutionalize (r=-0.17).

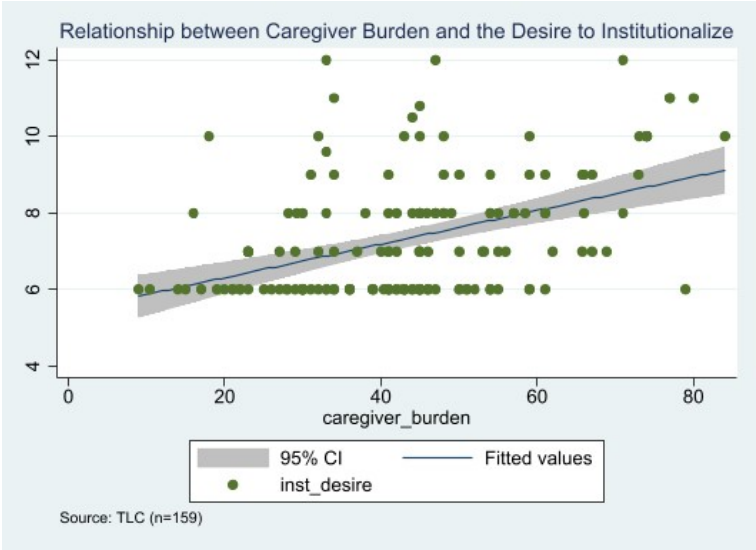

Figure 1. There is a weak, positive association between caregiver burden and the desire to institutionalize.

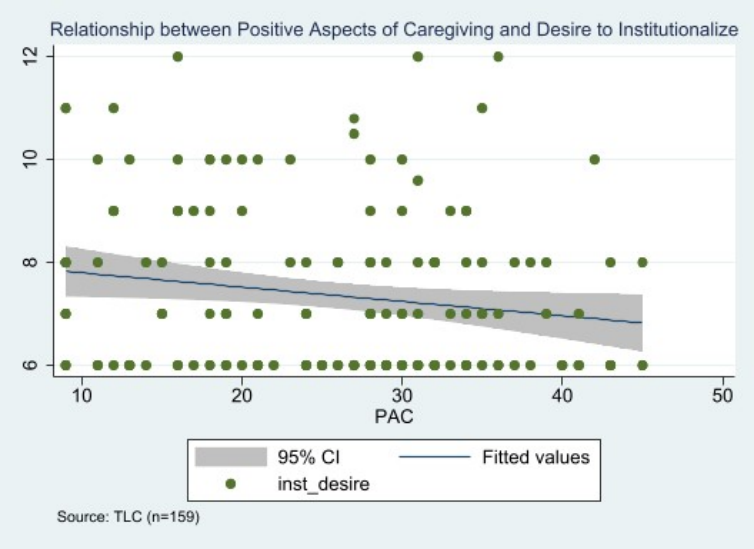

Figure 2. There is a weak, negative association between positive aspects of caregiving and the desire to institutionalize.

As shown in Table 1, caregiver burden remains significantly positively associated with the desire to institutionalize even when controlling for confounding variables ($p<0.001$), though positive aspects of caregiving become non-significant when other variables are controlled for ($p>0.05$).

Furthermore, sex becomes a significant predictor of the desire to institutionalize ($p<0.05$). While caregiver burden and positive aspects of caregiving are related to the desire to institutionalize, only sex and caregiver burden are significant predictors of the desire to institutionalize.

Table 1. Linear and Multivariate Regression Results for the Desire to Institutionalize

	Desire to Institutionalize							
	Model 1 (N=159)		*Model 2* (N=159)		*Model 3* (N=159)		*Model 4* (N=145)	
	Coef	*SE*	*Coef*	*SE*	*Coef*	*SE*	*Coef*	*SE*
Caregiver burden	0.04**	0.01			0.05**	0.01	0.05**	0.01
Positive Aspects of Caregiving			-0.03*	0.01	0.004	0.013	-0.004	0.015
Age							0.01	0.01
Female							-1.03*	0.34
Non-Hispanic white							-0.32	0.35
Good Health							0.09	0.36
Employed Full-time							-0.03	0.31
Less than adequate income							0.02	0.34
Caregiver to Spouse/Partner							-0.22	0.34
Children under 18 in house							-0.14	0.35

Note. * P>|z| 0.05, ** P>|z| 0.001

When comparing the summed scale scores of positive aspects of caregiving, caregiver burden, and the desire to institutionalize by sex alone, as shown in Figure 3, when compared to females, males have a higher perceived positive aspects of caregiving score (30.1 (S.D. 8.1) and 24.3 (S.D. 9.9)) and lower caregiver burden score (37.2 (S.D. 17.1) and 45.8 (S.D. 15.0)). However, both sexes have a similar desire to institutionalize score with males having a slightly higher score (7.7 (S.D. 1.7) and 7.3 (S.D. 1.6)). While there is a significant difference in positive aspects of caregiving and caregiver burden by sex ($p<0.05$), there is no significant difference in the desire to institutionalize ($p=0.17$). This result suggests that though there may be an association between all three variables, neither positive

aspects of caregiving or caregiver burden can predict desire to institutionalize in all cases.

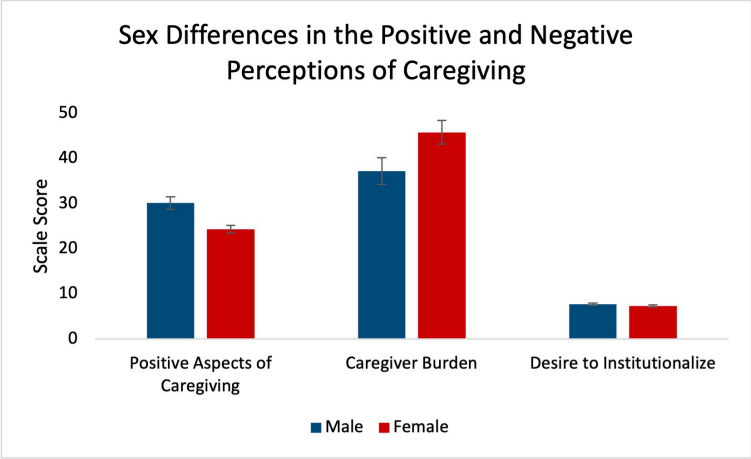

Figure 3. There are significant differences by sex between positive aspects of caregiving and caregiver burden, but no significant difference in the desire to institutionalize. Error bars represent standard error of mean.

Discussion

Although positive aspects of caregiving and caregiver burden are weakly correlated, they are not the same concept, and desire to institutionalize is primarily dependent on caregiver burden. It is important to provide caregivers with the education, support, and resources to help alleviate burden through methods including support groups or formal services such as in-home respite. By managing burden, family caregivers may be better equipped to provide care for persons

with dementia for longer, reducing dementia-related institutionalization and preventing the overburdening of the healthcare system.

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Bibliography

Centers for Disease Control and Prevention. (2019). *Caregiving for Family and Friends – A Public Health Issue*. U.S. Department of Health and Human Services. https://www.cdc.gov/aging/caregiving/caregiver-brief.html

Centers for Disease Control and Prevention. (2023). *Caregiving for a Person with Alzheimer's Disease or a Related Dementia*. U.S. Department of Health and Human Services. https://www.cdc.gov/aging/caregiving/alzheimer.htm

Cho, J., Ory, M. G., & Stevens, A. B. (2016). *Socioecological factors and positive aspects of caregiving: findings from the REACH II intervention*. Aging & mental health, 20(11), 1190–1201. https://doi.org/10.1080/13607863.2015.1068739

Fields, N. L., Xu, L., & Miller, V. J. (2019). *Caregiver Burden and Desire for Institutional Placement-The Roles of Positive Aspects of Caregiving and Religious Coping*. American journal of Alzheimer's disease and other dementias, 34(3), 199–207. https://doi.org/10.1177/1533317519826217

Hoffman, D., & Zucker, H. (2016). A Call to Preventive

Action by Health Care Providers and Policy Makers to Support Caregivers. *Preventing chronic disease*, *13*, E96. https://doi.org/10.5888/pcd13.160233

Schulz, R., & Sherwood, P. R. (2008). Physical and mental health effects of family caregiving. *The American journal of nursing*, *108*(9 Suppl), 23–27. https://doi.org/10.1097/01.NAJ.0000336406.45248.4c

Vandepitte, S., Putman, K., Van Den Noortgate, N., Verhaeghe, S., Mormont, E., Van Wilder, L., De Smedt, D., & Annemans, L. (2018). *Factors Associated with the Caregivers' Desire to Institutionalize Persons with Dementia: A Cross-Sectional Study*. Dementia and geriatric cognitive disorders, 46(5-6), 298–309. https://doi.org/10.1159/000494023

Wong, D. F. K., Ng, T. K., & Zhuang, X. Y. (2019). *Caregiving burden and psychological distress in Chinese spousal caregivers: gender difference in the moderating role of positive aspects of caregiving*. Aging & Mental Health, 23(8), 976–983. https://doi- org.ezproxy.lib.utah.edu/10.1080/13607863.2018.1474447

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105.

REFLECTION ON 2023 SPUR EXPERIENCE

Anna Hsu

Faculty Mentor: Rebecca Utz (Sociology, University of Utah)

This summer, I worked with Dr. Utz and other lab members Amber Thompson and Catharine Sparks on multiple projects based on the Time for Living and Caring (TLC) study, which is a 16-week intervention funded by the National Institutes of Aging aimed to improve respite time-use satisfaction. I assisted Dr. Utz and Amber in the creation of a poster for the Alzheimer's Association International Conference (AAIC) 2023, which was held in Amsterdam, Netherlands in July. I also had the opportunity to attend the conference with them to present

the poster. Furthermore, I assisted Dr. Utz and Cathi in the examination of various demographic variables of enrolled participants and the creation of a couple tables for another project regarding recruitment methods for the TLC study. Lastly, I worked with Dr. Utz and Amber on a project for SPUR regarding perceptions of family caregivers and their desires to institutionalize. I briefly reviewed the literature to write a small annotated bibliography and analyzed the data using STATA with multiple regressions. The results of that project were written for this paper and presented at the Summer 2023 Undergraduate Research Symposium (URS).

As a Health Science student at Rice University with an interest in pursuing medicine, this experience has demonstrated the real-life implications of topics I study in class. The social determinants of health affect the ability and quality of caregiving, while caregiving is also a social determinant of health. This experience has also allowed me to develop some of my weakest research skills. I have learned data analysis in Stata and improved my written and verbal communication of research to an expert and general audience. In addition to the research experiences, Dr. Utz connected me to a couple physicians, whom I had the opportunity to shadow. Overall, this summer experience has been extremely valuable and has allowed me to gain the experience and skills necessary for researchers and physicians.

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Anna Hsu

106.

EXAMINING THE IMPACT OF HAGWONS AND THE SOUTH KOREAN EDUCATION SYSTEM ON THE SELF-EFFICACY AND ENTITY MINDSET DEVELOPMENT OF YOUNG SOUTH KOREAN ADULTS

Caroline Joung

Faculty Mentor: Daniel Porter Morgan (Political Science, University of Utah)

Abstract

When discussing the South Korean Education System, Hagwons are an integral factor that contributes to the academic pressure and intense competition between students to receive exemplary grades. This paper examines the impact of Hagwons and the South Korean Education System on the self-efficacy and entity mindset development of young adults in South Korea. Past literature has focused on the physical and psychological impact of hagwons on the adolescent population in South Korea. This paper extends beyond existing literature by examining how this privatized education system has impacted young adults who have now aged out of the hagwon target population. An interpretive methodology was utilized to conduct one-hour-long semi-structured qualitative interviews with South Korean undergra uates that had all attended hagwons during their adolescence. The interviews were then transcribed and coded by utilizing a thematic analysis method. Six key themes emerged: Agency loss during childhood, cultivation of an entity mindset, learned helplessness, mental burden, self-efficacy, and the parent's role in their children's education. I concluded that the South Korean Education System and Hagwons play a pivotal role in crafting an entity mindset amongst South Korean students that increases mental burnout and learned helplessness while also impacting the self-efficacy of these students throughout young adulthood.

About the Author

Caroline Joung

107.

INTEGRATION OF TRADITIONAL ECOLOGICAL KNOWLEDGE WITH STEM CURRICULUM ON THE WIND RIVER RESERVATION

Michael Joyfull Komigi; Tabitha Benney; Brett Clark; and Jordan Giese

Faculty Mentor: Tabitha Benney (Political Science, University of Utah)

Data from the U.S. Department of Education in 2019, shows that Native American students had the lowest on-time graduation rate in the United States. In 2023, the

Fort Washakie Schools with 97 percent Native American students experienced both lower graduation and attendance rates than the state average (Shippen, 2023; Maloney, 2023). In addition, previous work has indicated that this issue has been exacerbated by lack of material conditions and a lack of appropriate curriculum. To address this issue, our team has begun a study at the Fort Washakie High School to better understand how to improve educational outcomes, especially STEM fields. We hypothesize that the integration of STEM (Science, Technology, Engineering, and Mathematics) concepts with Traditional Ecological Knowledge (TEK), which includes the use of traditional knowledge and practices that have been passed down over generations in a specific place (Hunn, 1993), may help to create more interest among the student populations there. As Sobel (2005) proposes, pedagogy that is affiliated with local contexts, known as place-based education, can boost students' academic excellence, foster cultural connection, and empower youth to become agents of change within local communities. To study this hypothesis, we will develop curriculum for the High School at Fort Washakie, which explored varied socio-cultural values of Eastern Shoshone and Northern Arapaho—the two indigenous tribes of the reservation—and incorporated those with STEM education for 10th graders. This curriculum will be vetted by teachers on the reservation and then taught in the classroom there. We will then assess the impact of this curriculum on learning outcomes to better understand its long-term impact. Additionally, future research can track the effectiveness of these lessons and student response to the content in relation to schools on the reservation

that have not received the treatment. This can then help refine and develop further content for class in these communities.

Bibliography

Hunn, E. (1993). What is traditional ecological knowledge. *Traditional Ecological Knowledge*, *15*, 13-15.

Maloney, W. (2023). *Student Absenteeism and Expulsion Data Request*. The Wyoming Department of Education. https://wyoleg.gov/InterimCommittee/2023/STR-2023071307-02SelectCommitteeonTribalRelations7.13.23Final.pdf

Shippen, D. (2023). *Fremont County School Districts Enrollment and Performance Data, 2017 To Present*. The Wyoming Legislative ServiceOffice. https://wyoleg.gov/InterimCommittee/2023/STR-2023071307-0123RM004FremontCoSchoolDistrictEnrollmentandPerformanceData.pdf

Sobel, D. (2005). *Place-based education: Connecting classrooms and communities*. Great Barrington, MA: Orion Society.

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108.

VISUAL ATTENTION AND MEMORY FOR LANDMARKS DURING REAL-WORLD NAVIGATION

Lillian MacKinney

Faculty Mentor: Cory Inman (Psychology, University of Utah)

I reviewed, edited, and re-reviewed my application to SPUR. I knew I wanted to be part of Dr. Cory Inman's lab. His lab focuses on memory formation, and I would be working on a project that examines how visual attention in real-world navigation influences sequential memory development. Although I knew the premise of the

research, neither Dr. Inman nor myself knew how to execute the data analysis.

Our study went like this:

Five participants implanted with NeuroPace Responsive Neurostimulators recording local field potentials (LFPs) from their temporal lobes were tasked with navigating a complex 0.75-mile route well enough that the participant could navigate the route in the opposite direction. We cataloged 150 landmarks that were visible to participants along the route. Subjects walked the route 7-8 times across two days, with the 1st walk guided (encoding) and 6-7 of the walks navigated by the participants themselves (retrieval). They then completed a landmark recognition task. Participants were asked to distinguish between 150 landmarks that appeared on the route and 150 similar landmarks that did not appear on the route. For our analysis, we compared participants' visual attention — measured by fixation duration, saccade frequency, and number of fixations to each landmark — to the results of the recognition task. We created dynamic areas of interest in 1st person videos and began data processing and analysis for each participant. If our hypotheses are supported, our findings would show that the amount of visual attention to landmarks during real-world navigation influences subsequent memory and modulates medial and lateral temporal lobe activity during real-world memory encoding.

When I arrived at SPUR, a grad student in the lab, Lensky Augustin, guided me through the beginning stages of the research. Though Lensky was new to exploring the data, he was in it with me. He and I both wanted to

understand the program we were using to get the data extracted.

To even begin understanding how visual attention was associated with memory, we first needed to outline every landmark in the videos collected. That was my job. I spent countless hours making sure the outlines were accurately capturing the entire landmark in every frame of the video. The program we were using, Blickshift Analytics, then would analyze countless statistics; fixation duration, number of fixations, saccade length, saccade frequency, and so much more. But Blickshift was in its beta phase, having only come out 4 months prior. The program was unreliable. Shutdowns would occur every 10 minutes, or every time a landmark was renamed. The program would glitch, losing track of landmarks altogether. Once, after completing annotations for two videos (about a week's worth of time), the program updated, losing all prior work as the update was not backcompatible. As time went on, the Blickshift team created encouraging updates that sped up the process, making the end-goal feel more reachable. Blickshift wasn't the only issue I was running into. The server I logged into to access Blickshift would sometimes become inaccessible for hours at a time, slowing down my process.

I know it sounds like I am endlessly complaining. But this experience made me realize something I hadn't encountered before. Research will always come with dilemmas like these ones, whether it be slow data analysis programs or not getting enough participants for your data collection. While timelines and deadlines help structure research, sometimes those timelines may need to be extended due to unforeseen circumstances. Most

importantly, that's ok! As a stickler for deadlines, it might be harder for someone like me to shift these timelines, but it's something that needs to be recognized as I continue my journey through research. By getting to experience these hiccups firsthand, I can better understand what realistic research looks like, how to set expectations, and change them through the process.

When I began this research this summer, the goal was to get all 32 of the videos annotated and analyzed. Now leaving, I have completed 6 video annotations. I'm proud of what I was able to achieve in this lab, even though I didn't quite reach that initial goal. I learned so much working with Dr. Inman and his team and about my own research process. I'm incredibly grateful for such a wonderful opportunity and a wonderful group of people to get to know. I also want to especially thank Lensky Augustin for sticking by my side and teaching me new things every step of the way. The other SPUR students are also one of a kind. Everyone with their different perspectives and histories brought so much joy, learning, and growth this summer. I am forever thankful for them.

About the Author

Lillian MacKinney

109.

CONGRESSIONAL CREDIT CLAIMING AND BLAME AVOIDANCE IN ACA LAWSUITS

Siena Popiel

Faculty Mentor: Phillip Singer (Political Science, University of Utah)

The purpose of this research is to examine the role of the Credit Claiming and Blame Avoidance theory in congressional communications with the public. We specifically examine the theory in the context of the Affordable Care Act (ACA). According to this theory, elected officials selectively claim credit for actions that

benefit or are perceived to benefit their constituents, while avoiding attention and blame for actions that do the opposite. We use the legal history of the ACA and the Supreme Court cases challenging its constitutionality from the period 2010-2021 to examine how this theory applies to members of Congress. We also examine how the strategies used by members of Congress to take credit and avoid blame have changed and evolved over this ten-year period. In order to do this, we analyzed all available press releases from members of Congress relevant to constitutional challenges to the ACA during the time period. Each release was numerically coded to quantitatively measure these strategies and changes over time. Our findings will help to explain contemporary political strategies in the U.S., particularly as they pertain to policy retrenchment and communications.

About the Author

Siena Popiel

110.

RESEARCH REFLECTION BY SIENA POPIEL

Siena Popiel

Faculty Mentor: Phillip Singer (Political Science, University of Utah)

I have found the experience really helpful in better understanding how research is conducted in the field of political science. Oftentimes people are most familiar with the hard sciences when it comes to research, so it has also been very interesting to be able to share this example of social science research with them to broaden their understanding of research and science.

About the Author

Siena Popiel

111.

US EPA SUPERFUND SITES IN UTAH: APPLICATIONS FOR ENVIRONMENTAL HEALTH RESEARCH

Kevin Ramos; Sara Grineski; and Roger Renteria

Faculty Mentor: Sara Grineski (Sociology, University of Utah)

Research has documented adverse effects on human health from various environmental hazards. Most studies examining the effects of environmental hazards on health are cross-sectional and depend on publicly available pollution data that is limited in historical coverage. Sources of pollution (e.g., landfills, railyards, and

manufacturing facilities) have existed long before the establishment of monitoring by agencies like the US Environmental Protection Agency (EPA) in 1970. Using pollution data that is restricted in temporal scope to recent years precludes researchers from examining historical pollutant sources and their effects on human populations throughout the life course and across generations.

Thus, assembling historical exposure data is valuable as it allows researchers to examine long-term and transgenerational health effects of environmental hazards. One underutilized source of historical exposure data pertains to sites designated by the EPA under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA; also known as Superfund). In Utah, we identified 576 Superfund sites associated with polluting industrial operations dating as far back as the 1850s. All sites are impacted by the release of various contaminants that impact human health, ranging from historic residential toxic chemical spills to emissions from mining and smelting. Using historic records and other resources such as the Utah Department of Environmental Quality, we comprehensively compiled information on years of operation, site types (e.g., 146 are manufacturing-related), chemical type (e.g., 76 include hydrocarbon contamination), and location (e.g., 233 are in Salt Lake County)

The next step in our project is to use these historical data to estimate parents' exposures to Superfund site hazards and test for health effects on their children. Specifically, we will use protected demographic and health data from the Utah Population Database to examine the

associations between parental exposures at the time of their birth and the risk of their children having an intellectual disability (ID).

About the Authors

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112.

INFLUENCE OF NATURE ON EFFORTFUL PROCESSING OF EMOTIONALLY CHARGED STIMULI

Astra Storie and Amy McDonnell

Faculty Mentor: Amy S. McDonnell (Psychology, University of Utah)

Abstract

Immersion in natural environments is thought to have a restful and restorative effect on individuals living in urban areas. Attention Restoration Theory (ART) suggests that depletion of attentional resources strained by life in urban environments is a primary driver of the restorative

benefits of nature, and is substantiated by a body of evidence showing the benefits of nature on cognitive processes related to attention. This study sought to examine if immersion in nature benefits two aspects of attention– cognitive control and emotional inhibition–as assessed by a Classic Stroop Task and Emotional Stroop Task, respectively. Participants (N=27) completed self-report measures and both cognitive tasks once in an urban environment, and once in a natural environment during a five-day camping trip. We predicted that performance on the Classic Stroop Task and on the Emotional Stroop Task would improve in nature compared to the urban control environment. Contrary to our hypotheses, linear mixed models did not show a significant impact of environment type on performance on either task. We did, however, find that self-reported connectedness to nature increased in natural environments. These results suggest no effect of immersion in nature on behavioral indices of cognitive control or emotional inhibition, but did show that immersion in nature enhances perceived connectedness to nature.

Introduction

Urbanization has rapidly increased since the industrial revolution of the 19th century, resulting in 56% of the global population living in urban environments (The World Bank, 2023). Epidemiological research has found that populations living in urban environments experience greater rates of mental illness (Golembiewski, 2021) and decreased attentional capacity (Linnell et al., 2012; Lambert et al., 2015). Although the restorative properties of natural environments have been known since antiquity, it has only been in the last several decades that these

effects have been tested with the scientific method by the psychological science community. This research has resulted in a growing body of research in support of the restorative properties of nature on cognition and mood.

One framework that explains how these benefits may precipitate from interacting with nature is Attention Restoration Theory (ART; Kaplan, 1995). ART suggests that the over- stimulation and attentional demands of urban environments place high demand on our voluntary, directed attention. We are forced to move from one task to the next and we are unable to fully replenish our cognitive resources before this effortful form of attention is next required. Over time, this constant task-switching leads to mental fatigue, reduction in our voluntary attention capacity, degraded cognitive performance, and increased stress. Natural environments, by contrast, feature stimuli which are inherently pleasing or salient such as vast landscapes, wildlife, and diverse vegetation. These features engage our more passive, involuntary attention in a less effortful manner. This reduction in use of directed attention results in the restoration of attentional resources, and subsequent improvements to cognitive performance and mood (Kaplan, 1995).

ART is supported by research that shows exposure to nature benefits multiple facets of attention including cognitive flexibility (Hartig, 1991), response inhibition (Bailey et al., 2018), creativity (Atchley et al., 2012), and working memory capacity (Berman et al., 2012).Additionally, exposure to nature has been shown to improve affect (Berman et al., 2012; Bratman et al., 2015), anxiety, and stress (Koselka et al., 2019). Although ART suggests that nature primarily restores attention and

the emotional benefits are dependent on this restoration, contemporary research points toward these benefits being interrelated (Scott et al., 2021). For example, self-reported connectedness to nature has even been shown to partially mediate the positive effects of nature on cognitive processes (Mayer et al., 2008).Additionally, recent research has demonstrated that children tested in more natural "green" spaces exhibit less distraction from negative emotional stimuli than those tested in indoor settings (Mason et al., 2022). These results are particularly important as recent research has found cognitive control to have a limited ability to improve emotional distraction (Straub et al., 2021). It is more likely that cognitive control and emotional distraction are related, and draw from shared attentional resources instead of being dependent on the restoration of attention alone.

A common means of assessing cognitive control is the use of Stroop tasks (Stroop, 1935), which require participants to exert effortful, inhibitory control to sort presented stimuli. Variations exist such as the Emotional Stroop task which specifically engages *emotional* response inhibition. Since these tasks require directed, effortful attention they have been used in previous studies to demonstrate the restorative effect of nature on attention (Bailey et al., 2018). Benefits to both a Classic and Emotional Stroop task after exposure to nature would support the emerging view that cognitive control (Classic Stroop Task) and emotional cognitive control (Emotional Stroop Task) operate using shared resources. Such findings would also implicate that the restorative effect of nature extends beyond directed attention to benefit other processes such as emotional control.

The present study seeks to investigate the benefits of immersion in nature on cognitive control and emotional response inhibition–two aspects of higher-order executive attention. We assessed behavioral performance on the Classic Stroop Task and the Emotional Stroop Task while participants were immersed in the wilderness on a five- day camping trip compared against control testing in an urban environment. We examined if immersion in nature impacts cognitive inhibitory control, emotional inhibitory control, or both. Furthermore, we examined if self-reported connectedness to nature strengthens or weakens the impact of immersion in nature on these cognitive processes, as observed in previous studies (Mayer et al., 2008). Improvement on both tasks would suggest that immersion in nature enhances cognitive control capacity not just for neutral stimuli but also emotionally charged stimuli, thus suggesting the attentional benefits of exposure to nature are domain-general.

Methods

Participants

Twenty-seven undergraduate students (15 females, 11 males, and 1 other; Mage = 22.63; SD = 3.80) at the University of Utah with normal neurological functioning, normal or corrected-to-normal vision, and fluent in English participated in the study as part of a course at the University of Utah. While attendance on the nature trip was required for course credit, participation in the presented research study was voluntary and

participants were paid $60 for completion of the research study.

Design

Each participant completed testing at two time points–once in a natural environment and once in an urban environment– for a within-subjects design. The order of testing was counterbalanced across participants to control for potential practice effects.

Measures

The Stroop task (Stroop, 1935) is a widely used cognitive test to assess a facet of attention called inhibitory cognitive control. The task presents participants with the names of colors (red, blue, yellow, or green) in different colored fonts (red, blue, yellow, or green) and requires the participant to respond to the color of the font while ignoring lexical meaning. For example, if the word "red" was presented in blue ink, the correct answer would be "blue". The difference in reaction times where the lexical meaning and font color are incongruent and the trials where they are congruent (i.e., response to "RED" printed in blue ink minus "RED" printed in red) is referred to as *the Stroop Effect*. Smaller *Stroop Effect* scores indicate greater inhibitory control in participants. The Emotional Stroop task (Ben-Haim et al., 2016) is similar to the original Stroop task in that

participants are required to respond to the font color while ignoring lexical meaning. In the Emotional Stroop task however, the presented words are common English words which either have a neutral valence (e.g., “FIELD”, “NEAR”, “BLOOM”), or an emotional valence (e.g., “DEATH”, “FAILURE”, “GRIEF”). The difference between the response times to the emotionally charged trials and the neutral trials is referred to as *the Emotional Stroop Effect*. Smaller *Emotional Stroop Effect* scores indicate reduced interference from the emotional valence of the word and indicate less emotional distraction in participants.

Connectedness to nature was assessed with the Connectedness to Nature scale (Mayer & Frantz, 2004), which has previously been shown to partially mediate positive emotional and cognitive benefits to exposure to nature (Mayer et al., 2009). This inventory consists of fourteen questions assessing affective responses of an individual in response to nature. Responses are recorded on a 5-point scale where 1 indicates the least connection with nature, and 5 the highest. After adjusting for reverse-coded items, total scores are calculated as an average of the 14 questions on the scale.

Other Measures

Other self-report measures and cognitive tasks were administered as part of the original study to address other research questions not pertinent to the present analysis.

They are included in the procedure for clarity and comprehensiveness, but will not be discussed in the present analysis.

Procedure

After participants provided informed consent, they were randomly assigned to one of two groups. Participants completed testing either before and during (Group 1) or during and after (Group 2) a five-day camping trip at Sand Island Campground in Bluff, UT. This counterbalanced AB-BA design was chosen to allow for a testing session during the immersion in nature and a control, urban testing session for each participant, while controlling for practice effects from repeated measures. The urban testing session of Group 1 was conducted one week prior to the trip, while the urban testing session for Group 2 was conducted one week after the camping trip.

The nature testing sessions for all participants occurred on either day three or four of the camping trip, outside of time reserved for meals and class related activities. Testing occurred at a campsite approximately 200 yards away from the class campsite in order to separate research activities from class activities, and to minimize distractions during testing. During testing, participants were seated in a foldable camp chair inside of a pop-up nylon shelter as shown in Figure 1 to protect from glare on the testing screen and natural elements such as wind, rain, and insects. Participants were sat in the same conditions in the urban condition for testing

consistency. The remainder of the study procedure was identical for all testing sessions, only differing in location of testing.

Figure 1: Example testing setups in the urban condition (left) and natural condition (right). At the beginning of a testing session, participants completed an IRB-approved consent document and general demographic survey to verify they met the study requirements.

Participants then completed the Operation Span test, Stroop Task, and then Emotional Stroop Task on a laptop provided by the experimenters. Written instructions and a brief practice test were given for each cognitive task, and a break of 10 minutes was given between these tasks. Participants then took the Reading The Mind In The Eyes task on paper. Finally participants responded to the Perceived Positive and Negative Affect Scale (PANAS), Connectedness to Nature Scale (CNS), a social connection scale, sleep scale, and physical activity scale.

Analysis

Statistical analyses were conducted using R software, version 4.3.1. On both the classic Stroop and the emotional Stroop task, reaction times that were 3 standard deviations above the mean response time, or

that were under 100 ms were considered to be the result of inattention to the task and were removed from future analyses. For the classic Stroop task, each participant's mean response time for congruent trials was subtracted from their mean response time to incongruent trials in each testing environment. Greater differences between these reaction time means indicated greater interference from incongruence of the ink and lexical color of the stimuli, and indicates decreased cognitive control capacity. Similarly, for the Emotional Stroop task, each participant's mean response time for neutral trials was subtracted from their mean response time to emotional trials. Greater differences indicated greater interference from the negative valence of the word, and indicated decreased cognitive control in suppressing emotional responses. The Perceived Connectedness to Nature responses were converted to scores of 1-4 for each question, and averaged into one total score for each participant at each testing session.

To account for anticipated variability between and within groups, repeated measures within each individual, and missing data, data were analyzed using linear mixed effects models (Bates et al., 2015). For each outcome measure of interest, three models were run such that Environment Type, Session, and the interaction between Environment Type and Session were each entered one at a time as fixed effect predictors with Subject ID as the random intercept. A subsequent likelihood ratio test

was run to test for significance of each model in which the model of interest was compared to a null model with the variable of interest removed. This test results in a chi-squared statistic and associated p-value for each model. Effect sizes for significant effects are reported as Cohen's *d* scores.

Results Self-report

Results

The results from the self-report Connectedness to Nature Scale can be visualized in Figure 2. Linear mixed models revealed a significant main effect of environment type on score on the connectedness to nature scale ($\chi 2(1)=7.16$, $p=0.00745$) such that there was a significant increase in the connectedness to nature scale score in nature compared to urban environments (β = 0.21, SE=0.076, $df=26.00$, $t=2.81$, $p=0.00928$; Cohen's $d=0.38$)

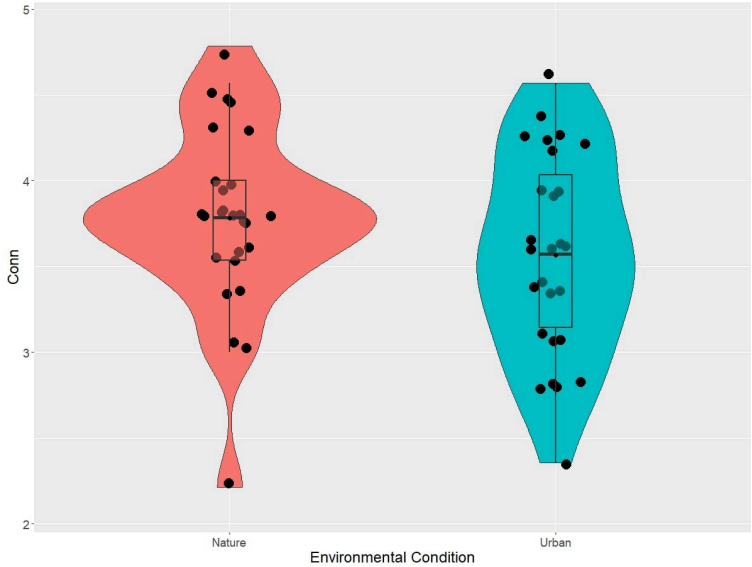

Figure 2: Self-reported connectedness to nature scores between environmental conditions

Classic Stroop Task Results

Reaction time results from the Classic Stroop task can be visualized in Figure 3, while difference scores on this task broken down by environment type are visualized in Figure 4. Linear mixed models revealed no significant main effect of environment type on difference scores on the Classic Stroop task ($\chi2(1)=1.27$, $p=0.260$). Adding score on the Connectedness to nature scale as a covariate in the model did not significantly influence model results ($\chi2(1)=0.53$, $p=0.465$). Next, the effect of session number on the difference scores was assessed. Linear mixed models did not reveal a significant

main effect of session on the Classic Stroop task ($\chi2(1)=3.50$, $p=0.0623$). Adding the score on the connectedness to nature scale as a covariate factor in the model did not influence the model results ($\chi2(1)=1.19$, $p=0.280$). Linear mixed models did not find the interaction of session and environment type to have a significant effect on the difference scores on the Classic Stroop Task($\chi2(1)=0.946$, $p=0.354$). Again, adding the connectedness to nature scale as a covariate did not have a significant impact on the model results ($\chi2(1)=0.442$, $p=0.375$).

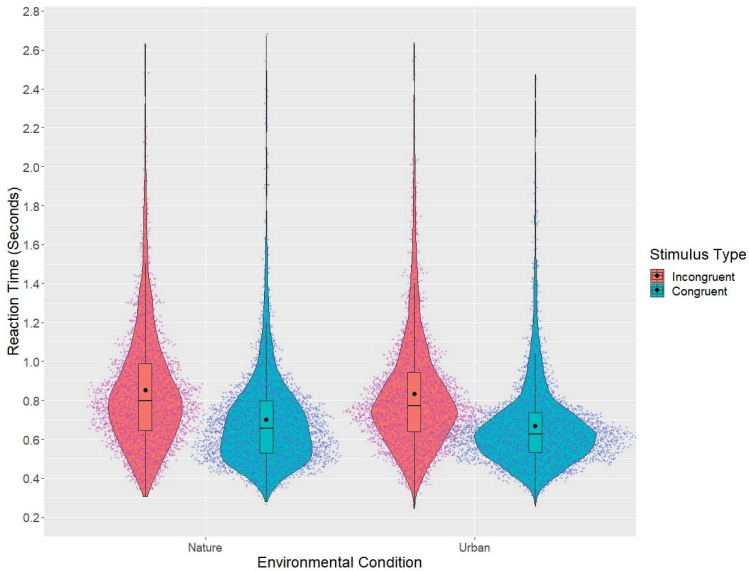

Figure 3: Results reaction times to the Classic Stroop task, broken down by stimulus type and testing environment.

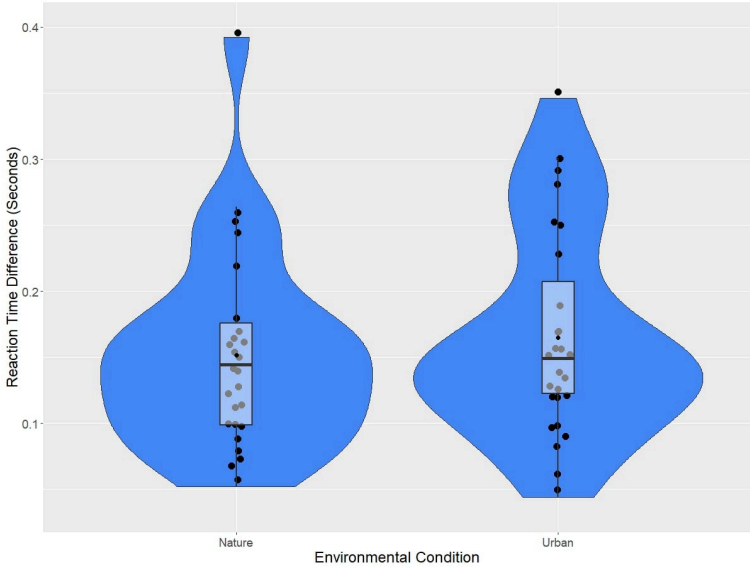

Figure 4: Difference scores on the Classic Stroop task, broken down by environmental condition.

Emotional Stroop Task Results

Reaction time results from the Emotional Stroop task can be visualized in Figure 5, while difference scores on this task broken down by environment type are visualized in Figure 6. Linear mixed models revealed no significant main effect of the environment type on the difference scores on the Emotional Stroop Task ($\chi2(1)=2.86$, $p=0.101$). Additionally, linear mixed models did not reveal a significant main effect of session on the difference scores of the Emotional Stroop Task ($\chi2(1)=0.273$, $p=0.612$). Linear mixed models also did not find a significant interaction between environment type and session on the Emotional Stroop Task difference scores ($\chi2(1)=3.91$, $p=0.390$). Adding connectedness to nature scores did not significantly impact the models for

environment ($\chi2(1)=3.71$, $p=0.159$), session ($\chi2(1)=1.66$, $p=0.539$), or the interaction of environment and session ($\chi2(1)=0.842$, $p=0.408$).

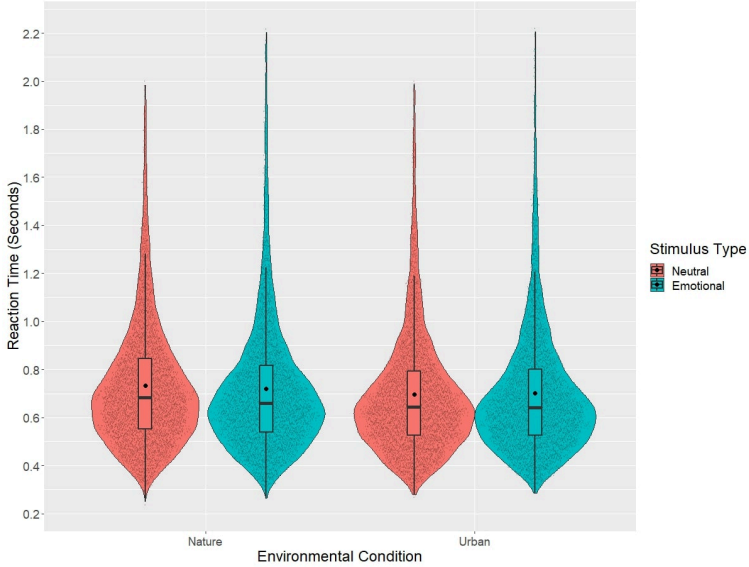

Figure 5: Reaction times to the Emotional Stroop task, by stimulus type and environment.

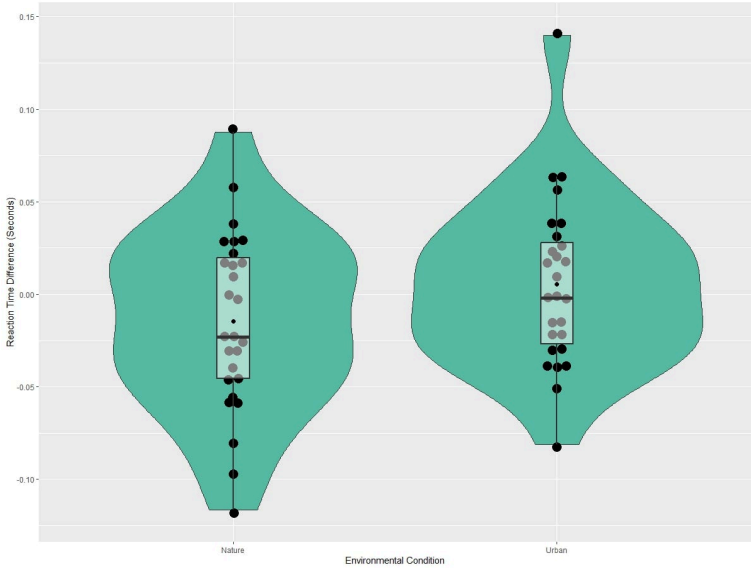

Figure 6: Difference scores for the Emotional Stroop task by environment.

Discussion

The present study sought to explore whether or not immersion in nature influenced cognitive control (as measured via performance on the Classic Stroop Task) and emotional inhibitory control (measured via performance on the Emotional Stroop Task), and how these relationships may have been influenced by each participants' self-reported connectedness to nature. Both of these cognitive processes are thought to be facets of directed, executive attention and thus are thought to be improved by immersion in nature per Attention Restoration Theory (Kaplan, 1995).

Our analysis did not reveal a significant effect of environment type on Classic Stroop or Emotional Stroop task performance. Furthermore, neither the

connectedness to nature (CNS) scores nor session number had a significant impact on the performance of these tasks. Our analysis however did find that CNS scores were significantly higher in the nature condition compared to the urban condition.

Our hypothesis that exposure to natural environments would result in significant benefits to the Stroop and Emotional Stroop task was not supported by the results. There are a number of factors why this may have been the case. First, although the locations that were selected in both conditions were intended to be free from distractions, elements such as nearby wildlife, sun and ambient sounds may have still distracted participants and affected overall results. Furthermore, since only the difference scores on the tasks were analyzed, it is possible that subjects made similar improvements in responding to both the congruent and incongruent trials in the classic Stroop task, and to the neutral and emotional trials in the Emotional Stroop task. Such improvements would not result in a change of difference scores, and thus would not be captured by the analyses performed. Finally, although score on the Connectedness to Nature scale has been previously found to partially explain benefits from exposure to nature (Mayer et al., 2008), these correlations are not universally observed and may be a proxy to related influences such as familiarity with natural environments which may reasonably impact the restorative benefits of nature. This is supported by the greater variability in reaction times in the natural condition which can be seen in Figure 3 and Figure 6. Finally, it is possible that the sample size of 27 participants resulted in our analyses being underpowered

to detect more minute effects. We did observe a significant effect of environment type on Connectedness to Nature scores, which has important implications. Although the study sought to uncover benefits to cognitive and emotional processing in nature, higher levels of connectedness to nature are still a notable benefit. Increased CNS scores are correlated with higher engagement with natural environments, increased pro-environmental behaviors, and greater sense of stewardship for natural environments (Martin et al., 2020; Whitburn et al., 2019).

Conclusion

While this study did not find significant evidence that immersion in natural environments improves cognitive control in response inhibition or emotional response inhibition, benefits to self-reported connectedness to nature were found. Furthermore, the sample size of this study may have resulted in underpowered analyses that were not able to detect smaller effects which may be present. Future studies should seek to expand on the impact of immersion in nature on subjective feelings toward nature. Additionally, replicating these results with a larger sample size may implicate differences in restorative effects of nature based on the specific natural environment subjects are exposed to.

References

Atchley R. A., Strayer D.L., & Atchley, P. (2012). Creativity in the Wild: Improving Creative Reasoning through Immersion in Natural Settings. *PLoS ONE*, 7(12): e51474. https://doi.org/10.1371/journal.pone.0051474

Bailey, A. W., Allen, G., Herndon, J., & Demastus, C. (2018). Cognitive Benefits of walking in natural versus built environments. *World Leisure Journal, 60(4),* 293-305. https://doi.org/10.1080/16078055.2018.1445025

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*, 1–48. https://doi.org/10.18637/jss.v067.i01

Ben-Haim M.S., Williams P., Howard, Z., Mama, Y., Eidels, A., & Algom, D. (2016). The Emotional Stroop Task: Assessing Cognitive Performance under Exposure to Emotional Content. *Journal of Visualized Experiments*, 29(112). doi: 10.3791/53720.

Berman, M. G., Kross, E., Krpan, K. M., Askren, M. K., Burson, A., Deldin, P. J., … & Jonides, J. (2012). Interacting with nature improves cognition and affect for individuals with depression. *Journal of affective disorders*, 140(3), 300-305.

Bratman, G. N., Hamilton, J. P., Hahn, K. S., Daily, G. C., & Gross, J. J. (2015). Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proceedings of the National Academy of Sciences*, 112(28), 8567–8572. https://doi.org/10.1073/pnas.1510459112

Crossfield, E., Damian, M.F. (2021) The role of valence in word processing: Evidence from lexical decision and emotional Stroop tasks. *Acta Psychologica*, 218(2021). https://doi.org/10.1016/j.actpsy.2021.103359

Golembiewski, J. (2019). Neuroscience of mental illness in the city. In Bhugra, D., Ventriglio, A., McCay, L., Castaldelli-Maia, J.(Eds.), *Urban Mental Health* (108-120).

Oxford University Press. https://doi.org/10.1093/med/9780198804949.003.0009

Hartig, T., Mang, M., & Evans, G.W. (1991). Restorative effects of Natural Environment Experiences. *Environment and Behavior*, 23(1), 3-26. https://doi-org.ezproxy.lib.utah.edu/10.1177/0013916591231001

Hasshim, N., & Parris, B. A. (2021). The role of contingency and correlation in the Stroop task.

Quarterly Journal of Experimental Psychology, 74(10), 1657–1668. https://doi.org/10.1177/17470218211032548

Johnson, D.R., (2009). Goal-directed attentional deployment to emotional faces and individual differences in emotional regulation. *Journal of Research in Personality*, *43*(1), 8-13. https://doi.org/10.1016/j.jrp.2008.09.006.

Kaplan, S., and Berman, M.G., (2010). Directed attention as a common resource for executive functioning and self-regulation. *Perspectives on Psychological Science*, *5*,,43-57. https://doi.org/10.1177/1745691609356784'

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, 15(3), 169–182

Koselka, E.P.D., Weidner, L.C., Minasov, A., Berman, M.G., Leonard, W.R., Santoso, M.V., de Brito, J.N., Pope, Z.C., Pereira, M.A., & Horton, T.H. (2019). Walking Green: Developing an Evidence Base for Nature Prescriptions. *International Journal of Environmental Research and Public Health* 2019, 16(22). https://doi.org/10.3390/ijerph16224338

Lambert, K. G., Nelson, R. J., Jovanovic, T., & Cerdá, M. (2015). Brains in the city: Neurobiological effects of urbanization. *Neuroscience & Biobehavioral Reviews*, 58, 107-122. https://doi.org/10.1016/j.neubiorev.2015.04.007

Linnell, K.J., S. Caparos, J.W. de Fockert, and J. Davidoff. (2013). Urbanization decreases attentional engagement. *Journal of Experimental Psychology: Human Perception and Performance 39(5)*: 1232–1247. https://doi.org/10.1037/a0031139

LoTemplio, S. B., Scott, E. E., McDonnell, A. S., Hopman, R. J., Castro, S. C., McNay, G. D., McKinney, T. L., Greenberg, K., Payne, B. R., & Strayer, D. L. (2020). Nature as a potential modulator of the error-related negativity: a registered report. *International Journal of Psychophysiology*, 156, 49–59. https://doi.org/10.1016/j.ijpsycho.2020.06.014

Martin, L., White, M., Hunt, A., Richardson, M., Pahl, S., & Burt, J. (2020). Nature contact, nature connectedness, and associations with health, wellbeing and pro-environmental behaviors. *Journal of Environmental Psychology*, 68. https://doi.org/10.1016/j.jenvp.2020.101389

Mayer, F. S., & Frantz, C. M.(2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology, 24(4),* 503-515.

Mayer, F. S., Frantz, C. M., Bruehlman-Senecal, E., & Dolliver, K. (2009). Why Is Nature Beneficial?: The Role of Connectedness to Nature. *Environment and Behavior, 41(5),* 607–643. https://doi.org/10.1177/0013916508319745

Scott, E. E., McDonnell, A. S., LoTemplio, S. B., Uchino, B. N., & Strayer, D. L. (2021). Toward a unified model of stress recovery and cognitive restoration in nature. *Parks Stewardship Forum*, *37*(1). https://doi.org/10.5070/p537151710

Straub, E.R., Schmidts, C., Kunde, W., Zhang, J., Kiesel, D., & Diganth, D. (2021). Limitation of cognitive control on emotions distraction – Congruency in the Color Stroop task does not modulate the Emotional Stroop Task. *Cognitive, Affective, & Behavioral Neuroscience*, 22, 21-41.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18, 643–662.

The World Bank. (2023, April 03). *"Urban Development"*. The World Bank. https://www.worldbank.org/en/topic/urbandevelopment/overview#:~:text=Today%2C%20some%2056%25%20of%20the,people%20will%20live%20in%20cities

Whitburn, J., Linklater, W., & Abrahamse, W. (2019). Meta-analysis of human connection to nature and proenviornmental behavior. *Conservation Biology*, 34(1), 180-191. https://doi.org/10.1111/cobi.13381

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113.

ADVANCING THE RIGHT TO HEALTH: LESSONS FOR IMPROVING THE NEGOTIATION POWERS OF MEDICARE

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Abstract

The United States (US) spends more per capita on prescription drugs than other high-

income countries (Sarnak, Squires & Bishop, 2017). Yet, the high cost of drugs does not translate to better health outcomes. In fact, the US has a significantly lower life expectancy at birth and higher death rates for avoidable or treatable conditions compared to other high-income countries (Gunja, Gumas & Williams, 2023). While various factors contribute to these poor health outcomes, access to affordable medications is a major consideration.

The Inflation Reduction Act (IRA, 2022) is a recent policy that aims to address the issue of affordable access to prescription medication by granting negotiation power to Medicare. However, for these negotiations to be effective, it is important to examine drug pricing policies in nations that have successfully negotiated drug prices.

In this paper, I contend that the US has an obligation to provide affordable access to prescription medications, alleviate concerns about stifled pharmaceutical innovation, and finally, I review the process of drug negotiations in the United Kingdom and apply them to the proposed Medicare negotiation policy.

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Introduction

As a member of a generation that has witnessed an unprecedented surge in drug development, I’ve seen first-hand the life-saving potential of pharmaceuticals. Each year an average of 38 new drugs go to market, potentially saving someone’s life (CBO, 2021). Yet, for many, these life-altering drugs are tauntingly just out of reach. Personally, I witnessed my aunt struggle to afford a needed prescription. It was a frustrating and helpless experience. My aunt who worked and had insurance, conditions that should prevent extraordinary pharmaceutical bills, had to live on a meager budget to afford the medication. I initially thought that my understanding of how a free market works to efficiently allocate resources was flawed. Maybe I was missing

something and my aunt was an anomaly? Surely, I thought, the right to health, including access to medications, would be protected in a high-income country like the US. But firsthand experiences in the medical field, listening to stories from my friends and family, and reviewing data about the high cost of drugs has validated and deepened my concern about the accessibility and affordability of drugs in the US.

In contrast to other high-income countries, the US has allowed drug prices to reach soaring heights with little oversight. This is exemplified by the case of imatinib (Gleevec), a leukemia medicine, whose price in the US rose to $8,500 per month, while it remained at $4,500 in Germany (Bach, 2015). Even amid competition and other factors that would normally drive down prices of non-medical products, in the US, the cost continued to rise. Instead of directly addressing concerns, the US stance on containing prescription prices has relied on "market forces" to govern access to healthcare (Augustine, Madhavan & Nass, 2018). But the pharmaceutical industry is not directly tied to competitive market forces, unlike most sectors in the US.

Typically, the free market maximizes consumer choice. Consumers yield power with economic "votes" that influence which goods should be provided and at what price they should be offered (Augustine, Madhavan & Nass, 2018). Ideally, the free market is supposed to be the most effective way to balance consumer values and seller goals (Elegido, 2015). However, the pharmaceutical sector has many intermediaries and significant government privileges (Augustine, Madhavan & Nass, 2018). The pharmaceutical supply chain involves pharmacy benefit

managers, wholesalers, retail pharmacies and insurers that make profit at each step. The compounded price is ultimately borne by the patient and/or taxpayer.

The pharmaceutical sector doesn't fit neatly into the free-market model because insurers and physicians greatly influence what consumers purchase (Mwachofi & Al-Assaf, 2011). In other sectors, consumers have more autonomy with transactions and have significant information available about the product. But the nature of the pharmaceutical sector creates information asymmetry because most individuals are prescribed a certain medication from a physician and individual insurance plans affect what medication is available (Mwachofi & Al-Assaf, 2011). Further, the pharmaceutical industry enjoys research funding from the government and market exclusivity (Augustine, Madhavan & Nass, 2018).

Lastly, both positive and negative externalities related to the pharmaceutical sector impede the free market's ability to be effective (Mwachofi & Al-Assaf, 2011 and Augustine, Madhavan & Nass, 2018). In economics, an externality is a side effect of industry activity that impacts other parties without being represented in the cost of the product. An example of a positive externality might be the use of vaccines generally

benefits a wider population than just the vaccinated patients. Yet, vaccinated patients and their insurers generally bear the cost of the preventative action (Augustine, Madhavan & Nass, 2018). In contrast, a negative externality might be an unvaccinated person reducing herd immunity or increasing the spread of disease (Augustine, Madhavan & Nass, 2018).

Ultimately, pharmaceutical companies have greater freedom in price setting than other sectors. Because of price setting liberty, consumers (patients) are left to foot a large bill. This dilemma evokes the question: Are the wealthy the only ones deserving of life-altering medications?

Fortunately, the US Government has taken steps to reduce drug prices, such as granting Medicare the right to negotiate drug prices (albeit limited to a contained list of drugs). In this paper, I will review the US Government's moral and legal obligation to affordable drug prices, explore the balance between pharmaceutical innovation and affordability, showcase how other high-income states have lowered drug prices through negotiation, and provide policy recommendations for the upcoming Medicare negotiations.

Understanding the Right to Health and the US Relationship

In 1946, Eleanor Roosevelt, the First Lady

of the US from 1933-1945, played a pivotal role in drafting the Universal Declaration of Human Rights (UDHR) (United Nations). The UDHR was a landmark achievement in recognizing human rights on an international scale and aimed to prevent gross atrocities while promoting the development of human rights universally (United Nations). Within two years of its entrance, the United Nations (UN) General Assembly adopted the UDHR. For nearly 80 years, the UN has obtained and operated as an international legal personality and significant reputation as a human rights governing body (Behzadi, 1977).

As a founding member of the UN and its involvement in World War II, the US enjoys certain privileges such as a permanent seat on the UN Security Council and consequently, veto power. However, despite a historical presence in championing human rights abroad, human rights violations are fraught within the US (Amnesty International, 2022). Further, the US has only ratified a few international human rights treaties. Namely, the International Covenant on Civil and Political Rights (ICCPR).

For a treaty to be legally binding, it must be ratified. Although the US Senate expressed significant reservations1 and understandings of the ICCPR (making it less influential), they ultimately ratified the covenant (Kinney,

2002). This action had a sweeping impact on the human rights community and gave further legitimacy to the UN and human rights governing bodies. Still, the US refrained from committing legally to many other critical instruments like, the International Covenant for Economic, Social and Cultural Rights (ICESCR), Convention on the Elimination of All Forms of Discrimination against Women of 1979, and Convention on the Rights of the Child of 1989 (Kinney, 2002).

The International Covenant for Economic, Social and Cultural Rights (ICESCR) represents a glimmering ideal of quality of life and is an essential instrument in promoting societal improvement. The standard of living (based on OECD Better Index data) is significantly higher in member states that have ratified the ICESCR compared to those that have not (OCHR). In a post-COVID world, the right to health (article 12, ICESCR) is increasingly being recognized and was applied during the international allocation of COVID vaccines (Sekalala et al., 2021). Other pieces of political evidence to the right to health include President Roosevelt's proposed Second Bill of Rights and the UDHR (Maruthappu, Ologunde & Gunarajasingam, 2012). Furthermore, some

US states have taken steps to ensure the right to health in their own laws and policies, demonstrating the importance of this right at a local level (Matsuura, 2015). The ICESCR serves as a powerful tool to protect and uphold the right to health and other economic, social, and cultural rights.

Given the international importance and recognition of the ICESCR, it undoubtedly should not be undermined; however, the US remains staunchly opposed to its ratification (Kinney, 2002). Nevertheless, simply because the US has not ratified the treaty, may not absolve the US of a moral and legal obligation to realize and progress the right to health. In fact, there is growing literature that suggests customary international law may legally obligate the US to respect ICESCR (Kinney, 2002). Customary international law refers to legal obligations that develop from common international practice rather than international treaties (Cornell Law School). An example of customary international law is the granting of immunity for visiting heads of state (Cornell Law School). Due to the widespread ratification of the ICESCR, it stands that the ICESCR may be binding on all countries regardless of ratification status (Kinney, 2002).

Explicit within ICESCR is the right to health (Article 12). Part of the right to health

assumes access to affordable and available medications (OHCHR). Essential medicines are unavailable when prices are set at unreasonably high rates by the pharmaceutical industry. To abate high drug prices, other high-income states that have ratified ICESCR have, in some way, become involved with negotiating the prices of drugs.

In the US, there is a consensus that "allowing individuals to suffer or die because they cannot afford health care is morally wrong" (Augustine, Madhavan & Nass, 2018 and Lynch & Gollust, 2010). The US can realize and respect the right to health by negotiating for a lower price of drugs. Granting Medicare, the power to negotiate prices is an essential first step. To effectively negotiate prices, it is necessary to look towards similar nations and their negotiation strategies and systems.

Why Are US Drug Prices High? The Pharmaceutical Dilemma

"Capping prices or profits within the drug-supply chain could restrict patients' access to medicines and result in fewer new treatments" (Pfizer). Innovation, as drug manufacturers say, comes at price. This is a heralded cry from pharmaceutical representatives when faced with cutting costs on drugs. Current US law allows

pharmaceutical companies to place profit first and patients second with the understanding that market forces will indicate where, when, and how to innovate life-altering medication. In the face of public outcry about the affordability of medicine, the pharmaceutical industry claims that patients (specifically in the US) can directly access innovative drugs because companies have the freedom to set prices and recoup on research and development investments.

But this is not entirely true. While concerns about a loss of revenue leading to a loss of innovation are rampant amongst the pharmaceutical sector and opponents of public involvement, there is significant research that dismantles this argument (Dranove & Garthwaite, 2020, Gutierrez & Waldrop, 2021 and Conti, Frank, Gruber, 2021). According to the Congressional Budget Office (CBO), drug manufacturers invest projected profits into research and development (CBO, 2021). In this way, "innovative" drugs are made based entirely on the expected amount of profit (Dranove & Garthwaite, 2020). Due to a focus on profit, "pharmaceutical companies develop drugs to generate gains on their investment—not to develop significantly improved treatments" (Gutierrez & Waldrop, 2021). So, conditions

that are historically not as lucrative but have serious health implications, like neglected diseases, are left on the sidelines of drug innovation.

Further, with a profit mindset, drug manufacturers are pushed to create new versions of an already available drug rather than develop a drug which there is no cure for (Conti, Frank, Gruber, 2021). A few years ago, authors Richard Frank, Jerry Avron and Aaron Kesselheim, found that 37% of new molecular entities introduced in 2017 had no or minor clinical benefit over existing treatments (2020). Despite a lack of clinical benefit, many of those drugs were priced at exorbitant rates.

To be fair, pharmaceutical companies are in a unique position. They have to meet the expectations of patients to provide affordable drugs, but they are also legally obligated to provide competitive investment returns to shareholders (Augustine, Madhavan & Nass, 2018). However, some bioethicists argue that pharmaceutical companies have a special obligation that their products are available to those who need them, even when it comes at a cost to shareholders (De George, 2005).

According to an estimation by the Congressional Budget Office, a loss in pharmaceutical revenue would lead to a loss in two drugs over the next decade and 23 fewer in the following decade (Blumenthal,

Miller & Gustafsson, 2021). However, given that pharmaceutical companies are incentivized to develop small changes to already existing drugs, it would be unlikely that the loss of drugs are innovative. In the article, "The US Can Lower Drug Prices Without Sacrificing Innovation," David Blumenthal, Mark Miller and Lovisa Gustafsson write that many would be created to "merely extend patent protections and thus monopolies over existing therapeutics" (2021). Most patents filed by pharmaceutical companies are for minor modifications to drugs already on the market.

The practice where a company extends the life of a patent by making minor tweaks to a drug that often has little clinical benefit to maintain market power is described as "evergreening" (Collier, 2013). For example, when a drug is nearing the end of its patent life, it may be reformulated into an extended release, effectively thwarting generic competition (Committee for a Responsible Federal Budget, 2021). In many cases, this leads to a prolonged period of market exclusivity where one pharmaceutical company can monopolize a certain treatment and drive up the price. The argument stands that a loss in revenue will likely only lead to a loss in a few non innovative drugs.

If the private US pharmaceutical industry

continues in the market without government intervention, like effective negotiation, it will likely continue to develop ineffective and costly drugs. Further, health policy advocates believe that the current high cost of drugs negates progress of other health reform initiatives. Fortunately, there are examples in Europe where reasonable drug prices are agreed on without hampering innovation.

Lessons from the United Kingdom

As of 2023, the US is one of the highest spenders on health care compared to other high- income countries, yet it ranks significantly lower in health outcomes (Gunja, Gumas, Williams & 2023). In 2021, researchers at the Commonwealth Fund identified that the US spent 17.8% of gross domestic product (GDP) on health care (Gunja, Gumas & Williams, 2023). By a significant margin, the US was the highest OECD2 spender, and yet the US averaged 3 years lower for life expectancy at birth compared to other OECDs (Gunja, Gumas & Williams, 2023). There are a few differences that explain the discrepancy. One being that most peer countries negotiate drug prices in some way3. Hence, it's reasonable to presume that negotiated drug prices may be a contributing factor to lowered health care

spending and higher life expectancies at birth.

The United Kingdom (UK) exemplifies how an OECD can lower drug prices and maintain positive health outcomes. It is important to note, however, that the UK centers on a universal healthcare system called the National Health System (NHS). Unlike the US where coverage is limited to those who can afford insurance or qualify for programs like Medicaid and Medicare, the universal healthcare system provides coverage to all, regardless of income (Shapiro, 2010). There was a consensus, in the UK, following the second world war that there should be an egalitarian and utilitarian approach to healthcare, leading to the birth of the NHS (Shapiro, 2010). The NHS represented a post-war movement in 1948 that sought for health care to "no longer [be] exclusive to those who could afford it but to make it accessible to everyone" (Brain, 2021). The establishment of the NHS reflects a fundamental shift in societal values towards the idea that health is a human right. Hence, healthcare should be accessible to all, regardless of their ability to pay.

Negotiating drug prices in the UK is a complex process that involves several steps but can be distilled into three main steps. First, the clinical and economic value of a drug is assessed by the National Institute for Health and Care Excellence (NICE). Then, price negotiations with the drug manufacturer and branches of the federal government begin. Finally, an agreement is

reached, and the drug is made available for NHS patients.

The National Institute for Health and Care Excellence (NICE) is a key institution in the UK healthcare system, providing evidence-based guidance and recommendations for the use of drugs and treatments in the NHS. NICE and similar review bodies play a critical role in negotiations for the NHS and its value-based approach, which is a relatively new concept in the UK. Prior to the establishment of these bodies, the UK government negotiated prices without explicit criteria from 1948-1957 (Rodwin, 2021). At the time, the Ministry of Health "negotiated NHS purchase prices individually, [which was] a time-consuming task, without a fixed methodology" (Rodwin, 2021). This approach proved to be burdensome for the government and resulted in poor outcomes. As a result, the pharmaceutical industry ultimately accepted price and earning caps that were similar to those for other government contractors.

In March 2003, NICE published its first guidelines. Initially, NICE only evaluated roughly half of new drugs that came to market (Rodwin, 2021). In doing so, NICE had to prioritize what factors to include for appraisals. Ultimately, NICE reviewed drugs based on "population size, disease severity, resource impact, and whether, without

guidance, there would be significant controversy over the evidence on clinical effectiveness and cost-effectiveness" (Rodwin, 2021). As NICE proved to be a reputable source for drug evaluations, they were able to evaluate a greater proportion of drugs coming to the market.

Underpinning the NICE guidelines are principles centered on being robust, transparent, inclusive, independent, and contestable (Rawlins, 2015). For each piece of guidance, NICE completes at least one systematic review of the current literature. When developing a clinical guideline, though, NICE conducts more than a dozen systematic reviews.

An essential aspect of NICE is its independence from the government and inappropriate stakeholders. NICE is primarily composed of independent members from the academic community and NHS (Rawlins, 2015). One of the unique features of NICE is its emphasis on transparency and inclusivity. NICE seeks input from a range of stakeholders, including clinical specialists, patient groups and industry representatives, who are encouraged to participate in developing guidance via submission of written or oral evidence. The last principle that supports NICE guidance is its

contestability. Each draft is given to stakeholders to comment on, and there are several series of appeal mechanisms should a stakeholder wish to contest the guidance. For example, as many as "2000 comments can [appear] on a single clinical guideline" (Rawlins, 2015). If pharmaceutical manufacturers feel inclined, they may appeal to the Department of Health.

Since its conception, NICE has built an impressive reputation and power over the pharmaceutical industry. Today, a positive review from NICE about a drug or device indicates more funding from the NHS. Additionally, most UK prescribers follow NICE guidelines (Castle, Kelly & Gathani, 2022). However, in the event that NICE finds a drug not to be cost effective, manufacturers have two options. They can either lower their price to the NHS or forgo almost all sales to the NHS (Rodwin, 2021). Manufacturers want to avoid forgoing sale to the NHS because NICE is commonly used as external reference pricing for other nations (Rodwin, 2021). To work around this issue, pharmaceutical companies offer confidential discounts to the NHS and maintain their list price (Rodwin, 2021).

In recent years, NICE has expanded its role beyond providing guidance on individual drugs and treatments. The organization has

also developed guidance on broader issues such as health inequalities, social care, and public health. These initiatives reflect a growing recognition that healthcare is influenced by a wide range of factors.

Former chairman-designate, Micheal Rawlins, highlighted some key areas of improvement for NICE moving forward in "National Institute for Clinical Excellence: NICE works" (2015). First, he recognized that guidance should be made publicly available. In 1999, the pharmaceutical industry threatened that a draft for guidance could be shared "in confidence" amongst stakeholders. When NICE agreed to keep it private, companies who did not agree with the guidelines leaked the document. This, while not illegal, could create a so-called "false market" because those with information trade shares to their own advantage. To avoid creating a false market, NICE made the draft guideline publicly available and continued to be transparent following that incident.

Rawlins also recognized the need for NICE to use plain language and concepts that are more familiar to the general public when communicating health economics and its guidelines. Health economic language can be highly technical and nuanced, making it difficult for non-experts to understand the implications of NICE's recommendations. Language and data in all scientific

fields can easily be misinterpreted by the media and general public (Peters, 2013). Currently, there is a push from the scientific community to produce Plain Language Summaries and Frequently Asked Questions to counter misinterpretation (Shailes, 2017).

Lastly, Rawlins identified the challenge of accounting for comorbidities in NICE's guidelines. Comorbidity is the presence of two or more disease/medical conditions in a patient (Divo, Martinez & Mannino, 2014). Many patients, particularly those over 65, have comorbidity (Divo, Martinez & Mannino, 2014). While it is important that comorbidities are accounted for, designing a guideline is challenging. On one hand, listing only a few guidelines is not comprehensive enough for individuals with a nearly unlimited combination of comorbidity (Rawlins, 2015). On the other hand, having an exhaustive list of guidelines is impractical (Rawlins, 2015). Today, NICE is currently undertaking this challenge and looking towards other health guideline bodies.

Part of NICE's evaluations (used by VPAS and subsequently the NHS) contains a threshold that indicates prices at which a product would be effective for different clinical patient groups. This threshold4 is set at £20,000-£30,000 per quality adjusted life year (QALY) gained (Sampson et al., 2022).

QALY is a measure of disease burden on the quality and quantity of life years. It is "anchored" on a cardinal scale of 0–1 (Whitehead & Ali, 2010). 0 indicates death and 4 This proposal spurs multiple ethical considerations. How does society establish pricing? Implicit in this form of pricing is the implementation of social values. What if those social values aren't representative of the whole population? Today, US representatives aren't all that representative of their constituents (Schaeffer, 2023). 1 denotes full health (Whitehead & Ali, 2010). This means that if a person lives in perfect health for one year, they have 1 QALY. QALYs are common in health economic research and policy; however, it has been cited as being reductionist5 (Knapp, 2007). For instance, an improvement in health for a mother may also benefit her children. These changes are not captured in QALY. Critics state that a sole threshold for all drugs is not appropriate because NHS expenditures are not uniform (Claxton, 2014). Due to political pressure, NICE allows paying £50,000 per QALY or more for end-of-life care drugs (Charlton, 2019). Still, QALY remains the best practice for health economists and policymakers.

The Department of Health recognized that patients benefit (and so does the overall budget for the NHS) from a faster adoption of the most clinically and cost-effective medications. The Department of Health writes that "commitments in VPAS around

patient access and uptake for innovative medicines have had a substantial positive impact on the speed of medicines access in England, ensuring that NHS patients benefit from cutting-edge treatments" (DH Media, 2023). Recently, government funds have poured into NICE to increase its ability to evaluate all eligible drugs and provide a baseline for negotiations. With NICE's new funding, more drugs will likely be approved for faster uptake by patients.

There are several negotiation and price-setting mechanisms that the single-payer NHS (England) relies on to contain drug costs. Two main instruments are the Voluntary Scheme for Branded Medicines Pricing Scheme (VPAS) and the Statutory Scheme (Castle, Kelly & Gathani, 2022). In the simplest terms, the VPAS is an agreement to control the prices of branded drugs between the NHS, Department of Health and Social Care, and the Association of the British Pharmaceutical Industry (ABPI) (Department of Health & Social Service, ABPI, 2018). The VPAS sets forth admirable goals: deliver clinically effective and cost-effective prescriptions, deliver value for money for the NHS and continue to support life science innovation (Department of Health & Social Service, ABPI, 2018). As part of the VPAS, all Branded Health Service Medicines are covered, including branded generics, in vivo diagnostics, blood products, and dialysis fluids (Department of Health & Social Service, ABPI, 2018). Patented Branded Medicines

cost substantially more than generic medicines. Branded Health Service Medicines are negotiated through value-based pricing, NICE and pressure to secure uptake.

In 2019, the Pharmaceutical Pricing Regulation Scheme (PPRS) was succeeded when the VPAS entered into force. Prior to 2019, PPRS relied on profit and general price control methodology to keep drugs affordable (Parliamentary Office of Science & Technology, 2010). Currently, VPAS sets a limit on annual spending and uses a "value-based" approach to pricing. The NHS is evolving to have a "multilayered landscape for drug pricing in the UK" that uses price caps, value-based approach, and myriad policy factors (Castle, Kelly & Gathani, 2022).

The VPAS sets a limit on annual spending of prescription drugs (of the 172 member companies) that ensures the NHS would not pay more than a 2% growth rate annually (Cohen, 2023). The cap is meant to keep drug prices affordable and available. Interestingly, the cap was considered a "win" by the pharmaceutical industry because the longstanding PPRS had set a 1.1% annual growth rate cap (Walker, Borga & Ribeiro, 2019).

To maintain a set annual growth rate of 2%, Member companies pay scheme payments (Parliamentary Office of Science &

Technology, 2010). These payments are based on the agreed growth rate and the predicted growth in sales. Member companies must pay the Department of Health and Social Care a fixed percent of their net profit of branded medicines sold to the NHS (Castle, Kelly & Gathani, 2022). However, there are some notable exceptions for scheme payments. Member companies who are small (sell less than £5 million to NHS) are exempt from scheme payments. Further, medium size companies (£5-25 million) are exempt from paying for the first £5 million. Lastly, Member companies who sell new active substances to the NHS within 36 months of launch are exempt.

There has been a historic rise in scheme payment percentages from 5.1% in 2021 to 15% in 2022 (Castle, Kelly & Gathani, 2022). In part, the rise is due to COVID related expenditures. Throughout the pandemic, the 2% annual agreed limit was likely exceeded and caused an increase in the 2022 scheme payments (Castle, Kelly & Gathani, 2022). (Scheme payments will likely increase for the next few years to tamper the pandemic related expenditures). The pharmaceutical industry is particularly concerned because the commercial viability of certain products with low profit margins is required to pay high rebates (Castle, Kelly & Gathani, 2022).

The former PPRS focused mainly on price control, which remains a component of the

new method, VPAS. Under VPAS, a Member cannot increase a list price without prior consultation with the Department of Health (Parliamentary Office of Science & Technology, 2010). They must provide a justification for raising the price and undergo an evaluation of their profits to gain approval from the Department of Health. However, Members with new active substances within 36 months of marketing authorization have the freedom to set list prices, which is intended to incentivize pharmaceutical innovation.

VPAS shifted away from PPRS' profit and general price control methodology (2014-2019) to value-based pricing in 2019. Value-based pricing is a principle that dictates that drugs will only be approved for use at prices that ensure their expected health benefits exceed the health displaced (Claxton, 2008). In 2015, Bach and Pearson coined value-based pricing as "the price of a drug on data demonstrating its benefits and harms". This approach incentivizes the development of drugs that provide the greatest magnitude of benefit by using considerable sound data. Since value-based pricing relies on considerable sound data, the NHS uses a cost effectiveness analysis and the implementation of an ICER threshold (Kaltenboeck & Bach, 2018).

The NHS announced that the system saved

£1.2 billion through its negotiations (Morris, 2022). However, the UK's negotiation process is not without limitations and setbacks. Recently, AbbVie and Eli Lilly have pulled out of VPAS (Taylor, 2023). Now, the two companies fall under the Statutory Scheme for Branded Medicines which has historically carried a high repayment percentage. The two large pharmaceutical companies leaving VPAS signals to the UK government that the rising repayment percentage is unsustainable for the pharmaceutical market. Since AbbVie and ELi Lilly pulled out of VPAS in January 2023, it's not clear how the shift of two large pharmaceutical companies will impact the UK and global market.

Pharmaceutical innovation is set to improve in the UK. Moreover, drug prices have remained stable due to the price controls and negotiation processes. In 2021, the UK approved 35 new drugs (the EU approved 40 and the US approved 52) on par with another independent OECD, Switzerland (also 35 drugs that year) (Hofer, 2023). At this time, it is unclear whether the transition of Brexit has challenged the approval process for new drugs in the UK. To combat a slower approval process, the UK government has announced a £10 million investment into NICE (Limb, 2023). Despite a slightly slower approval

process, the UK outpaced the US in the development of new molecular entities (NME) in proportion to GDP (Keyhani, Wang, Hebert, Carpenter, & Anderson, 2010).

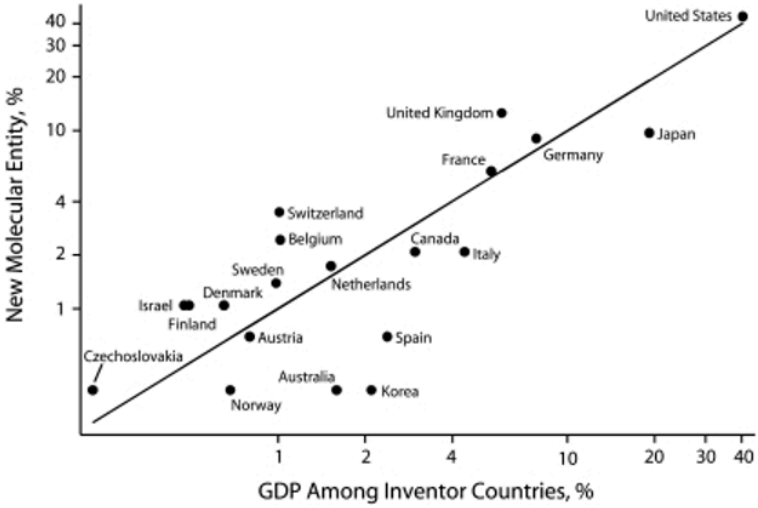

Figure 1. *Pharmaceutical innovation as a function of gross domestic product (N = 288): 2000.* (Keyhani, Wang, Hebert, Carpenter, & Anderson, 2010)

Medicare negotiations and the Department of Health can learn from the history and current policies that the UK employs to contain costs. First, it is important that the US has some form of rigorous evaluation of the clinical and cost-effectiveness of therapies. However, politics will likely influence which drugs are assessed and what threshold(s) will be available. Arguably, the most effective drug price control as seen in the UK, comes from setting a budget and requiring drug manufacturers to pay rebates when the budget is exceeded. However, should repayment

percentages rise too much, pharmaceutical companies could threaten to pull out of the agreement.

Process of Future US Drug Negotiation

After many failed legislative attempts at constraining the rising cost of US drugs, Congress passed sweeping prescription drug pricing reforms as part of the Inflation Reduction Act (August 2022) (Cubanksi, Neuman & Freed, 2023). The Inflation Reduction Act enables the Department of Health and Human Services to negotiate drug prices with the greatest spending for Medicare Part B and Part D through the newly established Drug Price Negotiation Program. According to the Congressional Budget Office, these negotiations are expected to save Medicare $98.5 billion over the next decade (Cubanksi, Neuman & Freed, 2023).

The "noninterference" clause for Medicare Part D, which covers retail pharmaceuticals, and Medicare Part B, physician administered pharmaceuticals, has been a significant barrier to drug price negotiations in the US for a long time (Cubanksi, Neuman & Freed, 2023). The clause cites that the Secretary of Health and Human Services "1) may not interfere with the negotiations between drug manufacturers and pharmacies and PDP [prescription drug plan] sponsors, and 2) may not require a particular formulary or institute

a price structure for the reimbursement of covered part D drugs" (Social Security Administration). Clearly, this clause limits the federal government's ability to lower drug prices, especially for high-priced drugs without competition. Fortunately, the Inflation Reduction Act amended that clause to allow exceptions. The amendment requires the Secretary of Health and Human Services to negotiate single-source brand-named drugs or biologics with no generic or biosimilar competition that are covered under Medicare Part B and D (starting in 2028 and 2026 respectively) (Cubanksi, Neuman & Freed, 2023).

Although the new Drug Price Negotiation Program is a significant step forward towards lowering prescription drug prices, it represents an extensive compromise from the Elijah E. Cummings Lower Drug Costs Now Act (HR 3), which originally proposed broader reforms (Hwang, Kesselheim, & Rome, 2022). The main compromise is the limited number of drugs subjected to negotiation. In the first year (2026) of the Drug Price Negotiation Program, 10 drugs are eligible with 20 being available annually by 2029 (Hwang, Kesselheim, & Rome, 2022). Further limitations on negotiations include extended market exclusivity for drugs. Drugs will be eligible for negotiation only 9 years post launch or 13 years for biologics (Hwang, Kesselheim, & Rome, 2022).

Upon entry of a generic or biosimilar competitor, drugs will no longer be eligible for negotiations (Hwang, Kesselheim, & Rome, 2022). If an eligible manufacturer refuses to negotiate, they will be subject to excise taxes (Hwang, Kesselheim, & Rome, 2022).

Similar to the UK, Medicare is expected to review the therapeutic evidence of the intended negotiated drug. As a guideline, legislation has set upper bounds on negotiated prices ("maximum fair price") (Cubanksi, Neuman & Freed, 2023). Medicare will not spend more than "75%, 65% and 40% of the nonfederal average manufacturer price for 9 to 12 years, 12 to 16 years, and more than 16 years after approval, respectively" (Hwang, Kesselheim, & Rome, 2022). There are many considerations that the Secretary of Health and Human Services must meet (as per the IRA) before setting the maximum fair price. A few of the considerations include accounting for research and development costs, federal aid, current unit costs of production and distribution, market data/ revenue and evidence about alternative therapies (Cubanksi, Neuman & Freed, 2023).

Starting in September 2023 the first negotiation process will be about two years. On September 1, 2023, the first 10 Medicare Part D drugs to be negotiated will be published (Cubanksi, Neuman & Freed,

2023). Then negotiation between the Secretary of Health and Human Services and selected drug manufacturers will take place between October 1, 2023, and August 1, 2024 (Cubanksi, Neuman & Freed, 2023). Finally, the negotiated "maximum fair price" will be published on September 1, 2024 (Cubanksi, Neuman & Freed, 2023).

While the Inflation Reduction Act has offered massive improvements for containing drug prices in the US there remain significant limitations. Missing from the Inflation Reduction Act are policies that directly target launch prices. Namely, manufacturers have 9 years of potential market exclusivity. As discussed, other peer countries allow for immediate negotiations at the time of market entry. Further, peer countries do not cap the number of drugs that are eligible for negotiation. Finally, commercially insured individuals are not benefited by the provisions in the Inflation Reduction Act. However, complementary initiatives could support commercially insured individuals.

From a literature review on the UK's drug negotiations, I recommend three policy recommendations: 1) clarify and develop a method for assessing clinical and cost-effectiveness of a drug, 2) lobby for price negotiations closer to the launch of a new drug, 3) expand the number of drugs for negotiation.

As seen with the case of price negotiations

in the UK, having an authoritative body that evaluates the clinical and economic effectiveness of a drug is critical. The Institute for Clinical and Economic Review (ICER) is a US organization that already reviews and makes recommendations on drugs in the US. It conducts a thorough clinical review of "all available data, an understanding of the patient perspective, comparative clinical effectiveness research, long-term effectiveness analyses, potential other benefits, and other considerations" (ICER, 2021). Similar to NICE, ICER encourages stakeholders to engage with the review process and holds public meetings to ensure comments are discussed and considered.

ICER has made a significant impact on drugmakers in the US. For instance, an ICER review of a cholesterol-lowering drug, Praulent, encouraged drugmakers to lower the price to one that was considered fair by ICER (Synnott, Ollendorf & Neumann, 2022). In doing so, Express Script, a large pharmacy benefit manager in the US, expanded patient access to Praluent and offered a portion of the rebates it received to patients (Synnott, Ollendorf & Neumann, 2022).

However, should the US decide to create a new public body for reviewing drug efficacy

it could do so with a mix of internal and contracted researchers allowing for federal flexibility similar to the National Institute of Health (Ginsburg & Lieberman, 2021). Additionally, to avoid annual appropriations, creating a Federally Funded Research and Development Center, a nonprofit with a long-term federal contract, could secure multi-year funding (Ginsburg & Lieberman, 2021). Creating a new body would require an impressive initial investment but the payoff of having US value-based assessment and an understanding of local costs would be beneficial.

A final, but least ideal, option is the implementation of reference pricing from other high- income countries. Not investing in a US drug evaluation body would be cost saving initially. But prices in other countries are based on local costs and standards of care as well as societal values (Synnott, Ollendorf & Neumann, 2022). To this end, the US would be implementing other countries' value assessments that may not align with US values.

A second consideration for US drug negotiations would be the expansion of negotiations at or near drug launch. At the moment, Medicare negotiations are set to include drugs only after they have enjoyed

9 years post launch or 13 years for biologics of market exclusivity (Rome, Lee, Kesselheim, 2020). Researchers (Rome, Nagar & Egilman, 2023) ran a policy simulation of the new Drug Price Negotiation Program if it had been implemented from 2018 to 2020 and found that the 9 year or 13 year protection from negotiation "would have prevented selection of 34 high-spending drugs in 2018". By delaying negotiation, the federal government risks paying significantly higher drug prices. The same group of researchers also identified in the article, "Trends in prescription drug launch prices, 2008-2021", that launch price for new drugs increased by 11% per year (Rome, Nagar & Egilman, 2022).

The third recommendation for US drug negotiations is to include a greater number of drugs eligible for negotiation. Currently, the Inflation Reduction Act designed a rigid selection process for drugs. While the top 10 drugs in terms of spending account for a large percentage of Medicare's Part B and Part D drug spending, it would be more effective to include a greater number of drugs for negotiation (Hwang, Kesselheim, & Rome, 2022). As already mentioned, no other peer country limits the number of drugs available for negotiation.

In the US, where basic healthcare is

considered a luxury, the new Drug Price Negotiation Program is an impressive start to lowering drug prices and further advancing the right to health. By reviewing other high-income countries like the UK, we can avoid the pitfalls of ineffective measures and implement beneficial ones that lead to better health outcomes. It is essential that the federal government create a robust system for evaluating clinical and economic effectiveness of drugs, negotiate drugs closer to launch price and expand the number of drugs eligible for negotiation.

It is my belief that everyone deserves the best chance at life, regardless of financial standing. The balance of life and death should not be in the hands of pharmaceutical companies. Making drugs accessible and available through Medicare negotiations is a powerful step towards improving the lives of countless Americans. By implementing successful health policy strategies and recommendations, we can unite and take action to ensure that the right to health is not just a privilege for the wealthy, but a fundamental right meant to be enjoyed by all.

Bibliography

Cornell Law School. (n.d.). *Customary international law*. Legal Information Institute. Retrieved May 3, 2023, from

https://www.law.cornell.edu/wex/customary_international_law#:~:text=Customary%20international%20law%20results%20from,for%20visiting%20heads%20of%20state.

Dolan, P. (2001). *Utilitarianism and the measurement and aggregation of quality–adjusted life years*. Health care analysis : HCA : journal of health philosophy and policy. Retrieved April 27, 2023, from https://pubmed.ncbi.nlm.nih.gov/11372576/

Dranove, D., & Garthwaite, C. (2020, September 2). *Pharma companies argue that lower drug prices would mean fewer breakthrough drugs. is that true?* Kellogg Insight. Retrieved April 17, 2023, from https://insight.kellogg.northwestern.edu/article/pharma-companies- argue-lower-drug-prices-fewer-breakthrough-drugs

Augustine, N. R., Madhavan, G., & Nass, S. J. (2018). *Making medicines affordable: A national imperative. National Library of Medicine*. National Academies Press. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK493099/.

Bach, P. (2015, October 6). *A new way to define value in drug pricing*. Harvard Business Review. Retrieved April 1, 2023, from https://hbr.org/2015/10/a-new-way-to-define-value- in-drug-pricing

Bach, P., & Pearson, S. (2015, December 15). *Steps to support value-based pricing for drugs*. JAMA. Retrieved April 18, 2023, from https://jamanetwork.com/journals/jama/fullarticle/2474095

Blumenthal, D., Miller, M., & Gustafsson, L. (2021, October 1). *The U.S. can lower drug prices without sacrificing innovation*. Harvard Business Review. Retrieved

April 19, 2023, from https://hbr.org/2021/10/the-u-s-can-lower-drug-prices-without-sacrificing-innovation

Blumenthal, D., Seervai, S., & Bishop, S. (2018, August 22). *Three essentials for negotiating Lower Drug Prices*. Commonwealth Fund. Retrieved April 18, 2023, from https://www.commonwealthfund.org/blog/2018/three-essentials-negotiating-lower-drug- prices

Brain, J. (2021, June 30). *The Birth of the NHS*. Historic UK. Retrieved April 17, 2023, from https://www.historic-uk.com/HistoryUK/HistoryofBritain/Birth-of-the-NHS/#:~:text=The%20National%20Health%20Service%2C%20abbreviated,taking%20its%20first%20tentative%20steps

Castle, G., Kelly, B., & Gathani, R. (2022). *Pricing & reimbursement laws and regulations: United Kingdom: GLI*. GLI – Global Legal Insights – International legal business solutions. Retrieved April 1, 2023, from https://www.globallegalinsights.com/practice-areas/pricing-and-reimbursement-laws-and- regulations/united-kingdom

Charlton, V. (2019). *Nice and Fair? Health Technology Assessment Policy under the UK's National Institute for Health and Care Excellence, 1999-2018*. Health care analysis : HCA: journal of health philosophy and policy. Retrieved April 17, 2023, from https://pubmed.ncbi.nlm.nih.gov/31325000/

Claxton, K. (2014). *Causes for concern: Is nice failing to uphold its responsibilities to all NHS patients?* Wiley. Retrieved April 18, 2023, from https://onlinelibrary.wiley.com/doi/full/10.1002/hec.3130

Claxton, K., Briggs , Buxton, Culyer , McCabe , Walker, & Sculpher. (2008). *Value based pricing for NHS drugs: An opportunity not to be missed?* BMJ (Clinical research ed.).Retrieved April 18, 2023, from https://pubmed.ncbi.nlm.nih.gov/18244997/

Cohen, J. (2023, January 23). *U.K.'s voluntary scheme for branded medicines, pricing, and Access (VPAS) faces a potential crisis*. Forbes. Retrieved April 17, 2023, from https://www.forbes.com/sites/joshuacohen/2023/01/19/uks-voluntary-scheme-for-branded- medicines-pricing-and-access-vpas-faces-a-potential-crisis/?sh=27fae70e77c3

Collier, R. (2013, June). *Drug patents: The evergreening problem*. CMAJ : Canadian Medical Association journal . Retrieved April 19, 2023, from https://pubmed.ncbi.nlm.nih.gov/23630239/

Committee for a Responsible Federal Budget. (2021). *Limiting evergreening for name- brand prescription drugs*. Committee for a Responsible Federal Budget. Retrieved April 19, 2023, from https://www.crfb.org/papers/limiting-evergreening-name-brand- prescription-drugs

Conti, R. M., Frank, R., & Gruber, J. (2021, December 15). *Addressing the trade-off between lower drug prices and incentives for Pharmaceutical Innovation*. Brookings. Retrieved April 17, 2023, from https://www.brookings.edu/essay/addressing-the-trade-off- between-lower-drug-prices-and-incentives-for-pharmaceutical-innovation/

Cubanski, J., Tricia Neuman, T., Freed, M., & Damico, A. (2023, January 24). *How will the prescription drug provisions in the Inflation Reduction Act affect Medicare beneficiaries?* KFF. Retrieved April 19, 2023, from https://www.kff.org/

medicare/issue- brief/how-will-the-prescription-drug-provisions-in-the-inflation-reduction-act-affect-medicare-beneficiaries/

Cubanski, J., Neuman, T., & Freed, M. (2023, March 16). *Explaining the prescription drug provisions in the Inflation Reduction Act*. KFF. Retrieved April 19, 2023, from https://www.kff.org/medicare/issue-brief/explaining-the-prescription-drug-provisions-in- the-inflation-reduction-act/

De George, R. T. (2005, October). *Intellectual property and pharmaceutical drugs: An ethical analysis: Business ethics quarterly*. Cambridge Core. Retrieved April 17, 2023, from https://www.cambridge.org/core/journals/business-ethics- quarterly/article/intellectual-property-and-pharmaceutical-drugs-an-ethical- analysis/2C77EB82C5E84CD5DE7DAA08330840C0

Department of Health & Social Care, ABPI. (2018). *The 2019 voluntary scheme for branded medicines pricing and access- chapters and glossary*. Retrieved April 18, 2023, from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_da ta/file/761834/voluntary-scheme-for-branded-medicines-pricing-and-access-chapters-and- glossary.pdf

DH Media, D. H. M. (2023, March 28). *Voluntary scheme for branded medicines pricing and access (VPAS) – media fact sheet*. Department of Health and Social Care Media Centre. Retrieved April 1, 2023, from https://healthmedia.blog.gov.uk/2023/03/28/voluntary-scheme-for-branded-medicines- pricing-and-access-vpas-media-fact-sheet/

Divo, M., Martinez, C., & Mannino, D. (2014, August).

Ageing and the epidemiology of multimorbidity. The European respiratory journal. Retrieved April 17, 2023, from https://pubmed.ncbi.nlm.nih.gov/25142482/

Elegido, J. (2015, September). *The just price as the price obtainable in an open market* . JSTOR. Retrieved April 17, 2023, from https://www.jstor.org/stable/24703523

Faunce, T., & Lexchin, J. (2007). *'linkage' pharmaceutical evergreening in Canada and Australia*. Australia and New Zealand health policy. Retrieved April 19, 2023, from https://pubmed.ncbi.nlm.nih.gov/17543113/

Frank, R., Avorn, J., & Kesselheim, A. (2020, April 29). *What do high drug prices buy us?*. Health Affairs. Retrieved April 17, 2023, from https://www.healthaffairs.org/do/10.1377/forefront.20200424.131397

Ginsburg, P., & Lieberman, S. M. (2021, August 31). *Government regulated or negotiated drug prices: Key Design Considerations*. Brookings. Retrieved April 5, 2023, from https://www.brookings.edu/essay/government-regulated-or-negotiated-drug-prices-key- design-considerations/

Gunja, M. Z., Gumas, E. D., & Williams , R. D. (2023, January 31). *U.S. health care from a Global Perspective, 2022: Accelerating spending, worsening outcomes*. Commonwealth Fund. Retrieved April 17, 2023, from https://www.commonwealthfund.org/publications/issue-briefs/2023/jan/us-health-care- global-perspective-2022

Gutierrez, G., & Waldrop, T. (2021, September 17). *Prescription drugs can be affordable and innovative*. Center for American Progress. Retrieved April 17, 2023, from https://www.americanprogress.org/article/prescription-drugs-can-affordable-innovative/

Human rights in United States of America. Amnesty International. (2022). Retrieved April 1, 2023, from

https://www.amnesty.org/en/location/americas/north-america/united-states- of-america/report-united-states-of-america/

Hwang, T., Kesselheim, A., & Rome, B. (2022, August 19). *New reforms to prescription drug pricing in the US: Opportunities and challenges*. JAMA. Retrieved April 17, 2023, from https://pubmed.ncbi.nlm.nih.gov/35984652/

ICER. (2021, September 14). *Methods & process: Our approach*. ICER. Retrieved April 18, 2023, from https://icer.org/our-approach/methods-process/

Kaltenboeck , A., & Bach, P. (2018, June 5). *Value-based pricing for drugs: Theme and variations*. JAMA. Retrieved April 17, 2023, from https://pubmed.ncbi.nlm.nih.gov/29710320/

Keyhani, S., Wang, S., Hebert, P., Carpenter, D., & Anderson, G. (2010). US pharmaceutical innovation in an international context. *American journal of public health*, *100*(6), 1075–1080. https://doi.org/10.2105/AJPH.2009.178491

Kinney, E. D. (2002). *The international human right to health: What does this mean for our nation and world?* Retrieved April 17, 2023, from https://mckinneylaw.iu.edu/ilr/pdf/vol34p1457.pdf

Knapp, M. (2007). *Economic Outcomes and levers: Impacts for individuals and Society*. International psychogeriatrics. Retrieved April 17, 2023, from https://pubmed.ncbi.nlm.nih.gov/17391570/

Limb M. (2023). *UK to give "near automatic sign off" for treatments approved by "trusted" regulators*. BMJ. 380 :p633 doi:10.1136/bmj.p633

Lynch, J., & Gollust, S. E. (2010, December 1). *Playing fair: Fairness beliefs and health policy preferences in the United States*. Journal of health politics, policy and law. Retrieved April 17, 2023, from https://pubmed.ncbi.nlm.nih.gov/21451156/

Maruthappu, M., Ologunde, R., & Gunarajasingam, A. (2012, February 5). *Is health care a right? health reforms in the USA and their impact upon the concept of care*. Annals of medicine and surgery (2012). Retrieved April 19, 2023, from https://pubmed.ncbi.nlm.nih.gov/25973184/

Matsuura, H. (2015, July). *State constitutional commitment to health and health care and population health outcomes: Evidence from historical US data*. American journal of public health. Retrieved April 19, 2023, from https://pubmed.ncbi.nlm.nih.gov/25905857/

Morris, L. (2022, July 1). *NHS negotiating power saving taxpayer £1.2bn on Medicine*. National Health Executive. Retrieved April 1, 2023, from https://www.nationalhealthexecutive.com/articles/nhs-negotiating-power-saving-taxpayer- 1.2bn-on-medicine-pharma

Mwachofi, A., & Al-Assaf, A. F. (2011, August). *Health care market deviations from the ideal market*. Sultan Qaboos University medical journal. Retrieved April 1, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3210041/

OHCHR. (n.d.). *Access to medicines – a fundamental element of the right to health*. OHCHR. Retrieved April 19, 2023, from https://www.ohchr.org/en/development/access- medicines-fundamental-element-right-health

Parliamentary Office of Science & Technology. (2010, October). *Number 364 Drug Pricing – Parliament*. Retrieved April 18, 2023, from https://www.parliament.uk/globalassets/documents/post/postpn_364_Drug_Pricing.pdf

Peters, H. P. (2013). *Gap between science and Media Revisited: Scientists as public communicators*. JSTOR. Retrieved April 17, 2023, from http://www.jstor.org/stable/42713438

Price controls could limit patient access to lifesaving medications. Pfizer. (n.d.). Retrieved April 17, 2023, from https://www.pfizer.com/responsibility/ready-for- cures/price_controls_could_limit_patient_access_to_lifesaving_medications

Rawlins, M. D. (2015, June). *National Institute for Clinical Excellence: Nice Works*. Journal of the Royal Society of Medicine. Retrieved April 5, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4480561/

Research and Development in the Pharmaceutical Industry. Congressional Budget Office. (2021, April). Retrieved April 17, 2023, from https://www.cbo.gov/publication/57126

Rodwin, M. (2021, March 25). *How the United Kingdom controls pharmaceutical prices and spending: Learning from its experience*. International journal of health services : planning, administration, evaluation. Retrieved April 1, 2023, from https://pubmed.ncbi.nlm.nih.gov/33764174/

Rome, B., Kesselheim, A., & Lee, C. W. (2020). *Market exclusivity length for drugs with new generic or biosimilar competition, 2012-2018*. Clinical pharmacology and

therapeutics. Retrieved April 19, 2023, from https://pubmed.ncbi.nlm.nih.gov/32654122/

Rome, Egilman, & Kesselheim. (2022, June). *Trends in prescription drug launch prices, 2008-2021*. JAMA. Retrieved May 3, 2023, from https://pubmed.ncbi.nlm.nih.gov/35670795/

Rome, B., Nagar, S., & Egilman, A. (2023). *Simulated Medicare drug price negotiation under the Inflation Reduction Act of 2022*. JAMA health forum. Retrieved April 19, 2023, from https://pubmed.ncbi.nlm.nih.gov/36705916/

Sampson, C., Zamora, B., Watson, S., Cairns, J., Chalkidou, K., Cubi-Molla, P., Devlin, N., García-Lorenzo, B., Hughes, D. A., Leech, A. A., & Towse, A. (2022, September). *Supply-side cost-effectiveness thresholds: Questions for evidence-based policy*. Applied health economics and health policy. Retrieved April 17, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9385803/

Sarnak, D. O., Squires, D., & Bishop, S. (2017). *Paying for prescription drugs around the world: Why is the U.S. an outlier?* Commonwealth Fund. Retrieved April 19, 2023, from https://www.commonwealthfund.org/sites/default/files/documents/media_files_publicat
ions_issue_brief_2017_oct_sarnak_paying_for_rx_ib_v2.pdf

Shailes, S. (2017, March 15). *Plain-language summaries of research: Something for everyone*. eLife. Retrieved April 17, 2023, from https://elifesciences.org/articles/25411

Shapiro, J. (2010, August). *The NHS: The story so far (1948-2010)*. Clinical medicine (London, England).

Retrieved April 17, 2023, from https://pubmed.ncbi.nlm.nih.gov/20849005/

Schaeffer, K. (2023, February 28). *The changing face of congress in 8 charts*. Pew Research Center. Retrieved April 27, 2023, from https://www.pewresearch.org/short- reads/2023/02/07/the-changing-face-of-congress/

Schneider, P. (2022, May). *The Qaly is ableist: On the unethical implications of health states worse than dead*. Quality of life research : an international journal of quality of life aspects of treatment, care and rehabilitation. Retrieved April 27, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9023412/#:~:text=A%20long%2Dstanding%20criticism%20of,of%20'more%20healthy'%20individuals.

Social Security Administration. (n.d.). *Subpart 2—Prescription Drug Plans; PDP Sponsors; Financing*. Social Security. Retrieved April 19, 2023, from https://www.ssa.gov/OP_Home/ssact/title18/1860D-11.htm

Synnott, P., Ollendorf, D., & Neumann, P. (2022, May 6). *A value-based approach to America's costly prescription drug problem*. Commonwealth Fund. Retrieved April 18, 2023, from https://www.commonwealthfund.org/blog/2022/value-based-approach- americas-costly-prescription-drug-problem

Taylor, P. (2023, January 16). *AbbVie, Lilly pull out of UK voluntary drug pricing agreement*. pharmaphorum. Retrieved April 18, 2023, from https://pharmaphorum.com/news/abbvie-lilly-pull-out-of-uk-voluntary-drug-pricing-agreement#:~:text=AbbVie%20and%20Eli%20Lilly%20have,signal%20to%20the%20UK%20government%22.

United Nations. (n.d.). *Human rights day – women who shaped the Universal Declaration*. United Nations. Retrieved April 17, 2023, from https://www.un.org/en/observances/human-rights-day/women-who-shaped-the-universal- declaration

Vincent Rajkumar S. (2020). The high cost of prescription drugs: causes and solutions.*Blood cancer journal*, *10*(6), 71. https://doi.org/10.1038/s41408-020-0338-x

Vogler, S., & et al. (2017). *How can pricing and reimbursement policies improve affordable access to …* ProQuest. Retrieved April 17, 2023, from https://www.proquest.com/docview/1973390391?accountid=14677&parentSessionId=qoTGALmTZ2UJT5vL%2B3XAxcWG8nFq9j0egPR7SAUk8eY%3D&pq-origsite=primo

Vokinger, K., & Naci, H. (2022, December 22). *Negotiating drug prices in the US-lessons from Europe*. JAMA Health Forum. Retrieved April 17, 2023, from https://jamanetwork.com/journals/jama-health-forum/fullarticle/2799713

Walker, A., Borga, P., & Ribeiro, A. (2019). *PNS140 POTENTIAL IMPACTS OF THE U.K. VOLUNTARY SCHEME FOR BRANDED MEDICINES PRICING AND ACCESS: A REVIEW OF STAKEHOLDER OPINION*. Value in Health. Retrieved from https://doi.org/10.1016/j.jval.2019.09.2041

Whitehead , S., & Ali, S. (2010). *Health Outcomes in economic evaluation: The QALY and Utilities*. British medical bulletin. Retrieved April 17, 2023, from https://pubmed.ncbi.nlm.nih.gov/21037243/

Whitehead, S., & Ali, S. (2010, October 29). *Health outcomes in economic evaluation: the QALY and utilities*. Academic.oup.com. Retrieved April 5, 2023, from https://academic.oup.com/bmb/article/96/1/5/300011

WHO. (2017). *Access to medicines: Making market forces serve the poor*. World Health Organization. Retrieved January 22, 2022, from https://www.who.int/publications/10-year- review/chapter-medicines.pdf

About the Author

Hannah Willis

114.

RESEARCH REFLECTION BY HANNAH WILLIS

Hannah Willis

Faculty Mentor: Matthew Slonaker (Sociology, University of Utah)

My undergraduate research experience centered on human rights work and explored the intersection of health in relation to the enjoyment of other human rights. I was also involved with clinical research at Primary Children's Emergency Department. My research experience at the University of Utah has encouraged me to continue research in my future career.

About the Author

Hannah Willis

SECTION XIII

HONORS COLLEGE

115.

WHY WALKABILITY? MAKING US INFRASTRUCTURE FRIENDLIER

Nicole Merhi and Eric Robertson

Faculty Mentor: Eric Robertson (Honors College, University of Utah)

Infrastructure that heavily relies on the use of cars, wide roads, and highways plays an integral part in how cities and communities are built and operated in the United States. Even though every American uses this system, it provides a variety of issues, such as negative environmental, physical, and social impacts on society.

Though this problem affects everyone, it makes it especially difficult for people who live in rural areas or people who do have limited to no access to transit, as well as other groups such as the elderly and disabled people. However, integrating walkability into cities could drastically improve this issue. Walkability is the idea that more people have on-foot access to necessary and desired services like grocery stores, clinics, bus and/or train stops, shops, or restaurants. Cities that are walkable and accessible to all are vital because they improve safety for both drivers and pedestrians, enhance the physical and mental well-being of people, and bring a sense of culture and community.

First, making cities walkable and accessible will provide pedestrians and drivers safety and security. A research paper completed by Tanishita, Masayoshi, Yuta Sekiguchi, and Daisuke Sunaga that studies road injuries reveals that "Approximately 1.3 million people suffer fatal injuries as a result of road traffic crashes every year, and approximately 20-50 million people suffer non-fatal injuries, with many incurring a disability as a result of their injury. Therefore, the severity of pedestrian accidents has been examined in several studies."[1]. Another study relating to road infrastructure claims "Khan and Habib revealed many factors related to road infrastructure and traffic control, showing that accidents on arterial roads, sloping roads, curved roads, and roundabouts resulted in pedestrian injuries with high severity." [2] This quote connects poorly built infrastructure to pedestrian safety. These types of roads are personal to my driving experience. I live in a rural area with lots of wildlife, as well as bikers and runners. I must be conscious to avoid them while also

paying attention to the curvy and narrow roads I drive on. There are no sidewalks or bike paths, which are dangerous to pedestrians. This also makes it difficult for drivers to avoid them. Finally, within the novel *Walkable City (Tenth Anniversary Edition): How Downtown Can Save America, One Step at a Time,* author Jeff Speck provides a variety of studies on this specific issue. A group of researchers named Wesley Marshall and Norman Garrick completed a definitive study at the University of Connecticut, who "looked at more than 130,000 crashes over nine years, and were able to divide the subjects into twelve "safer" cities and twelve "less" safe cities. All told, doubling of block size corresponded with a tripling of fatalities."[3] Speck also states that "A typical street in downtown Salt Lake City, with blocks over six hundred feet per side, holds six lanes of traffic. And six-lane streets are much more dangerous than two-lane streets." [4] As someone who has lived in Utah for my whole life, I can agree that many block sizes are exceptionally large and difficult to cross quickly. Speed limits are also typically high in these areas, making it harder and more dangerous to cross. I feel if road infrastructure and safety were more acknowledged and prioritized, pedestrians and drivers would feel more secure and more protected.

Next, increased walkability in cities gives citizens the opportunity to build culture and community within where they live. Without walkability within areas such as neighborhoods, the opportunity for a friendlier culture and more social way of living is diminished. Studies show the relationship between walkability and physical activity, revealing that "A US study for example (Eyler, Brownson, Bacak, & Housemann, 2003) found that as many as one

fifth of residents claim they never or rarely walk within their neighborhood environment."[5] This quote links a lack of walkability to the fact that many people do not move in their neighborhoods. Not only are people not getting the exercise they need, but it removes potential connections with others within the areas where they live. In Japan, for example, *Radio Taiso*, a daily three-minute calisthenics broadcast, is used by millions of Japanese citizens simultaneously to get little bits of exercise in. In *The Extended Mind* written by Annie Murphy Paul covers this, stating "The benefits of this activity, practiced by everyone from the youngest school children to top executives at Sony and Toyota-may go well beyond fitness and flexibility for those who take part. A substantial body of research shows that *behavioral* synchrony-coordinating our actions, including our physical movements, so that they are like the actions of others-primes us for what we might call *cognitive* synchrony: multiple people thinking together efficiently and effectively." [6] This simple three-minute exercise brings people of all groups together in a physical and social way. Even if the United States does not have a broadcast system of the same effect, creating walkable areas in the country allows people to move together physically and connect on a more personal level, which brings a greater sense of community. A study surrounding mental health and walkability hypothesizes that "It is however arguable that walkable environments also facilitate opportunities for residents to meet, interact and engage in their neighbourhood, which can foster sense of community (Leyden, 2003, Lund, 2002, Lund, 2003) and could improve mental health outcomes. Conversely, it is also plausible that a sense of community

has a favourable influence on resident's propensity to walk within their neighbourhood." [7] This statement reinforces the idea that walkability in cities provides the opportunity for people to come together.

Finally, walkability improves both the physical and mental health of citizens. A review article written by authors Baobeid, Koç, and Al-Ghamdi quotes that "Health studies examining physical activity cite walking and biking as measures that facilitate physical rehabilitation and mitigate modern chronic diseases such as obesity, diabetes, hypertension, and mental health and depression. (Barton et al., 2009; Johansson et al., 2011; Roe and Aspinall, 2011; Mackenback et al., 2014). Walkability and walking are closely entwined with the concepts of livability of local communities as well as sustainability and its three pillars: the economic, social, and environmental." [8] This quote confirms that walking and biking improve physical and mental health and that walking, biking, and good transit should be implemented into cities in order to make the lives of its citizens better. The article suggests ideas for making a city walkable, stating "Therefore, to encourage walking and physical activity, the built environment must provide comfortable pedestrian sidewalks, vehicle speed limits, appropriate road crossings, and good lighting." [9] This quote assembles ideas of how to make cities walkable and safe, which can enhance the overall health of people using and living in cities. Again, if walkability were available to all, the wellness of all people would be boosted.

The solution to the United States' poorly built infrastructure is to encourage and implement more walkable aspects within our cities. Walkability is proven

to improve the physical and mental health of citizens because it allows pedestrians to be safe and protected, while also allowing people to get out and exercise while getting to a place they need. More importantly, it brings a community a sense of unity and culture.

Bibliography

Tanishita Masayoshi, Yuta Sekiguchi, and Daisuke Sunaga. "Impact Analysis of Road Infrastructure and Traffic Control on Severity of Pedestrian–Vehicle Crashes at Intersections and Non-Intersections Using Bias-Reduced Logistic Regression." IATSS Research, April 6, 2023. https://doi.org/10.1016/j.iatssr.2023.03.004

Jeff Speck, "" Step 5: Protect the Pedestrian."" Essay. In *Walkable City (Tenth Anniversary Edition): How Downtown Can Save America, One Step at a Time*, 165. (Picador USA, 2022.)

Lisa Wood, Lawrence D. Frank, Billie Giles-Corti. "Sense of community and its relationship with walking and neighborhood design." Social Science and Medicine, May 2010. https://doi.org/10.1016/j.socscimed.2010.01.021

(Paul, A. M. (2022). "" Thinking Within Groups"". *The extended mind: The power of thinking outside the brain* (p. 197). essay, Mariner Books.)

Abdulla Baobeid, Muammer Koç, Sami G. Al-Ghamdi. "Walkability and Its Relationships With Health, Sustainability, and Livability: Elements of Physical Environment and Evaluation Frameworks." Frontiers in Built Environment, September 30, 2021. https://doi.org/10.3389/fbuil.2021.721218

[1] Tanishita Masayoshi, Yuta Sekiguchi, and Daisuke Sunaga. "Impact Analysis of Road Infrastructure and Traffic Control on

Severity of Pedestrian–Vehicle Crashes at Intersections and Non-Intersections Using Bias-Reduced Logistic Regression." IATSS Research, April 6, 2023. https://doi.org/10.1016/j.iatssr.2023.03.004

[2]Tanishita Masayoshi, Yuta Sekiguchi, and Daisuke Sunaga. "Impact Analysis of Road Infrastructure and Traffic Control on Severity of Pedestrian–Vehicle Crashes at Intersections and Non-Intersections Using Bias-Reduced Logistic Regression." IATSS Research, April 6, 2023. https://doi.org/10.1016/j.iatssr.2023.03.004

[3] Jeff Speck, ""Step 5: Protect the Pedestrian."" Essay. In *Walkable City (Tenth Anniversary Edition): How Downtown Can Save America, One Step at a Time*, 165. (Picador USA, 2022.)

[4] Speck, 165.

[5] Lisa Wood, Lawrence D. Frank, Billie Giles-Corti. "Sense of community and its relationship with walking and neighborhood design." Social Science and Medicine, May 2010. https://doi.org/10.1016/j.socscimed.2010.01.021

[6] (Paul, A. M. (2022). "" Thinking Within Groups"". *The extended mind: The power of thinking outside the brain* (p. 197). essay, Mariner Books.)

[7] Lisa Wood, Lawrence D. Frank, Billie Giles-Corti. "Sense of community and its relationship with walking and neighborhood design." Social Science and Medicine, May 2010. https://doi.org/10.1016/j.socscimed.2010.01.021

[8] Abdulla Baobeid, Muammer Koç, Sami G. Al-Ghamdi. "Walkability and Its Relationships With Health, Sustainability, and Livability: Elements of Physical

Environment and Evaluation Frameworks." Frontiers in Built Environment, September 30, 2021. https://doi.org/10.3389/fbuil.2021.721218

[9] Abdulla Baobeid, Muammer Koç, Sami G. Al-Ghamdi. "Walkability and Its Relationships With Health, Sustainability, and Livability: Elements of Physical Environment and Evaluation Frameworks." Frontiers in Built Environment, September 30, 2021. https://doi.org/10.3389/fbuil.2021.721218

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116.

RESEARCH REFLECTION BY NICOLE MERHI

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Undergraduate research has given me the opportunity to further explore and learn more about topics that I am both interested in and that personally affect my day to day life. In this research project, I was able to explore more about why not having access to walkable cities is a problem, who it affects, and how we can make a difference. In the future, I would like to educate myself on topics that affect others, and learn potential ways to improve certain problems.

About the Author

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117.

LIFTING THE BURDEN: INTEGRATING THE TECHNOLOGY OF 3D PRINTING INTO HEALTHCARE TO LOWER THE COST OF PROSTHETIC LIMBS

Allison Sveum and Eric Robertson

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As of right now, there are approximately 2.1 million people living in the United States who live with an amputated limb, whether congenital or surgical. Of these 2.1 million, an unknown number are children, who have much more complex needs when it comes to their prosthetics. In an article published by BioMed Central, the authors discuss how "[c]hildren's prosthetic needs are complex due to their small size, constant growth, and psychosocial development" which exposes the intricacies and need for cheaper materials to lower the cost of prosthetics for families with a child amputee (Zuniga et. Al., 2015). According to Annie Murphy Paul, the author of the book *The Extended Mind,* "our thoughts…are powerfully shaped by the way we move our bodies" (Paul, 2021). Movement is so important in our process of thinking and using our brain, so when these kids lose the function of a limb, their brain starts shutting down, too. These prosthetics are integral to kids continuing to develop mentally. Even if the limb isn't physically there, the thought of the movement that powers myoelectric prosthetics to work, has the same effect on the brain. The utilization of new materials and technologies, such as 3D printing, can help lower overall cost of prosthetics, make the creation process easier on the patient, and make the prosthetic more functional without adding unnecessary weight, especially for families with a child amputee.

Prosthetics are some of the most expensive medical devices in the world. Not only are the necessary for an amputee to return to a somewhat normal life, but they need to be durable enough for them to use in their

everyday lives. The prospect of 3D printing in the medical field has the potential to lower overall costs in producing prosthetics, which would save families thousands of dollars in the long run. In 2015, an article published by BioMed Central explores how 3D printed prosthetics can help respond to the needs that amputee children face. These children grow at such a quick pace that they are outgrowing their prosthetics that unfortunately come with a huge price tag. This research states that "[t]he cost of a body-powered prosthetic hand ranges from $4,000 to $20,000" this price range puts extreme limits on the kind of prosthetic a family is able to purchase for their child (Zuniga et. Al., 2015). This quote benefits my research because it shows just how much of a burden prosthetics can be on a family's financial situation. The choice for many families becomes one expensive myoelectric prosthetic or multiple prosthetics that don't provide the same functionality. In "A Leg to Stand On," an essay written by Vivian Sobchack, she shares her experience dealing with her amputation and the medical care that surrounds her recovery and return to a normal life. Within this essay, she states that "my full (and rather ordinary) leg probably cost no less than $10,000 to $15,000 per leg"

for the most basic prosthetic that doesn't include any myoelectric workings (Sobchack, 2004). This price almost guarantees a heavy financial burden on any person who experiences a lost limb, which can include family in the case of a child.

In the case study performed by Tong et al and published by PLOS ONE in 2019, the researchers concluded that "the integration of 3D scanning and 3D printing processes offers the ability to rapidly design and fabricate low-cost personalized and anatomical wearable systems" to share how new technologies can make necessary prosthetics more affordable (Tong et Al., 2019). This conclusion identifies and shares that 3D printing can be a solution for more affordable prosthetics which is relevant to my project because healthcare providers can share a cheaper treatment method with these children's families, especially when their prosthetics need to be adjusted consistently. Organizations such as The Amputee Coalition will also be able to share this incredible technology to the patients that reach out to them. On their website, their goal is to "relentlessly seek opportunities to improve, always seek new answers, and offer potential solutions" for amputees (amputee-coalition.org). Part of this process of innovation is sharing the new technology of integrating 3D scanning and printing into the fabrication of prosthetics to make them so low cost. This means that the body of the prosthetic will be much cheaper for the patients and their families, so they would be able to add much higher end technology to the medical devices. Adding myoelectric workings means

that the prosthetic is much more functional than a regular one; it could give the patient some autonomy back into their lives, almost if they had never lost the limb.

Another aspect of integrating 3D printing into the production of prosthetics is that the process involved in making prosthetics is long and painful, and this new technology allows the process to be easier for the patient. The current process of making prosthetics is very difficult. As stated in an article published by BioMed Central in 2015, "these devices require extensive fitting procedures to develop the terminal device and often include a complex system of cables and harnesses" (Zuniga et. Al., 2015). This quote clarifies the complexity of my problem because it discusses the invasive and painful methods needed to size a prosthetic to fit. The research presented by Zuniga et Al. shows that 3D printing may be the solution to lowering the overall cost of these essential medical devices. These prosthetics can be made with cheaper materials and made to be more comfortable for the patient, all while lowering the financial strain it puts on the family. In the article published by PLOS ONE in 2020, the affordability and versatility of "3D printing of soft materials due to the capability of 3D printing methods in delivering very sophisticated and complex geometries with

no need of post- processing" is examined to inform readers about how 3D printing can change the world of prosthetics for the better and cheaper. Using a computer, accurate scans of a patient's limb can be taken and mapped to make a more comfortable prosthetic to attach to the missing limb. The patient's exact measurements can be considered, without a messy and painful process involved.

The current standard of making prosthetics includes plastering and molding the limb, which takes a long time and is very uncomfortable. Vivian Sobchack also comments on this process in her essay, "A Leg to Stand On." She discusses the process she undergoes anytime she needs a new prosthetic, "I have had four successive sockets that were molded of fiberglass and 'thermo-flex' plastic to conform, over time, to the changing shape of my stump" (Sobchack, 2004). If a patient's measurements can be stored in the computer, then the patient saves money on the cost of materials to mold their limb every time they need a new prosthetic made. Currently, carbon-fiber, fiberglass, and many other materials are combined to form a prosthetic, which usually involves layers of molding to the site of amputation, peeling off the mold, and then waiting for the prosthetic

to be formed. Since these child amputees have gone through enough losing limbs, the process for shaping these devices should be as easy as possible for them. Computer programs will be able to take away the pain or discomfort of making these medical devices, allowing these kids to enjoy their lives away from the doctor's office.

In 2020, Mohammadi et Al. published an article that explored using different materials within the process of 3D printing a prosthetic. This group created a "hand [that] was 3D printed from soft material, into which all the actuation and control systems are embedded" to prove that myoelectric prosthetics don't need to be unnecessarily rigid or heavy with extra parts (Mohammadi et Al., 2020). This notion refers to 3D printing as a method to make prosthetic devices not only more affordable, but better functioning for the user, which is relevant to my research in making prosthetics more affordable in a time where they are becoming more technologically advanced. In 2019, Tong et al published an article that explores a case study of using 3D printing to help create more affordable prosthetics for families and make the design process easier by using 3D scanning techniques. The group's research investigated many different technologies, but their conclusion found that 3D printing techniques are "relatively low cost, [portable], [flexible] in range and resolution, and [user-friendly]" (Tong et Al., 2019). This research gathers information into the tools that are used in conjunction with 3D printing to make creating prosthetics easier, more affordable for families,

and lighter for the patient to wear. Due to the way 3D printing works, taking a solid form of a material, and melting it to be printed into layers, brand new materials can be used when making prosthetics. These materials can be much lighter than the traditional combination of carbon, plexiglass, and fiberglass. These materials can also give the prosthetic a flexibility that they haven't had before while still being durable and able to protect an expensive myoelectric system.

The current model of prosthetics includes a heavy price tag, and a long and sometimes painful creation process, which leaves the prosthetic being much heavier than a normal limb. 3D printing is opening a new door for families, healthcare workers, and everyone involved in the life of a child amputee. In 2020, Brian Hare and Vanessa Woods wrote *Survival of the Friendliest,* a book examining our origins and understanding our common humanity. Within their research, they found that "most of us would respond to a child in distress…we have tremendous potential for compassion, and we evolved uniquely to show friendliness to intragroup strangers" (Hare & Woods, 2020). Wanting to help these children and families who are burdened by expensive medical care is intrinsic to who we are as people. Everyone should be excited by the prospect of 3D printing being integrated into the creation of prosthetics, as it will alleviate much of the burden of having a prosthetic and needing to keep it in great condition. 3D printing could help these kids be kids and lose the emotional toll that constant appointments to fix or resize the prosthetic can take on a child because the medical device that makes them whole again doesn't need to be taken away again and again.

Bibliography

Amputee Coalition. (2023). Mission and Vision: We Actively Innovate. Mission & Vision – Amputee Coalition (amputee-coalition.org)

Hare, B, Woods, V. (2020). Survival of the Friendliest: Understanding our Origins and Rediscovering our Common Humanity. Random House.

Mohammadi, A., Lavranos, J., Zhou, H., Mutlu, R., Alici, G., Tan, Y., Choong, P., & Oetomo, D. (2020). A practical 3D-printed soft robotic prosthetic hand with multi-articulating capabilities. PLoS ONE, 15(5), 1–23. https://doi.org/10.1371/journal.pone.0232766

Paul, A. (2021). The Extended Mind: The Power of Thinking Outside the Brain. HarperCollins.

Sobchack, V. (2004). A Leg to Stand On: Prosthetics, Metaphor, and Materiality. In Carnal Thoughts: Embodiment and Moving Image Culture (1st ed., pp. 205–225). University of California Press. http://www.jstor.org/stable/10.1525/j.ctt1pnx76.13

Tong, Y., Kucukdeger, E., Halper, J., Cesewski, E., Karakozoff, E., Haring, A. P., McIlvain, D., Singh, M., Khandelwal, N., Meholic, A., Laheri, S., Sharma, A., & Johnson, B. N. (2019). Low-cost sensor-integrated 3D-printed personalized prosthetic hands for children with amniotic band syndrome: A case study in sensing pressure distribution on an anatomical human-machine interface (AHMI) using 3D-printed conformal electrode arrays. PLoS ONE, 14(3), 1–23. https://doi.org/10.1371/journal.pone.0214120

Zuniga, J., Katsavelis, D., Peck, J., Stollberg, J., Petrykowski, M., Carson, A., & Fernandez, C. (2015). Cyborg beast: a low-cost 3d-printed prosthetic hand for

children with upper-limb differences. BMC Research Notes, 8(1), 155–171. https://doi.org/10.1186/s13104-015-0971-9

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118.

RESEARCH REFLECTION BY ALLISON SVEUM

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This paper was a piece of the final project for the class HONOR 2211. My original attitude towards this class was that it's just another writing class I need in order to graduate. Being able to work with Eric Robertson throughout this process made this paper truly special. All semester, we built little pieces of our essay, and once I compiled them all, I was left with a paper I am really proud of. I picked this topic because I think prosthetics are really cool and it's a niche within my major, biomedical engineering. After this paper, I believe that my future

career may have something to do with prosthetics. This paper changed my attitude towards this class and my major; it was truly so impactful and inspiring.

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