22nd Annual Gemstone Honors Program Thesis Conference

Friday, April 16, 2021
University of Maryland, College Park

GEMSTONE
HONORS COLLEGE
UNIVERSITY OF MARYLAND

Gemstone Staff

Dr. David J. Lovell, Director
Dr. Kristan C. Skendall, Associate Director
Dr. Vickie E. Hill, Assistant Director for Operations
Dr. Leah K. Tobin, Assistant Director for Student Engagement

Please join us…

You are cordially invited to attend the
Gemstone Citation and Awards Ceremony
May 19, 2021 at 7:00pm EDT
Register here: https://go.umd.edu/gemscitationceremony21

Thesis Conference Schedule

Time	Team	https://go.umd.edu/
1:30pm	METR	gems2021metr
	TOXIC	gems2021toxic
	TUMOR	gems2021tumor
2:45pm	AIMAR	gems2021aimar
	CYCLE	gems2021cycle
	FORMULA	gems2021formula
4:00pm	ACID	gems2021acid
	ASTRO	gems2021astro
	CONTACT	gems2021contact
5:15pm	CASCADE	gems2021cascade
	IPOV	gems2021ipov
	NOSALT	gems2021nosalt

ACID: A Systematic Investigation on the Medicinal Use of Lysergic Acid Diethylamide

Research Team

Kayla Marie Foster, Public Health Science; Sustainability Studies
Abigail Reece Hansen, Criminology & Criminal Justice and Spanish and Latin American Literature, Culture and Media
Matthew Lee, General Biology
Alan Musa Mohammed, Biological Sciences: Cell Biology and Genetics, Chemistry
Thach-Vu Hoang Nguyen, Biochemistry
Caroline Louise Olson, Bioengineering
Luke Vincent Pascale, Physics, and Astrophysics

Faculty Mentor

Dr. Nishanth Sunny, Assistant Professor, *Animal and Avian Sciences*

Librarian

Amy Trost, *University Libraries, UMD*
Susan Weisner, *University Libraries, UMD*

Discussants

Dr. Natalie Gukasyan, Postdoctoral Fellow, *Johns Hopkins Center Psychedelic and Consciousness Research*
Dr. Agnessane Danehey, Associate Research Professor, UMD *Counseling, Higher Education, and Special Education Department*
Dr. Albert Garcia-Romeu, Assistant Professor, *Johns Hopkins Center Psychedelic and Consciousness Research*

Research Description

Evidence points to several mechanistic relationships where lysergic acid dimethylamide (LSD) alters the serotonergic system in autism spectrum disorders (ASD) and positively impacts ASD-related clinical outcomes. Clinically relevant endpoint measurements resulting from the interaction of LSD with various psychiatric disorders and the etiology of ASD were selected and analyzed for a review. Peer reviewed and publicly available original scientific studies in humans, animal models, or cell cultures with LSD as the primary treatment and a reasonable sample size were included in the search. The endpoints selected for the review fall into the following categories: neurotransmitters, physiological markers, metabolites and intermediates, brain connectivity, brain morphology and histology, receptor activity and expression, and gene expression. The review intends to elucidate a promising mechanism of action through which LSD could be interacting with the factors responsible for the etiology of ASD. The goal of the review is to illustrate the potential for the therapeutic use of LSD and its analogues towards the management of various psychological and neurodevelopmental disorders, including ASD. This review could reveal a refined hypothesis for future research in order to identify specific molecular targets of LSD or its analogues for the treatment and management of ASD.

Acknowledgements

We would like to thank our mentor, Dr. Nishanth Sunny, for his guidance, advice, and support over the past 3.5 years. Without his knowledge and enthusiasm for our project, this research would not have been possible. We would like to thank our librarians Dr. Susan Weisner and Ms. Amy Trost for all of their support in finding sources to support our project. We would also like to express our gratitude to all of the LaunchUMD donors who helped to support our research monetarily. We are grateful to our discussants for sharing their time and expertise with us, and we are grateful to Aaron Orsini, author of Autism on Acid, for sharing his lived experience with our team. Finally, we would like to thank our family and friends along with all of the Gemstone staff, Dr. Skendall, Dr. Hill, Dr. Lovell, and Dr. Tobin, for the unwavering support during our time in the Gemstone Program.

AIMAR (Artificially Intelligent Medical Assistant Robot): Implementing Artificial Intelligence and Robotics to Assist in Healthcare Decision Making

Research Team

Paulos Daniel, Electrical Engineering
Nina Horne, Mechanical Engineering
Kevin Kuo, Computer Science, and Mathematics
Michelle Marsandi, Computer Engineering
Natalie Offenberg, Computer Science, and Mathematics
Dana Ronin, Bioengineering
Ryan Utz, Mechanical Engineering, and Computer Science
Johan Vandegriff, Computer Engineering

Faculty Mentor

Dr. Anil Deane, Associate Research Professor in the *Institute for Physical Science and Technology*; Director of the *Laboratory for Computation and Visualization*

Librarian

Nedelina Tchangalova, *University Libraries, UMD*

Discussants

Dr. Mark Fuge, Assistant Professor, *Mechanical Engineering*
Dr. Aniket Bera, Assistant Research Professor, *Institute for Advanced Computer Studies*
Dr. James Borelli, Post Doctoral Fellow, *School of Medicine*
Dr. Ian White, Associate Professor and Associate Chair, *Bioengineering*
Dr. Marc Levitt, Chief and Professor, *Children's National Hospital and George Washington University*

Research Description

Healthcare providers face financial, regulatory, and logistical obstacles in supplying quality care. A physical robotic system coupled with artificial intelligence software can improve patient outcomes and reduce demands on providers by automating data collection and supplementing medical diagnoses. Team AIMAR (Artificially Intelligent Medical Assistant Robot) constructed such a system, which was divided into a robotic base and advanced diagnostic modules. Base functionality consisted of basic navigation, mapping, and conversational abilities. For two prototype modules, AIMAR used a deep neural network to identify skin lesions and utilized natural language technologies to talk to patients and diagnose conditions. Additionally, Team AIMAR created a framework to test and assess the functionality of the fully integrated system in a simulated environment. Many diverse directions exist for future work, including expanding the functionality of the user interface, improving motion and sensing capabilities, and communicating with electronic health record systems.

Acknowledgements

We would like to thank Dr. Deane for guiding and mentoring our team, Dr. Skendall and Dr. Coale for supporting us in the Gemstone program, and Dr. Babadi, Dr. Plaisant, Mr. Katragadda, and Ms. Tchangalova for their advice on various areas of our research as we were developing our project. We would also like to thank our discussants, Dr. White, Dr. Levitt, Dr. Borelli, Dr. Fuge, and Dr. Bera, for taking time out of their day to provide our team with their valuable input and feedback on our thesis.

ASTRO (Assessment of Space Technologies for Robotic Operations): Robotic Technologies for Minimizing Crew Maintenance Requirements in Space Habitats

Research Team

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Jaime Callejon Hierro, Aerospace Engineering, and Mathematics
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Librarian

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Discussants

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Lemuel Carpenter, Aerospace Vehicle Design and Mission Analyst, *NASA Langley Research Center*
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Brian Roberts, Deputy Division Director of NASA Exploration and In-Space Services Division, *NASA Goddard Space Flight Center*
Gardell Gefke, Chief Robot Systems of NASA Exploration and In-Space Services Division, *NASA Goddard Space Flight Center*
Dr. Carl "Glen" Henshaw, Section Head of Robotics and Machine Learning Section, *US Naval Research Laboratory*

Research Description

The International Space Station (ISS) is crewed continuously by astronauts conducting scientific research in microgravity. However, their work is not limited to scientific research alone; in fact, logistics, maintenance, and repair tasks on the ISS require more than 80% of available crew time, severely limiting opportunities for performing scientific experiments and technological development. NASA is planning a new project known as Gateway (also referred to as the Lunar Orbital Platform- Gateway). This station will orbit the Moon and be uncrewed for 11 months per year. Astronauts will only be present in the outpost for a limited period of time and will not always be available for continuous repairs and maintenance, as is required for Gateway to operate. Therefore, robotic system(s) are necessary to regularly accomplish these tasks both in the absence and presence of astronauts. Throughout this project, Team ASTRO (Assessment of Space Technologies for Robotic Operations) explored the feasibility of integrating dexterous robotic systems in space habitat architectures to perform routine and contingency operational and maintenance tasks. Ultimately, this allows for astronauts, when present, to focus on exploration and scientific discoveries. The team conducted this research through three approaches: Gateway component analog taskboard development and end effector assessment, Cargo Transfer Bag (CTB) manipulation and logistics, and AprilTag situational awareness simulation development. Based on analyses and experimental results gained from this research, the team found that robotic systems are feasible alternatives for space habitat operation. Team ASTRO also determined that AprilTags can be used for optimization of the Gateway design to facilitate uncrewed operations and robotic servicing to improve crew productivity when present.

Acknowledgements

First and foremost, we would like to thank our mentors, Dr. David Akin and Dr. Mary Bowden for their guidance and support throughout this project. We deeply appreciate all that they have done and we would not have been able to accomplish all that we have without them! We would also like to thank our Team Librarian, Dr. Sarah Over, for her help on all of our papers. A huge thank you goes out to Dr. Kristan Skendall, Dr. David Lovell, and the rest of the Gemstone Honors Program staff for their support over the past four years. Additionally, we would like to thank all those who supported us for the NASA 2019 X-Hab Academic Innovation Challenge and the NASA 2020 RASC-AL Competition. Thank you to all of the Space Systems Laboratory graduate students who fixed the robots multiple times when they broke. Finally, we would like to thank our discussants, Dr. Julia Badger, Lemuel Carpenter, Gardell Gefke, Dr. Glen Henshaw, Brian Roberts, and Dr. Brook Sullivan for their feedback on our thesis.

CASCADE (Comparing Allergic Signaling Chain Antagonists to Inhibit Degranulation Expression): Computational Screening for Novel Inhibitors of Proteins in the Mast Cell Degranulation Pathway

Research Team

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Librarian

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Discussants

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Dr. Paul Paukstelis, Associate Professor, *Chemistry and Biochemistry*
Dr. Xiaoping Zhu, Professor and Chair, *VA-MD College of Veterinary Medicine*

Research Description

Allergies are a pervasive issue and require novel ways of alleviating symptoms. Existing treatments focus on symptom management and immunotherapy in response to an allergic reaction. However, there is also potential for prophylactic treatment that inhibits molecules involved in the mast cell degranulation pathway, which causes allergic symptoms. We identified compelling target proteins downstream of this pathway including PKC, PLCγ, and PI3K isoforms, the activation of which results in the degranulation of mast cells. We modelled protein-inhibitor binding interactions in PyRx and identified inhibitors with the highest binding affinity to the target pathway proteins. We extended our analysis to ZINC database analogs of the most efficient inhibitors to determine which chemical properties of the inhibitors contributed to the highest binding affinity. The identified inhibitors have the potential to hinder mast cell

degranulation, limit histamine and cytokine release, and therefore prevent allergic symptoms, making them ideal targets for future pharmacology research.

Acknowledgements

We would like to thank, first and foremost, our mentor Dr. Kenneth Frauwirth for providing us intellectual support and guidance throughout the past four years. We would also like to thank Dr. David Mosser and Kajal Hamidzadeh from the Mosser lab for providing us with laboratory space and supervision while we were in lab. In addition, we want to acknowledge our librarian Celina McDonald, our generous LaunchUMD donors, our discussant panel, as well as Dr. Coale, Dr. Lovell, Dr. Skendall, and Dr. Hill for their assistance, advice, and guidance. Finally, we would like to thank Noah and Ruby, for growing alongside us.

CONTACT: Improving Non-Contact Tonometry: A Deep Neural Network-Based Method for Corneal Deformation Mapping

Research Team

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Lauren S. Cho, Chemical and Biomolecular Engineering, and Chemistry
Kun Do, Physics
Aaron E. Green, Computer Science, and Physics
Samuel B. Klueter, Materials Science and Engineering
Eliana S. Krakovsky, Physics
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Discussants

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Dr. Amal Isaiah, Assistant Professor, *University of Maryland School of Medicine*
Dr. Peter Kofinas, Professor and Chair, *UMD Chemical and Biomolecular Engineering Department, UMD A. James Clark School of Engineering*

Research Description

Glaucoma, a disease characterized by increased intraocular pressure (IOP), is one of the leading causes of preventable blindness worldwide. Accurate measurement of IOP is essential in monitoring glaucomatous progression in order to deliver treatment and prevent long-term vision loss. Currently, non-contact tonometry, known as an “air-puff test”, is a common diagnostic method despite its inaccessibility, discomfort, high cost, and reliance on a trained professional. To improve upon these shortcomings, we designed a cheaper tonometer integrating a novel depth-mapping neural network with a custom air-puff generation system. We deformed porcine corneas with a controlled-intensity air-puff while imaging the deformation with a single stationary camera\textemdash a contrast to the standard Scheimpflug method. From the footage, our neural network predicted a three-dimensional map of corneal deformations. The network was able to predict a general negative trend between the IOP and the corneal deformation extracted. we compared our results to accepted literature deformation values and ground truth footage, allowing us to determine that the deformation amplitudes were physically plausible. With a more robust imaging setup, we present a promising alternative to traditional IOP measurement methods. Future studies should make the simulated footage more representative of clinical conditions to increase the generalizability of the neural network. Additionally, anatomical

differences between porcine and human eyes as well as corneal variability due to socio-demographic differences must be addressed for our results to be applied to clinical settings.

Acknowledgements

We would like to thank our mentor, Dr. Scarcelli, for his guidance in our project; the graduate students in his lab, for training us in lab skills and protocol; our librarian, Ms. Rachel Gammons, for helping us pursue and present research; and the Gemstone staff and faculty—Dr. Frank Coale, Dr. David Lovell, Dr. Kristan Skendall, Dr. Leah Kreimer Tobin, Dr. Vickie Hill, and Jessica Lee—for supporting our research endeavors.

CYCLE: Evaluating the Biosorptive Properties of Local Algae to Facilitate Heavy Metal Removal from Contaminated Water

Research Team

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Discussants

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Dr. Peter Ian May, Assistant Research Professor, *Environmental Science and Technology*
Dr. Stephanie Lansing, Associate Professor, *Environmental Science and Technology*
Dr. Lora Harris, Associate Professor, *Center for Environmental Science Chesapeake Biological Laboratory*

Research Description

Arsenic, cadmium, and chromium are among the major industrial heavy metal pollutants that can cause adverse effects on human and environmental health. Conventional remediation treatments tend to be financially and environmentally disadvantageous. Algal biosorption is an alternative that utilizes the functional groups on algae's surface to remove metals from solution. We tested the remediating capabilities of algae in both a laboratory and prototype setting. We observed how arsenic, cadmium, and chromium were sorbed by the algae at select time intervals. We found that 100% of chromium and arsenic and 35% of cadmium were removed after 24 hours, with peak rates occurring for all three metals at two hours. Results from the prototype show promise, but shortcomings suggest this technology is better suited for use in pretreatment, not for immediate discharge. More research is needed to improve the system's practicality in real world application.

Acknowledgements

First and foremost, we'd like to thank our mentor Dr. Natasha Andrade, who has become a close friend to all of us. Second, thanks to Sami Smith, who helped extraordinarily in the early development of our project. We'd also like to thank Marya Anderson, who spent many hours wrangling uncooperative lab equipment, and Ted Baker, who provided us space to build our prototypes. Further thanks go to our discussants, Dr. Stephanie Lansing, Dr. Lora Harris, Dr. Peter May, and Dr. Jose-Luis Izursa; our librarians, Stephanie Ritchie and Jodi Coalter; and the Sea Grant and UMD Sustainability Fund. Lastly, we'd like to say thanks to Gemstone staff past and present – Dr. Vickie Hill, Dr. Leah Tobin, Dr. Kristan Skendall, Dr. David Lovell, Dr. Frank Coale, and Jessica Lee, who made our four years in Gemstone successful.

FORMULA: Dynamic Wireless Power Transfer Using DC Power

Research Team

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Emily Aynn James, Fire Protection and Engineering; Project Management Minor
Katherine Elizabeth Kemp, Mechanical Engineering, and Computer Science; Innovation and Entrepreneurship Minor
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Discussants

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Dr. Romel Gomez, Professor, *Electrical and Computer Engineering*
Dr. Eyad Abed, Professor, *Electrical and Computer Engineering*
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Research Description

Constant stops for charging and lengthy charging times make electric vehicles (EVs) inconvenient to operate for extended travel. Innovative charging methods are necessary if EVs are expected to gain traction in the market over the coming years. Current advancements allow EVs to be charged wirelessly while parked over a charging source. This method does not mitigate the issue of interrupting a trip to spend a significant amount of time charging the vehicle. We theorized that – by expanding on the current technology – EVs could be charged while in motion. The primary goal of this project was to develop a model that optimized the operation of a dynamic wireless power transfer (DWPT) system using DC power. Through a combination of digital simulations and physical tests, the team determined the factors that significantly impacted the power transfer to a receiving wire coil as it moved over a series of stationary transmitting coils. The results were used to confirm the feasibility of a DWPT system and to make recommendations as to the optimum operating conditions.

Acknowledgements

Team FORMULA would like to extend our thanks to our mentor Bryan Quinn for providing us with guidance, as well as lab space, equipment, and materials for our project. We'd like to thank Siavash Toosi, Shawn Fickes, and Brian Beaudoin for lending time and technical expertise for our simulations and test rig. We'd like to thank our former librarian Kelsey Corlett-Rivera and our current librarian Sarah Over for help with our proposal and thesis. We'd like to acknowledge our discussants for taking the time to read our thesis and be here today. We would also like to thank all of the Gemstone faculty and staff for their support, especially over the last year. Finally, we would like to pay our gratitude and respects to our former teammate Trevor Quinn. Trevor had an immense impact on our team and research through the insightful and positive attitude he brought to every meeting.

IPOV (Investigating Parental Opinions on Vaccines): An Analysis of the Factors that Influence Vaccine Hesitancy

Research Team

Kellyann M. Bock, Criminology and Criminal Justice, and Psychology
Tara K. Cecil, Bioengineering
Amelia C. Huppert, Economics, and English
Molly C. Jones, Civil and Environmental Engineering; Professional Writing Minoir
Daniel Kozimbo, Economics, and Finance
Alyssa L. Pitt, Public Health Science
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Discussants

Dr. Woodie Kessel, Professor of the Practice, *Family Science*
Dr. Patricia Alexander, Distinguished University Professor, *Human Development and Quantitative Methodology*
Dr. Sarah McGrew, Assistant Professor, *Teaching and Learning, Policy and Leadership*
Dr. Christine Palmer, Associate Director, *Gritstone Oncology*
Amelia Jamison, Research Affiliate, *Center for Health and Equity*

Research Description

Due to the current rise of the vaccine hesitancy movement, there has been an increase in vaccine-preventable disease outbreaks (Mnookin, 2011; Reich, 2016). Parental rationalizations for opting out of vaccination vary; however, some of the more commonly cited rationalizations include concerns for the child's safety, distrust of medical professionals, and protection of civil liberties and individual decision-making processes (Glanz et al., 2013). The vaccine hesitancy movement has been propagated through people's consultation of the Internet, friends, and personal opinion publications (Kennedy, Lavail, Nowak, Basket, & Landry, 2011; Vrdelja, Kraigher, Verčič, & Kropivnik, 2018). However, little research exists on how to intervene in parents' decision-making processes regarding vaccines. To address this gap, Team IPOV created and distributed a national survey designed to examine how parents' levels of background knowledge, trust, and personal beliefs regarding the influenza and varicella vaccines predicted vaccination hesitancy. Hierarchical linear regression revealed that trust in vaccinations predicted an appreciable amount of variance in vaccination hesitancy, above and beyond background knowledge. However, personal beliefs, although a significant predictor, only predicted a relatively small amount of variance in vaccination hesitance, above and beyond trust.

Acknowledgements

We would like to thank our mentor, Dr. Doug Lombardi, for his never-ending guidance, support, and expertise over the course of our research process. We would also like to thank our librarian, Ms. Judith Markowitz, for her guidance and support during our time in this program. Additionally, we would like to express our appreciation for all of the individuals who helped make our research project possible through their monetary support via LaunchUMD donations. Thank you to our discussants - Dr. Kessel, Dr. Alexander, Dr. McGrew, Ms. Jamison, and Dr. Palmer - for their time. We are grateful for their expertise and advice. We would also like to thank both current and former Gemstone Honors Program staff including Dr. Kristan Skendall, Dr. David Lovell, Dr. Frank Coale, Dr. Vickie Hill, Dr. Leah Kreimer Tobin, and Ms. Jessica Lee for their support throughout the entirety of this four-year experience with the Gemstone Honors Program. We are also grateful to Dr. Quinn, Dr. Hadden, Dr. Solway, and Dr. Dyer for their educational consultations. Finally, we would like to thank our family and friends for all of their support. Our research project has taught us about the significance of herd immunity in a population and about the value of learning from others and understanding their knowledge and beliefs. Thank you to all who made up our community, we are endlessly grateful for what we have learned.

METR (Musicians' Experiential Trauma Research): A Systematic Review of Playing-Related Musculoskeletal Disorders in Musicians Relating to Biological Sex and Instrument Group

Research Team

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Discussants

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Dr. Lee Hinkle, Senior Lecturer, *School of Music*
Dr. Serap Bastepe-Gray, Joint Appointment in Neurology, Director for Peabody Occupational Health and Prevention Program, Co-founder, *Johns Hopkins Center for Music and Medicine*, Assistant Professor, *Johns Hopkins Department of Neurology and Peabody Conservatory*
Dr. Jan Dommerholt, President and Owner, *Bethesda PhysioCare*
Dr. Andrea Lasner, Clinical Specialist, *Johns Hopkins Hospital*

Research Description

Playing-related musculoskeletal disorders (PRMDs) are occupational health concerns that have been shown to affect many musicians and other performing artists by causing discomfort and, in some cases, chronic pain or disability. This meta-analysis gives an overview of the prevalence and incidence rates of PRMDs and investigates potential associated factors including biological sex and instrument type. **Methods:** We utilized a systematic review to address whether disparities in prevalence were observed based on biological sex and instrument played, and whether instrument choice was associated with previously reported disparities in PRMD prevalence between biological males and females. Six literature databases were searched for cross-sectional studies, longitudinal studies, and randomized control trials for which a pre-intervention or baseline prevalence or incidence rate could be determined for males or females,

or for specific instruments. Articles published at any time before August 13, 2020 were included for eligibility evaluation. Studies were evaluated by two reviewers for methodological quality using the Loney Scale, and data was extracted, summarized, and statistically evaluated in a meta-analysis. Results & Conclusion We identified 5961 articles in our initial search, 146 of which met eligibility criteria for methodological assessment using the Loney Scale. It is predicted that prevalence rates will be higher for females than males, and that these differences could be explained by instrument choice. Such results would support the hypothesis that instrument choice could potentially explain the higher reported prevalence of PRMDs in females than males as often seen in the literature.

Acknowledgements

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NOSALT: Alternative Methods of Desalination for Sub-Saharan Africa: A Review of Prefiltration and Microbial Desalination Cell Technology

Research Team

Ayotemi Naomi Adewale, Physiology, and Neurobiology
Shivani Pruthvish Amin, Computer Science, and Cell Biology and Genetics
Lauren Bahnsen, Electrical Engineering
Jessica Juliarose Boyer, Bioengineering
Stephen Alexander Caponetti, Biochemistry
Sharon Halevi, Computer Science, and Environmental Science
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Faculty Mentor

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Librarian

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Discussants

Dr. Natasha Andrade, Associate Chair for Undergraduate Programs, Senior Lecturer, *Civil and Environment Engineering*
Meigan McManus, Consultant, *Ramboll*
Dr. Matthias Young, Assistant Professor, *University of Missouri College of Engineering*

Research Description

Our research project has addressed the global need for greater accessibility to potable drinking water, specifically within the regions of sub-Saharan Africa. Initially, we planned to design a unique desalination system that was composed of a pre-filtration unit, a microbial desalination cell (MDC) and a post-desalination treatment unit. When in-person lab work was no longer feasible due to COVID-19 guidelines, we refocused our project to review the construction, efficiency, and cost-effectiveness of the different designs of potential prefiltration units and MDC configurations. Our review of potential prefiltration systems included both chemical and physical separation methods, and the review of the MDC included the air-cathode, bio-cathode and stacked configurations. While researching the technical details of the prefiltration and MDC systems, we also considered the cultural and societal impacts of introducing a technology such as the MDC into our project region. Our project started as an analysis of an emerging technology, but as the team has grown, the project has transformed into a comprehensive review of the

emerging microbial desalination technology and the societal impacts of implementing it into some of the water scarce regions of coastal sub-Saharan Africa.

Acknowledgements

First, we would like to thank our mentor Dr. Birthe Kjellerup, for her unrelenting support and encouragement during all phases of our project; Jordan Sly, for his insightful comments and suggestions throughout the course of our writing; and all past and present Gemstone staff, including Dr. Kristan Skendall, Dr. Frank Coale, and Dr. Leah Tobin, for their valuable guidance and their constant commitment to the success of our team and the rest of our cohort.

TOXIC: Interpretability in Computational Toxicology

Research Team

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David A. Polefrone, Chemistry, and Economics
Robert C. San, Computer Engineering
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Dr. Scott Auerbach, Molecular Toxicologist and Toxicinformatics Group Leader, *National Institute of Environmental Health Sciences*
Dr. Pratyush Tiwary, Assistant Professor, *Chemistry and Biochemistry*
Dr. Todd Martin, Research Chemical Engineer of National Risk Management Research Laboratory, *Environmental Protection Agency*

Research Description

A barrier to the incorporation of predictive models for drug design lies in their lack of interpretability. To this end, we examine on three fronts the interpretability of benchmark models for the 2014 Tox21 Data Challenge, an initiative in the domain with a dataset of measurements across twelve toxicity experiments. On the existing measures of model performance, we assess the current benchmark metric's ability to describe model behavior and recommend a set of metrics for the task. On the existing interpretability methods for machine learning models, we quantitatively and qualitatively evaluate their application to this domain by measuring desirable properties of explanations they produce. On the existing representations of molecules, we propose the addition of electrostatic potential data as novel model input and observe its resulting model performance and model interpretability.

Acknowledgements

We would like to thank our mentor, Dr. Soheil Feizi, for all the invaluable advice he has given our team in the past two years. We would also like to thank Dr. Aravind Srinivasan, our first mentor, who started our team off in a fruitful direction. Without the coordination, structure, and support of the Gemstone staff and program, including Dr. Skendall, Dr. Coale, and Dr. Lovell, none of this would have been possible. Our librarian, Ms. Lindsay Inge, also provided valuable assistance. We would like to thank former team members for all their contributions during their

time with us. Finally, we give our warmest regards to our friends and family who supported us all throughout our time in college.

TUMOR: Localizing Chemotherapeutic Drug Release to Treat Stage III Colorectal Cancer

Research Team

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Morgan A. Coley, Animal Sciences; Philosophy Minor
Matthew D. Hamers, Public Health Science
Nima R. Karodeh, Bioengineering
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Eva L. Minahan, Psychology; Neuroscience Minor
Matthew B. Nagler, Cell Biology and Genetics; Art History Minor
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Matthew J. Tiberino, Physiology and Neurobiology
Kevin K. Wendeu-Foyet, Physiology and Neurobiology

Faculty Mentor

Dr. Peter Kofinas, Chair and Professor, *Chemical and Biomolecular Engineering*

Librarian

Jordan Sly, *University Libraries, UMD*

Discussants

Dr. Giuliano Scarcelli, Associate Professor, *A. James Clark School of Engineering*
Dr. Isabel Lloyd, Associate Professor and Undergraduate Program Director, *Departments of Materials Science and Engineering*
Dr. John Daristotle, Postdoctoral Candidate, *Langer Lab and Koch Institute for Integrative Cancer Research at the Massachusetts Institute of Technology*
Dr. Mohamad Al-Sheikhly, Professor and Director of Radiation Facilities, *Laboratory for Radiation and Polymer Sciences, Department of Materials Science and Engineering, Maryland Energy Innovation Institute*

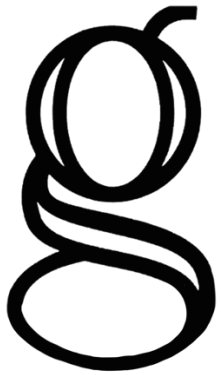
Research Description

Current cancer treatments, such as systemic chemotherapy, induce several complications affecting the entire body. Localizing chemotherapy to the tumor site has the potential to minimize these harmful side effects. Solution blow-spinning (SBS) offers the possibility of incorporating chemotherapy drugs into a polymer solution through the use of a compressed airbrush. This would allow for direct deposit of a polymer mat after surgically removing the tumor. Sutures, in combination with polymer sealants, could be used to prevent complications after surgery. This study focuses on stage IIIA colorectal cancer because cancer cells have not spread distantly yet and treatment typically involves surgery followed by chemotherapy. Three key aims were addressed in this study to assess polymer-drug combinations' compatibility with SBS, observe drug release patterns, and evaluate the effect of drug incorporation on polymer adhesion to intestinal tissue. Our results suggested that the polymer-drug combination of poly(L-

lactide-co-ε-caprolactone) (PLCL) and capecitabine show promise as an adhesive surgical sealant with a drug release pattern that is complementary to a typical resection healing timeline.

Acknowledgements

We would like to thank our mentor Dr. Peter Kofinas, for his continued support and guidance. We would also like to extend a special thank you to our past mentors, Dr. John Daristotle and Dr. Omar Ayyub, for their expertise in the early stages of our research. We are grateful for the assistance from members of the Kofinas Lab, namely Mr. Metecan Erdi. Thank you also to Mr. Jordan Sly for his guidance as our team librarian. We would like to acknowledge our generous donors from LaunchUMD as well as the Do Good Institute and Great Foundation for their financial support throughout this process. Finally, we would like to thank the Gemstone Staff- Dr. Frank Coale, Dr. David Lovell, Dr. Kristan Skendall, Dr. Leah Tobin, Dr. Vickie Hill, and Jessica Lee- for the opportunity to engage in extensive, interdisciplinary research as undergraduate students.



GEMSTONE
Honors College
University of Maryland

Class of 2022: JUNIOR POSTER ABSTRACTS

The Gemstone Honors Program is excited to share the work of the junior class. We hope to see you at next year's Thesis Conference on April 8th, 2022!

JUNIOR POSTER ABSTRACTS

TEAM AUTOCYCLE: Design, Construction, and Validation of an Autonomous Bicycle

Team Members: Michael Allen, Jacob Bartolomei, Jeremy Carter, Cooper Grill, Mikhail Khrenov, John Mirenzi, Joseph O'Leary, Isaac Rose, Evan Ruderman, Andoni Sangüesa, Logan Swaisgood
Faculty Mentor: Dr. Romel Gomez, Professor, *Department of Electrical and Computer Engineering*
Librarian: Nedelina Tchangalova, *University Libraries, UMD*

Research Description

Efficient urban transportation has time and time again proved to be a difficult problem to rectify. One modern solution is the bike-sharing system, where many bicycles are available either at hubs or spread across a city for short-term use. However, usage is limited to those located close enough to a bicycle hub that traveling to and from it is time-effective. As for hubless bike-shares, bicycles require redistribution over time to remain conveniently available to many. We propose the creation of an electric bicycle that can either be used by a cyclist manually or operated autonomously using locomotion, sensing, balance, and control systems. We have concluded that such a concept is possible and achievable, as we are making significant progress toward developing working prototypes for the self-stability and autonomous navigation of the Autocycle. Once those milestones are completed, we will integrate the two systems together in the final prototype. Our Undergraduate Research Day presentation will showcase the research and data we have collected up until this point and outline our future goals for the project. With the completion of this prototype, we want to show that such a bicycle could be implemented into a larger bike-sharing system that autonomously manages distribution and allows users to summon a bicycle to their location, expanding the range of use and encouraging environmentally-friendly transportation solutions in an urban setting.

TEAM BRAIN (Biomarker Research Applications in Neurocognition)

Team Members: Beatrice Acha, Zofia Cieslak, Danny Hemani, Anjali Kubli, Danika Lee, Rejoyce Mgboji, Madhulika Nallani, Michael Park, Mahalet Samson, Benjamin Wu
Faculty Mentor: Dr. J Carson Smith, Professor and Director *of the Kinesiology Undergraduate Program in the School of Public Health*
Librarian: Jodi Coalter, *University Libraries, UMD*

Research Description

Alzheimer's Disease affects millions of older individuals and is a growing problem without an adequate solution or early diagnosis tool. The Team BRAIN research question was to determine which lifestyle factors and blood biomarkers can be used as a method for detecting late onset Alzheimer's Disease. If biomarkers can be used to detect Alzheimer's Disease, then identifying them in individuals would be crucial because it would allow for quicker and more accessible diagnosis as well as preventative treatment options. Using the Alzheimer's Disease Neuroimaging Initiative, a database that compiles data from studies, we were able to access information about participant's levels of various biomarkers, lifestyle factors, demographics, relationships, and more. Our data analysis consisted of using programs such as Python and JASP to analyze data from the ADNI database, and finding significant relationships between variables through statistical analysis. So far, we have determined a significant effect of possessing the e4 gene on left hippocampal volume, and significant effects of having a diagnosis of mild cognitive impairment on scores on the Functional Activity Questionnaire and Geriatric Depression Scale, left and right hippocampal volume, scores on cognitive tests including the Rey Auditory Verbal Learning Test, Mini Mental State Exam and Alzheimer's Disease Assessment Scale, and processes including memory, executive function, language and visuospatial abilities. Our future goals include addressing disparities in Alzheimer's disease development among different demographic and socioeconomic groups, and using our findings to work towards a novel and cost-effective approach to diagnosing AD to eradicate boundaries in the access to care.

TEAM CHANGE (Correcting Hereditary Abnormalities with Novel stem cell Genetic Engineering)

Team Members: Jessica Conway, Akash Dhamsania, Eric Fields, Michael Jacobsen, Yubin Lee, Isabelle Lim, Nicole Salib, Katie Shrout, Deepika Tripu, Erik Vaughan, Ji Won (Ashley) Woo
Faculty Mentor: Dr. Kan Cao, Associate Professor, *Department of Cell Biology & Molecular Genetics*
Librarian: Jodi Coalter, *University Libraries, UMD*

Research Description

Huntington's disease (HD) is an autosomal neurodegenerative disorder caused by extended trinucleotide CAG repetition in the HTT gene. Although this mutation in the HTT gene is mostly associated with neurological and physical symptoms that HD typically exhibits, wild-type Huntingtin protein (HTT) is involved in a variety of cellular functions such as vesicle transportation, cell division, transcription regulation, autophagy, and tissue maintenance. The main cause of HD symptoms is due to aggregation and accumulation of mutant HTT (mHTT) proteins in neurons. Herein, we review multiple approaches targeting DNA and RNA to reduce mHTT expression and include a discussion of the potential application of the recent CRISPR prime editing technology. These approaches are categorized into non-allele-specific silencing and allele-specific-silencing using SNPs and haplogroup analysis, and the possible limitations of targeting mHTT is also discussed. Additionally, we discuss the results of basic cell work performed investigating the differences between expression of HTT and mHTT in fibroblast and neural cells.

TEAM FLOW

Team Members: Aaliyah Adkins, Christina Barrett, Gabby Fano, Katrina Hospes, Christina Kilby, Michael Mareno, Elizabeth Ollila, Jessica Pettit, Jayme Savoy, Tatiana Rowe, Lucy Wilkerson
Faculty Mentor: Dr. Mona Mittal, Associate Professor, *School of Public Health*
Librarian: Judith Markowitz, *University Libraries, UMD*

Research Description

Menarche (the onset of menstruation), along with puberty in general, presents as a trying time for adolescents as they adjust to changes occurring in their bodies. Family life and sexual education are imperative during this transitional stage as they set the foundation for future reproductive health decisions adolescents may make. Prior research on menstruation and menstrual hygiene has primarily focused on rural populations in developing countries; few studies on this topic have been conducted in the United States (U.S.). The findings of these studies show disparities in knowledge related to menstruation and menstrual hygiene among different racial and socio-economic groups in the U.S. We added to current literature by conducting a mixed-method study to investigate knowledge, attitudes, beliefs, and parenting practices related to menstruation and sexual health education among the parents of middle school students in the U.S. We conducted an online study and collected survey data from 1000 parents of middle school students, followed by 40 qualitative interviews with select parents (those who opted-in for this portion) to gain further insight into the attitudes and sentiments regarding menstruation and menstrual health. We also performed an in-depth analysis of the current state legislation on menstrual and sexual health to gain insight into the development and delivery of menstrual health education curriculum in middle schools.

TEAM GECKO: Developing Magnetic 3D Printing Inks to Gain Extra Contact for Key Operations

Team Members: Elizabeth Carlson, Anson Chen, Stephen Chung, Anjali Dhamsania, Bryan Huynh, Gillian Lee, William Mah, Lillian Mueller, Arjun Sivarajan, John Ting, Alex Wang
Faculty Mentor: Dr. Siddhartha Das, Associate Professor in the *Department of Mechanical Engineering*
Librarians: Dr. Sarah Over and Preston Tobery, *University Libraries, UMD*

Research Description

Our team worked to develop a ferromagnetically responsive ink that can be used to 3D print soft, magnetically actuated microstructures. The project performs an investigation into the development of a polydimethylsiloxane (PDMS) polymer-based ink mixed with iron oxide particles, with an approach consisting of using 3D printing to create smaller, more complex shapes. The structures are produced at low cost, from this ink of highly accessible materials, and can then be utilized in the form of microrobots. These ink-based microrobots aim to improve accessibility to relief institutions, and have a wide reach of applications, including but not limited to: drug delivery, minimally invasive surgery, and debris collection for disaster relief. Through the use of LAMMPS simulation software, the printing ink was simulated at a variety of material compositions, with the goal of finding optimal conditions of increasing magnetizability and flexibility of the film to be printed. LAMMPS was also used to simulate how the ink and nanoparticle system reacts to the presence of an applied magnetic field. Data collected from the simulations was utilized to narrow down the most ideal ink compositions, and these inks were then developed in a physical laboratory environment in the presence of an applied magnetic field. Further analysis was conducted to determine the statistical significance of these compositional differences and measure the relative magnetizable properties of the final structures produced by the inks.

TEAM LEMMA

Team Members: Nathan Hayes, Mitchell Fream, Sahil Kochar, Paul Kolbeck, Charlie Schneider, Russell Schwartz, Olivia Sharon, Yuang Shen, Winslow Weiss, Robert Wolle
Faculty Mentor: Dr. Pierre-Emmanuel Jabin, Professor, *Department of Mathematics and Huck Institutes, Pennsylvania State University*
Librarian: Stephanie Ritchie, *University Libraries, UMD*

Research Description

Team Lemma works to quantitatively model the spread of extremist ideas over Reddit. We quantify the severity of the extremist ideas a post propagates by matching its text content to several lexicons created by utilizing features of extremist narratives. These lexicons categorize relevant words as Hate Speech, Character Assassination, Insider Language, Call for Violence, Us vs. Them Language, and Problem with the World Language. Then, factors such as the visibility of the post and activity of the user are found through regression and used in a Consensus Model to calculate the change in opinion of a population of users over time. We hope to be able to predict how extremist ideas will spread on Reddit in the future given the correct lexicons and modeling parameters.

TEAM MIND (Mental Illness Recognition Through Neuroimaging and Deep Learning)

Team Members: Vatsal Agarwal, Sepehr Akhtarkhavari, Evan Ayoroa, Ryerson Burdick, Sandra Crenshaw, Pauline Comising, Aravind Ganeshan, Shika Inala, Caitlin Lee, Sagar Matharu, Neelesh Mupparapu, Madhava Paliyam, Sam Wood, Raymond Zou

Faculty Mentor: Dr. Anil Deane, Associate Research Professor in the *Institute for Physical Science and Technology* and Director of the *Laboratory for Computation and Visualization*

Librarian: Jordan Sly, *University Libraries, UMD*

Research Description

Currently, psychiatric diagnoses rely on observations of symptoms made by clinicians but the understanding of the biological mechanisms that lead to these disorders is limited. Psychotic spectrum disorders are particularly difficult to differentiate and diagnose due to overlapping clinical and biological features. We gained greater insight into psychotic disorders by empirically inspecting and classifying neuroimages with a supervised deep learning model. We trained the model to predict the disorder based on the neuroimage, allowing us to identify any regions of the brain indicative of a certain disorder. A similar model was then trained to predict symptoms associated with each image, allowing us to identify any regions of the brain indicative of a certain symptom. Comparison of the identified biomarkers from each model will allow us to evaluate whether symptom-based clinical scales reflect biological distinctions.

TEAM MUTATE (Making Universal Treatment Against The Epidemic flu)

Team Members: Wellington E Acquah, Cameron G Amini, Saharsh Buddula, Michelle H. Chen, Navya R Chintala, Quinn Dang, Noa R. Ferziger, Grace K. B. Hollis, Devin Jameison, Jyotsna Jayaram, Joseph Anthony L. Manus, Jacob S. Rosenberg, Julia A. Zhiteneva

Faculty Mentor: Dr. Stephanie Yarwood, Associate Professor, *Environmental Science and Technology*

Librarian: Nedelina Tchangalova, *University Libraries, UMD*

Research Description

Influenza (also known as the flu), a contagious respiratory viral illness, is a disease that affects a large number of people around the world each year. The current method for vaccinating against the influenza virus is limited, but due to COVID-19, mRNA vaccines have come into use, paving the way for future improvements on viral research, including, but not limited to, influenza. In this presentation, we will be looking at eleven potential conserved sequences within the influenza virus and seeing which of them is a likely target sequence for a vaccine. In addition, their viability in an mRNA vaccine will be discussed in an attempt to recommend a more conserved target in the wake of the COVID-19 pandemic. We organized the eleven investigated influenza virus proteins into three categories: primary, secondary, and tertiary, where primary proteins have historically shown the most promise in a broadly protective vaccine and have been most researched, and tertiary proteins have had little research done on them. Recommendations on future mRNA vaccine development are also provided, as well as directions for future research.

TEAM PASS (Password Alternative Security Systems)

Team Members: Zach Breit, Hunter Dean, TJ Generette, Nathan Higgins, Sam Howard, Balaji Kodali, Jim Kong, Jonah Tash, Philip Wang, John Wu

Faculty Mentor: Dr. John Baras, Lockheed Martin Chair in Systems Engineering, Distinguished University Professor, *Electrical and Computer Engineering, The Institute for Systems Research, Mechanical Engineering, Fischell Department of Bioengineering, Maryland Robotics Center*

Librarian: Suzanne Wilson, *University Libraries, UMD*

Research Description

FIDO2 is a passwordless authentication protocol for the web that leverages public key cryptography and trusted devices to avoid any shared secrets with servers. It was recently standardized by the World Wide Web Consortium (W3C) into the Web Authentication API, which is supported by most modern browsers. The API integrates with many popular authenticators such as Windows Hello, YubiKey, and Apple TouchID/FaceID. I was interested in the formal analysis. I reviewed recent efforts to formally analyze FIDO2's security with symbolic and computational models. After analyzing these findings, I proposed a more secure version of FIDO's Client to Authenticator Protocol (CTAP2) that levered a modified key exchange scheme to guarantee strong unforgeability of authentication gestures within the protocol. I also proposed investigating the potential of satisfying password-authenticated key exchange (PAKE) or PAKE-like authenticated protocols. I developed a web app using the Web Authentication API and proposed an experiment to test the usability. In this experiment, the subject registered a password and a FIDO acceptable credential. I tracked registration and authentication for each of these methods. The users were then guided through the account recovery process. Once these steps were completed, the user was provided a short survey.

TEAM PRINT (Printing Reparatively with IN-Situ Technology)

Team Members: Rohith Chintala, Brendan Cutick, Tyler Han, Elizabeth Myers, Eric Oh, Aidan Sandman-Long, Cynthia Sheng, Nathan Spicer-Davis

Faculty Mentor: Dr. Steven Mitchell, Lecturer, *Mechanical Engineering*

Librarian: Dr. Sarah Over, *University Libraries, UMD*

Research Description

Additive manufacturing enables the construction of near-arbitrary structures with the help of computational tool-path planning and print material properties. We explore an application of the technology to targeted repairs, such as mending holes or cracks, on 3D printed parts by using conformal tool-pathing, combining the precision of additive manufacturing with the strength and homogeneity of material adhesion. Repair configurations varying in shape, size, material, infill and loading type are tested in 3-point bending for structural strength and strain. We provide and summarize the collected data in addition to a structural analysis and optimization of parameters relevant to reparative 3D printing.

TEAM PRODUCE

Team Members: Christopher Acha, Robert Blanchard, Jonathan Brodsky, Lilly Ding, Andrea Fox, Kalina Gibson, Eleanor Grosvenor, Ann Hoy, Justin Hughes, Kristen Lee, Olivia Mihok, Cade Stanfield, Ananya Uniyal, Sydney Whitaker
Faculty Mentor: Dr. Mohamad Al-Sheikhly, Professor, *Materials Science and Engineering*
Librarian: Dr. Sarah Over, *University Libraries, UMD*

Research Description

Over one third of food products are wasted in the United States. In addition, the use of plastic packaging continues to pose global concerns because most food packaging is derived from petroleum. Our solution was to develop a food packaging material that is both biodegradable and shelf-life extending with enhanced mechanical, thermal, surface, and antimicrobial properties. Preliminary tests using electron paramagnetic resonance and Fourier-transform infrared spectroscopy indicated the ability of poly(lactic) acid (PLA) to undergo crosslinking when irradiated via electron beam in an inert atmosphere. We also utilized Monte Carlo simulations to confirm these results. Through subsequent experiments using differential scanning calorimetry and thermomechanical analysis, we measured the mechanical properties of the crosslinked PLA to determine its viability as a packaging material. We also studied the effects of crosslinking on biodegradation and gas permeability, both through laboratory experiments and COMSOL modeling, which directly relates to shelf life. Overall, our research has led to a biopolymer with enhanced packaging properties and paves the way for widespread biodegradable packaging in the near future.

TEAM REACH (Reviewing Efficacy and Cognitive Workload in Human-Machine Interface): Mental Workload and Performance Assessment During Upper Limb Prosthetic Training

Team Members: Maxine Asenso, McCauley Brown, Gabriel Dayanim, Erin Doyle, Maya Greenbaum, Gabrielle Lavarias, Natalia Nava Mercado, Christina Nguyen, Ashley Russell, Alexys Still, Carolyn Subramaniam, Anagha Rama Varma
Faculty Mentor: Dr. Rodolphe Gentili, Associate Professor, *Kinesiology*
Librarian: Jodi Coalter, *University Libraries, UMD*

Research Description

The acquisition of novel motor skills involves complex brain dynamics and cognitive-motor processes such as mental workload. Mental workload refers to the amount of mental resources that must be devoted to a given task demand. This project will study changes in mental workload and motor performance during prosthesis training. Able-bodied individuals will complete item grasp and manipulation tasks and activities of daily living over multiple practice sessions using an upper-limb body-powered or electromyogram-driven bypass prosthesis. These bypass prostheses aim to simulate the motor learning process undergone by individuals with an upper-limb amputation who engage in prostheses training. As individuals execute standard assessment tests involving reach-and-grasp motion (e.g., Box and Blocks Test; Southampton Hand Assessment Procedure) mental workload and motor performance during practice and retention and transfer tasks will be examined using electroencephalography, kinematic, and performance data, respectively. This research will inform the cognitive-motor processes underlying the learning of prosthesis use over multiple practice sessions. Although this work considers bypass prosthesis use in uninjured individuals, it can, to some extent, inform the corresponding cognitive-motor processes in individuals with upper-limb loss who are learning to use a prosthesis.

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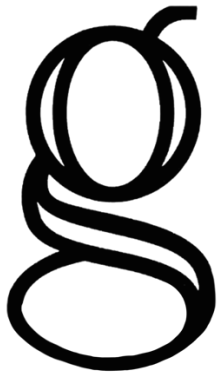

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Vision

Shaping the future through undergraduate interdisciplinary team research by addressing society's most crucial, compelling, and complex questions.

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The Gemstone Honors Program engages students in an academically rigorous and rewarding undergraduate research experience through an interdisciplinary team approach. In partnership with extraordinary faculty, Gemstone research teams advance knowledge and explore society's urgent questions. The Gemstone Honors Program challenges and supports student growth and learning in a community that instills the enduring values of leadership, mentorship, and relationship building.

Values

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