Relapse of Challenging Behaviors in Known and Unknown Context Changes within an Intensive Outpatient Behavior Clinic

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Introduction

• About 60% of individuals with developmental disabilities display challenging behaviors (CBs).1
• CBs are classified as behaviors with intensity, frequency, and duration that poses a safety concern to the individual exhibiting behaviors and/or to those around them.2
• This includes aggression, self-injury, destruction, elopement, etc.
• Function-based treatments are highly effective for treatment of CBs1, but their efficacy is limited by relapse.6
• This study examined a specific type of relapse in CBs that occurs following a context change, called renewal.6
• Common context changes include setting, therapist and task changes, which are observable and known; however, there are many other context changes that may not be observable or known (e.g., biomedical conditions).
• Objective: The purpose of this study was to evaluate the relapse of challenging behaviors for patients receiving function-based treatments. More specifically, we sought to determine the proportion of relapse episodes associated with known context changes versus unknown context changes and further analyze the types of known context changes, as well as the magnitude and maintenance of renewal episodes.

Participants

We conducted a consecutive controlled case series of 15 patients from the BioBehavioral Day Treatment Clinic at the University of Iowa between the years 2019 and 2023 who met the following criteria (see Table 1): 1. Must display CB(s) in both assessment/treatment. 2. Must have socially maintained behavior and no automatically maintained behavior.

Methods

General Procedures and Data Collection:
For each patient, we reviewed all treatment sessions and notes on context changes. Sessions were conducted in 5-min intervals and data were recorded using responses per minute (RPM) of CB. For this study, data were collected using two methods.

Method 1 – Known Context Changes: Data were collected on the rate of CB in the five sessions preceding a known context change (i.e., therapist, setting, or task change) and the three sessions following the context change (see Figure 1). Where the rate of CB in the three sessions following a context change exceeded the highest rate in the five preceding sessions, it was considered renewal.3

Method 2 – Unknown Context Changes: Data were collected on all relapse events and categorized as being associated with a known context change or an unknown context change. Incidents of renewal (Method 1) were further classified by type (setting, therapist, task) and the magnitude and maintenance of renewal incidents were calculated as follows: Magnitude: percent increase in CB from max of the five pre-change sessions to average of the three post-change sessions.

Maintenance: the maximum number of post-change sessions (in groupings of three) where the average exceeds the max of initial five pre-change sessions.

Results

• Within known context changes: Task-based context changes produced the greatest frequency of renewal (18.12%), followed by therapist (12.07%) and setting (9.30%) changes.
• Setting-based context changes were associated with the greatest maintenance (3.8 sessions) when compared to task (3.25 sessions) and therapist (3.42 sessions) changes.
• A therapist-based context change had the greatest magnitude (240% increase, on average), when compared to task (83%) and setting (158%) changes.
• When comparing known and unknown context changes: Unknown context changes occurred more frequently (68% vs. 32%).
• Unknown context changes had the greatest maintenance (4.04 sessions).
• Known and unknown context changes had similar levels of magnitude.

Of all events where renewal occurred, the majority were due to unknown context changes (68%), followed by context changes associated with task (16%), therapist (9.3%), and setting changes (6.7%).

Discussion

• Among known context changes, task-based renewal occurred at the greatest frequency, setting-based renewal occurred for the longest durations, and therapist-based renewal resulted in the greatest percentage increase in CBs.
• Each type of known context change exceeded the other two in one of the analyzed parameters of renewal (frequency, maintenance, magnitude).
• This suggests that each type of context change may have a unique effect on CBs and renewal.
• Future research might consider which of the parameters evaluated in this study are most detrimental to patient treatment and plan to mitigate those effects.
• Unknown context changes were associated with over half of all relapse events and demonstrated the greatest maintenance when compared to known context changes.
• This should be the focus of further study, as the majority of renewal events last longer, one minute and outside of typical therapies. These may be due to unknown internal/external factors that treatment providers are unaware of.
• These data suggest that the current definition of “known context change” in applied research should be broadened past “task,” “setting,” and “therapist” to incorporate context changes that may be internal or external to the patient. A broader definition would allow us to better monitor and identify connections between a patient's behavior and a respective context change.
• Of the parameters used to evaluate relapse, proportion of events and magnitude were associated with the greatest difference among context changes, while maintenance tended to be relatively similar across all context changes.

• Limitations include the small sample size and potential omissions of context changes within the patient documentation.
• Future steps include developing a larger sample and looking for unknown context changes that are observable for data collection.

References


Participants Demographics:

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Table 1: Demographics of fifteen study participants.

Maintenance/Magnitude:

- Maintenance Percentage: 36.44% (mean) of Renewal for each type of Context Change.

- Magnitude Percentage: 16.21% (mean) of Renewal for each type of Context Change.

Figures

- Figure 2: Frequency of Renewal for Known Context Changes (Setting, Therapist, and Task).
- Figure 3: Percentage of each type of Context Change in Renewal Events.
- Figure 4: Maintenance (Average Duration) of Renewal for each type of Context Change.
- Figure 5: Magnitude (Average Percentage Increase) of Renewal for each type of Context Change.
Automated Modeling of 3D Solar Cell Concentrators
Electrical & Computer Engineering Department, University of Iowa
Reyna Alam, Dorothy Zhang, Maxwell Leonard, Sebastian Hazlett, Daniel Keefe, Rezwan Mohammad Sayeed, and Fatima Toor, Ph.D.

Introduction
- Solar energy is a rapidly growing energy source, particularly with green initiatives.
- We aimed to determine the ideal solar cell concentrator shape among various polygonal compound parabolic constructions.
- We developed two methods of solar tracking to further improve solar cell efficiency.

Methods
We used OpenSCAD (parameterized, script-based CAD tool) to develop the 3D concentrator models using bash script.
N-sided polygonal compound parabolic 8.0X concentration concentrators shown below, all 1 cm radius of bottom aperture and 6 cm tall.

Coating and Ray-tracing
We chemically smoothed the 3D printed concentrators using X2C 3D print coating before coating them in reflective metal coating. Chromium, aluminum, copper, and nickel were tested on sample squares for reflectivity, as shown in figure A below. Chromium proved to be the most reflective and thus we coated our final concentrators with it.

Results
Our experimental results of measuring each solar cell concentrator’s short circuit density aligned with our observed theoretical pattern with an increasing number of sides for a given concentration ratio achieving a higher value and thus better observed efficiency.

Conclusions
Through my team’s investigation of the ideal design for solar cell concentrators, we devised a way to automate the 3D modeling process of these concentrators with our OpenSCAD program. In this way, other researchers looking to easily and efficiently develop concentrator 3D models can use our program as a tool in their own research or applications.

Acknowledgments
Thank you to my lab members for making this experience possible and always entertaining, and to my mentor Dr. Toor, graduate students Dan and Rezwan, and super cool guys Nick and Caleb for their guidance. I’m also glad to have spent time with the RA’s and made so many good memories.

References

Figure 1: Metals Reflectivity
Figure 2: Radiance Ray-tracing of Each N-Sided Compound Parabolic Concentrator
Figure 3: Short-Circuit Current Density (J_{SSC})
Figure 4: Radiance Ray-Tracing Results (With 256-Sided)

Smoothing and coated circular parabolic concentrator

Dual Axis Solar Tracking Systems
- Tower
- Pro Micro Servos
- Stepper motors
- Photoresistor Method
- Sun Tracking Method

MATLAB Code
Assessing Anti-Seizure Properties of Ibuprofen and Genistein in a Drosophila Epilepsy Model

Lila Anaft*, 1, Brady Williquet, 2, Oliver Cho, 2, Gouthami Vidhya, 4, J. Robert Manak 5

1Lower Merion High School, 2Department of Biology, University of Iowa, Iowa City, IA 52242, 3The Nueva School, 4Kings High School, 5Department of Pediatrics, University of Iowa Carver College of Medicine, Iowa City, IA 52242.

Abstract

One third of epilepsy patients do not respond to currently available medications 1. To search for alternative treatments, we tested whether the anti-inflammatory drug ibuprofen & anti-oxidant drug genistein alleviate seizures in a seizure-prone line of Drosophila melanogaster. We chose these drugs based on data generated by the Manak lab demonstrating that oxidative stress activates the brain innate immune response, which in turn leads to epilepsy progression 2.

Drosophila with mutations in the prickle gene, especially in the prickle-spiny legs isoform, exhibit myoclonic (isolated muscle contraction) seizures similar to those observed in human patients carrying PRICKLE mutations 3. Flies homozygous for pk+ were treated with varying drug concentrations, then assessed for seizure penetrance. While neither drug resulted in significant seizure reduction, 4µM of genistein showed a decrease in seizures.

Background

Epilepsy

• Affects 1% of population 1
• Associated with increased oxidative stress (production of reactive oxygen species in cells) 4
• Associated with increased activation of brain innate immune response 5
• Both decreasing oxidative stress levels & inactivating the brain innate immune response suppress seizures 6 (see Figures 1-3)

Genistein

• Phytoestrogen 7
• Reduces oxidative stress by increasing expression of anti-oxidant enzymes 8

Ibuprofen

• Anti-inflammatory
• Blocks cells’ production of prostaglandins, which help to trigger the innate immune response 4

Methods

Vials were prepared with 12.5 mL of food: varying amounts of Ibuprofen (10µM, 100µM, 1mM) and Genistein (40µM, 60µM, 400µM) were added via serial dilutions.

Methods

At 7-10 days post-eclosion, a fly was placed into each well of 96-well plate and videotaped for five minutes with a Canon H-Definition Vixia HF31 Camcorder.

Figure 6. A 20-well plate in which we placed flies for seizure assays.

Conclusions

Neither Genistein nor Ibuprofen was shown to significantly reduce pk+ mediated seizure penetrance at any concentration tested. However, 4µM of genistein showed a slight decrease in seizure penetrance.

Future Directions

Redo experiment with improved seizure calling accuracy and/or more flies to increase statistical power. The Manak lab will continue assessing antioxidant & anti-inflammatory drugs for anti-seizure properties in the prickle-spiny legs model.

Acknowledgements

I would like to thank Dr. Manak, Brady Williquet, & the Secondary Student Training Program for giving me the opportunity to contribute to this project.

Funding

University of Iowa Stead Family Department of Pediatrics Research Grant to J.R.M.

Figure 7. Author standing in front of the fly incubator.

References


Figure 5. No significant difference between controls and ibuprofen-treated flies was observed at any of the indicated concentrations. Data shown is mean ± SEM. Mann-Whitney test (uncorrected); 1-3 seizure assays; 7-10 flies per sex per assay; ns = not significant.

Figure 4. No significant difference between controls & genistein-treated plants+/- flies was observed at any of the indicated concentrations. Data shown is mean ± SEM. Mann-Whitney test (uncorrected); 1-3 seizure assays; 7-10 flies per sex per assay; ns = not significant.

Scan QR code for in-progress site on pk+mediated seizure identification.
Bioengineered Tissue Patches for Dynamic Organ Mimicry using Silk Fibroin

Donovan J Burke¹, Hannah J Vogts², Reza Amouzande³, Milad Arzani³, Mohan Yu³, Xuan Mu, Ph.D.²
¹College Park High School; ²Roy J. Carver Department of Biomedical Engineering, ³Department of Mechanical Engineering, The University of Iowa

Problem
Current Therapeutic Patches Are Not Biocompatible
- Contemporary therapeutic patches fail to compensate for the anisotropic deformation of organs that are intrinsically anisotropic or auxetic (negative Poisson’s ratio) (Chansoria et al., 2022).
- In addition, patches made from synthetic polymers often lack biocompatibility, which may cause a negative immune response in the body (Fernandez-Vique et al., 2022).

Research Goal
Engineering Goal
- Develop a therapeutic patch that accounts for the anisotropic deformation of organs, such as the heart, through the use of monolithic proteinaceous non-synthetic materials.

Materials
- InkRedible3D Printer
- Silk Cocoons
- Ultra Pure Water
- PDMS
- Lithium Bromide
- Dialysis Tubing
- Enrichment Cassette
- Salt bath

Approach
Accounting For anisotropic deformation
- Auxetic patch design, such as the one seen to the right, has demonstrated the ability to account for the anisotropic deformation of organs.

Biocompatible Materials
- To account for the lack of biocompatible hydrogels, silk fibroin was developed inside the Mu Lab. This silk fibroin is capable of being 3D-printed to create the therapeutic patches in this project (Mu et al., 2022).

Methodology
Silk Cocoons Harvesting
Silk Boiling/ Rinsing
Silk Dialysis/Centrifugation
Silk Enrichment
Silk 3D Printing
Dissolving Using LiBr

Results
Arrowhead
Poisson’s Ration: 0.024
Chiral Truss
Poisson’s Ration: 0.22
Lozenge Truss
Poisson’s Ration: 0.48
Re-entrant Honeycomb
Poisson’s Ration: 0.98

Discussion
Auxetic Design Implications
- The results indicate that the project goal has not been reached, and the patches are not yet ready to be produced. The stretching of the designs often leads to tearing, indicating that more layers are needed so that the patch can reach its fully stretched auxetic state.

Future Auxetic Designs
- Future patch designs will incorporate two significant changes:
  - First, the layer count of the patches will increase to prevent tearing when under significant strain of 20% or more.
  - Second, the size of each unit in the design will increase, which will decrease the overall number of units per patch. This will allow the strain and auxetic performance to be equally distributed across the structure.

Conclusion
Application of Tissue Patches
- Rapid Recovery of Organ-Based Surgeries
  - Using a biocompatible nonsynthetic material, cells are able to regenerate and grow on the patches. This will allow for a speedy recovery from injury or surgery.
- More Effective Small-Scale Bandage
  - Healslent regeneration
  - The auxetic design can account for the stretching of smaller appendages such as the fingers and feet.

Summary
- Contemporary therapeutic patches are unable to account for the anisotropic deformation of organs and may cause negative immune responses due to the nonsynthetic materials used.
- Testing indicates that the therapeutic patches created from silk fibroin, while functional, would likely become stronger with fewer units and more layers.

Acknowledgement
Thank you to the Buxi-Blank Center at the University of Iowa for granting me this opportunity, and a special thanks to the Mu Lab, especially Hannah J Vogts and Dr. Mu, for their mentorship throughout this project and my time in the lab.

References
Degradable and Electrically Conductive Polymers (DECPs)

- Biomedical applications: drug or gene delivery, tissue engineering, and medicine
- Ideally nontoxic, stable, and cleavable
- Have controlled degradation in the body

Fig. 1. DECP biosensors formed on flexible substrates (Paudel et al., 2023)

Polymers based on Polythiazyl (SN)

- Conjugated backbones with S-N bond
- Stable and easy to alter properties
- Carbarnates, ureas, and diamines have yet to be studied as monomers

Fig. 2. Polythiazyl Structure (Paudel et al., 2023)

Dibutyldithiophosphate • • •

Bibutyl carbamate reacting to form dibutyldithiophosphate

Hydrogen Sulfide in Agriculture

Fig. 5. H₂S releasing dibutylphosphite fertilizer was found to significantly increase harvest yield using a Tukey-Kramer test (Brown et al., 2021)

Research Question
How can a series of polymers with conjugated –NS- and –NSS-backbones be synthesized, isolated and characterized?

Methodology

Synthesis and Isolation of Polymers

- N₂ Purge
- Cool to -61°C
- Add Dropwise
- Warm

Vacuum Filtration
Extraction
Rotary Evaporator
High Vacuum

Spectroscopy & Chromatography Techniques

- ¹H NMR
- UV-Vis
- SEC-MALS

Polymers from Poly(N,N-phenylamino)disulfides
Poly(N,N-amino)sulfide

Hydrogen Sulfide in Agriculture

Fig. 3. Synthesis of Poly-NADs (Paudel et al., 2023)

Fig. 4. Synthesis of Poly-NAS (Paudel et al., 2023)

General Monosulfide Polymerization Scheme

- Amine + S₂Cl₂
- Color
- Solubility
- Brine
- 0.92:1
- Dark red
- Soluble
- 0.95:1
- Orange
- Insoluble
- Insoluble
- 0.97:1
- Yellow
- Soluble
- Soluble

Table 1. Optimization of molar ratios for greatest isolated yield of SN backbone polymers synthesized from butyl carbamate.

Effects of Molar Ratios on Polymerization

- Amine + S₂Cl₂
- Color
- Solubility
- Brine
- 0.92:1
- Dark red
- Soluble
- 0.95:1
- Orange
- Insoluble
- Insoluble
- 0.97:1
- Yellow
- Soluble
- Soluble

Fig. 7. Polymerization of derivatives of (a) carbamates and (b) ureas. DMP was reacted with S₂Cl₂ to produce a monosulfide transfer reagent.

NSS Polymerization

Fig. 8. Derivatives of (a) carbamates and (b) ureas were reacted with SCl₂ to produce a monosulfide transfer reagent.

Table 1. Optimization of molar ratios for greatest isolated yield of SN backbone polymers synthesized from butyl carbamate.

Monomers Used:

- Monomers Used: (a) carbamates, (b) ureas

Ureas vs. Carbamates

Fig. 9. SN polymers in solution with different functional groups. Monomers used (left-right): urea, 1,1-dimethylurea, butyl carbamate, tert-buty carbamate, phenyl carbamate

Fig. 10. (a-c) 0.92, 0.95, and 0.97 equivalence amine + S₂Cl₂ respectively.

NSS Polymerization

Fig. 13. Polymerized from (a) 4,4'-oxydianiline (b) 1,5-Diaminonaphthalene (c) 2,3,5,6-Tetramethyl-1,4-phenylenediamine (d) 4,4'-sulfonidodiamine

Fig. 12. Schematic of polymerization of diamine derivatives to yield NSS backbone polymers

Quick 2-D Printing

Fig. 11. The ¹H NMR spectra of the butyl carbamate monomer and its corresponding –NS- Polymer were obtained (400 MHz, CDCl₃). A broadening of peaks suggests the successful synthesis of the polymer.

These brightly colored –NS- and –NSS- backbone polymers are stable in organic solvents and ideal for applications including drug/gene delivery, sensors, medicine and fertilizer. In addition, they can be easily printed for biocompatible devices and act as colorimetric sensors.

Conclusion

- Polymers with conjugated –NS- and –NSS- backbones were produced, and their synthesis was confirmed using ¹H NMR.
- The colors of these polymers arise from their conjugated backbone that has an energy band gap in the visible light range.
- Different equivalences of amines affected polymer characteristics and yield.
- –NS- polymers were successfully used for quick 2-D printing.

Future Works

- Test electrical conductivity enhancing dopants (e.g., Br) on the polymer
- Synthesize polymeric polythiazoyl derivatives using hydrazine

Acknowledgements

Thank you Prof. Bowden and Shanari Wickremasinghage for mentoring and supporting me during this great experience. I would also like to thank the Bowden Group.

References

The Ajamization of Islamic Manuscripts in Arabic: An examination of Islamic faith and Arabic script in West African Manuscripts from the 17th to 20th Century

I recorded a total of eleven manuscripts. For each manuscript recorded, I also included a paragraph description, and information such as languages, scripts, forms, script format, material, find date, place of composition, current location, content, religion, coordinate location, and additional information on the appearance of each manuscript such as height and dimension, whether the manuscript is a colophon or palimpsest, and more.

- Multiliteracy of West African Scholars
- Help add to Professor Dilley’s Manuscript Database website

Introduction of Islamic Faith to West Africa

Islam first arrived in the North African Sahel region through Arab traders and later spread to Ancient Ghana and the zone of Kanem in West Africa. Wherever Islam spread, Arabic, considered the language of the gods in Islam, would follow. Therefore, Arabic was used by African scholars and became an important part of education in Africa.

What are Ajami Scripts?

- African Languages written in Arabic Script.
- Like how European languages adopted Latin Script and Japanese adopted the Chinese Script.
- Many manuscripts are in Arabic but have glosses in Ajami languages.

Results

I recorded a total of eleven manuscripts. For each manuscripts recorded, I also included a paragraph description, and information such as languages, scripts, forms, script format, material, find date, place of composition, current location, content, religion, coordinate location, and additional information on the appearance of each manuscript such as height and dimension, whether the manuscript is a colophon or palimpsest, and more.

- Multiliteracy of West African Scholars
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Methods

British Library Endangered Archives

Hill museum & manuscripts library

Significance

- African manuscripts have been under-represented in historical research and have often been dismissed or destroyed
- Gaining comprehensive understanding of world culture requires the study of all cultures
- Contributes to the Global Writing Culture website that will be used as an educational tool

Collection of Multilingual Ephemeral Texts III with glosses in Mandinka

Global Writing Culture Website

Fula Ajami Poetry

What are Ajami Scripts?

- African Languages written in Arabic Script.
- Like how European languages adopted Latin Script and Japanese adopted the Chinese Script.
- Many manuscripts are in Arabic but have glosses in Ajami languages.
GPR for Ionized Particle Energy Prediction
Reducing Computational Cost of WDM Simulations using Machine Learning
Kat Carver, Gabriel Smith, William Van Benschoten, James Shepherd

Introduction
Warm dense matter (WDM) is a classification of states of matter within the temperature range of a plasma (0.1 – 100 eV) and the density of a solid. It can be defined as having its coupling (Γ) and degeneracy (δ) parameters near 1, as defined by the equation
\[ \Gamma = 2\sqrt{\beta} / \delta a \Delta T \]
WDM can be modeled; however, its computational cost is substantial, necessitating the exploration of cost reduction strategies. In this case, Gaussian Process Regression. Gaussian Process Regression (GPR) is a versatile statistical technique used to model complex systems and predict outcomes with uncertainty estimation. It employs Gaussian processes to infer relationships from data, making it adaptable to diverse applications in science and engineering.

Research Question
How can the composition of a Gaussian Process Regression (GPR) model's covariance function be approached to enhance the prediction accuracy of the electronic energy in an ionized particle?

Methods
• Implementation of Gaussian Process Regression (GPR) in Python using the NumPy library for computational efficiency
• Empirical validation of GPR predictions using data obtained from Hydrogen 4 simulation for performance assessment
• Exploration of the influence of standard covariance functions on the predictive capabilities of GPR
• Development and integration of a new kernel using the generalized Matérn covariance function where ν ∈ R+.
• Based on prior observations, the empirical evidence suggested that the function would be well-suited for testing on larger carbon systems.

Python Libraries:
• Data processing: Numbers Python (NumPy), Pandas
• Plotting: matplotlib, matplotlib.pyplot

1. Matérn Covariance; Increasing the value of ν
• As ν (varying from ν = 0.5 to ν = 2.5 and ν → ∞) increases, a noticeable trend is observed with the prediction graph exhibiting gradual smoothing.
• Matérn 0.5 displayed considerable dispersion in error bars, whereas an increase in ν resulted in error reduction, especially noticeable in the case of the squared exponential.
• Matérn 2.5 exhibited acceptable fitting performance across the entire range, upon which Matérn 2.5 showed marginal improvement.

2. Matérn 2.5 on Equilibrium H4
• Matérn 2.5 with α = 10 and p = 10 is the result of testing using different hyperparameter values and the approximate optimal values of hyperparameter(s) for the function.
• Data observed after testing both Matérn 0.5 and Matérn 2.5 provided evidence supporting the hypothesis of graphs exhibiting less erratic patterns and error bars showing reduced dispersion with increasing ν.
• Based on prior observations, the empirical evidence suggested that the function would be well-suited for testing on larger carbon systems.

3. Proof of Concept: C/C+ testing
• While predictions remain marginally inaccurate at extreme values of beta, the function exhibits notably high accuracy for intermediate values.
• The error bars in the intermediate range are of negligible magnitude, allowing for clear differentiation between the graphs of the two systems.
• H4 predictions demonstrated high accuracy across the entire range, however, C and C+ predictions notably exhibited suboptimal accuracy for extreme values of β.

Summary of Findings
• The Matérn kernel family (Squared Exponential and Matérn 0.5) demonstrated unparalleled accuracy.
• The covariance matrices generated using the Matérn 2.5 function, as modeled by the generalized, equation yielded the best results overall.
• Only a few kernels produced unfavorable results; most performed reasonably well and were able to be further tuned through adjusting the hyperparameters.
• Some covariance functions excelled at predicting extreme β values, while others performed better at intermediate β values. We found that through multiplying kernels, the resulting graphs inherit properties of the graphs produced originally.

Future work
To enhance the predictive capacity and applicability of Gaussian process regression in ionized particle energy prediction, further research should aim to:
• Further investigate the multiplication or otherwise combination of individual covariance functions to leverage their distinct strengths at different β regimes.
• Conduct a systematic exploration of further increasing the value of ν and adjusting hyperparameters α and p to produce the optimal Matérn kernel configuration.

Acknowledgments
I extend my sincere appreciation to Gabe Smith and Professor Shepherd for their invaluable mentorship and constructive guidance throughout my project. Furthermore, I am grateful to the Belin-Blank Center and the SSTP for providing this exceptional research opportunity.

References
Assessing Anti-Seizure Properties of Antioxidants Gallic Acid and Allyl Disulfide in a Drosophila Epilepsy Model

Oliver Cho¹; Brady Williquett²; J. Robert Manak, Ph.D.²,³
¹The Nueva School, ²Department of Biology, ³Department of Pediatrics, University of Iowa

RESEARCH OBJECTIVE

To assess the effectiveness of two antioxidants, gallic acid and allyl disulfide, in suppressing myoclonic seizures in pk¹⁰⁴⁶ mutant flies.

INTRODUCTION

Epilepsy is a neurological disease characterized by recurrent seizures and affects over 50 million people worldwide. Despite a wide variety of anti-epilepsy drugs (AEDs) on the market, approximately one-third of epilepsy patients do not respond to available therapies and two-thirds report adverse side effects.

The pk¹⁰⁴⁶ gene found in Drosophila melanogaster expresses two adult isoforms: prickle-prickle and prickle-spiral-legs. Mutations in the prickle-spiral-legs (pk¹⁰⁴⁶) isoform lead to myoclonic seizures and locomotor defects in flies akin to those observed in human PRICKLE patients.

Research in the Manak Laboratory has revealed a significant increase in oxidative stress in pk¹⁰⁴⁶ mutant neurons, which activates the innate immune response (IR) in glial cells. This heightened IR activity promotes neuronal cell death, fostering a positive feedback loop that further amplifies glial IR activation and culminates in the exacerbation of the seizure phenotype and epileptogenesis. Given the connections between oxidative stress and epilepsy progression, we decided to test whether two antioxidants, gallic acid and allyl disulfide, had anti-seizure properties in our fly epilepsy model.

In this research, we discovered that the two antioxidants, gallic acid and allyl disulfide, do not have anti-seizure effects in pk¹⁰⁴⁶ mutants. These data serve to augment existing antioxidant drug screening research in Drosophila and assist in the discovery of novel therapeutics for managing epilepsy, particularly in cases unresponsive or adverse to conventional AEDs.

METHODS

Drosophila Stocks:
• The pk¹⁰⁴⁶ mutation was outcrossed into a w¹¹¹⁸ background. pk¹⁰⁴⁶/pk¹⁰⁴⁶ (w¹¹¹⁸) flies were used in all experiments.

Gallic Acid and Allyl Disulfide Feeding:
• Drug food was made by combining standard commercial mohuses Drosophila medium with gallic acid (10μM, 100μM, and 1mM) and allyl disulfide (20μM, 200μM, and 2mM).

Spontaneous Seizure Assay:
• pk¹⁰⁴⁶/pk¹⁰⁴⁶ flies were either treated or left untreated with drug throughout early development and then up to 7-10 days post-adlosion at 25°C.
• 10 male and 10 female flies were mouth-pipetted into a 20-well plate and recorded for 5 minutes.
• Seizures were assessed by eye with a single-blind setup.

RESULTS

Figure 6: Gallic acid-enriched diet does not decrease spontaneous seizure activity in pk¹⁰⁴⁶ mutants.
Quantification of seizure events in aps-ea4j/eata mutants on 10μM, 100μM, and 1mM gallic acid. ns = not significant. Mann-Whitney Test. Error bars: SEM. n = 2-4 biological replicates, 7-10 flies per sex in each seizure assay.

Figure 7: Allyl disulfide-enriched diet does not decrease spontaneous seizure activity in pk¹⁰⁴⁶ mutants.
Quantification of seizure events in aps-ea4j/eata mutants on 20μM, 200μM, and 2mM allyl disulfide. ns = not significant. Mann-Whitney Test. Error bars: SEM. n = 2-4 biological replicates, 7-10 flies per sex in each seizure assay.

CONCLUSIONS

• Neither gallic acid nor allyl disulfide were effective in significantly suppressing pk¹⁰⁴⁶-mediated seizures at the concentrations tested.
• While not statistically significant, 10μM GA in males showed a decrease in seizure penetrance.
• In females, all GA concentrations showed a decrease in seizure penetrance.
• For allyl disulfide, 200μM showed a decrease in seizure penetrance in females only.

FUTURE DIRECTIONS

• Redo experiment with more flies to increase statistical power.
• Improve accuracy in calling spontaneous seizures.
• Try a combination of gallic acid and allyl disulfide.
• Increase drug concentrations to determine whether higher doses might be more effective in suppressing seizures.

REFERENCES


ACKNOWLEDGEMENTS

I would like to thank Brady Williquett and Dr. John Manak for their continued support, guidance, and mentorship over the course of this research project. A special thanks to The University of Iowa and Belin-Blank Honors Center for this opportunity. This research was funded by the University of Iowa Waid Family Department of Pediatrics Research Grant to J.R.M.
Background

- One of the major issues facing the world today is the greenhouse effect from non-renewable energy sources.
- Hydrogen is one of the most abundant and efficient renewable energy sources and thus presents an enticing commercial opportunity.
- Cadmium-based semiconductors such as CdSe and CdTe are commercially viable in the United States and can be used in photovoltaic cells with the intention of producing hydrogen from water (Nafaji et al., 2019).
- Currently, most commercial cadmium-based semiconductors use a closed space sublimation technique to produce a thin layer of semiconductive material on a conductive substrate (Singh et al., 2019).
- While thin films are currently cheaper to produce, they have many drawbacks when compared to a nanowire structure which can be achieved by depositing the semiconductive material on anodized aluminum (AAO).
- AAO is produced through an electrochemical system in which a working electrode of pure aluminum (anode) and a counter electrode (cathode) are submerged in an electrolyte bath and subjected to a constant voltage until the target current density is reached (Fig. 1).
- Anodizing the aluminum creates a surface network of nanopores into which CdSe or CdTe are deposited upon to create standing nanowires, which are incredibly durable in addition to being efficient due to their high surface area; essentially the AAO acts as a mold for the semiconductive material (Kapoor et al., 2019).
- This project focused on optimizing the anodization process, specifically by testing the effect of using an aluminum counter electrode as opposed to a graphite counter electrode.

Results

- These results show a sample undergoing the typical anodization process. The initially reflective aluminum develops billions of nanopores, which results in a clear substrate. Semiconductive material is then deposited onto the sample which results in a darker color.
- The PEC results (Fig. 4) indicate that the samples anodized with graphite and aluminum counter electrodes did not yield significant differences in performance. This was concurrent with the hypothesis.

Discussion

- As there is no significant difference in performance, the next step in this research is to view the nanopores themselves using a high-resolution scanning electron microscope (SEM). If the nanopores show no difference in structure, the next step would be to test an aluminum oxalate buffer. The aluminum oxalate would act as a Bronsted-Lowry strong conjugate base and the solution would be highly resistant to pH changes. With both an aluminum working and counter-electrode the oxalic acid solution could maintain a high purity for many anodization runs, which would cut costs in a commercial setting.

Next Steps

- Thanks to SunHydrogen, The University of Iowa, Belin Blank Center, the Mubeen Research Group, and Dr. Mubeen for making this research possible!

Acknowledgements

Modifying piggyBac transposon vectors for high efficacy Factor VIII gene transfer to mediate Hemophilia A phenotypic correction

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Introduction

Hemophilia A
- X-linked genetic disorder affecting ~1:5000 males.
- Characterized by deficient Factor VIII (FVIII) protein levels.
- Blood coagulation cascade.
  - FVIII is a cofactor in the pathway, initiating the conversion of thrombin for the development of the platelet-fibrin plug in response to injury.
- If Hemophilia A is left untreated, resulting hemorrhagic and excessive bleeding events may lead to death.
- Current treatments have limitations:
  - Intravenous FVIII protein replacement therapy: Limitations: frequent injections, costly, inhibitor formation.
  - FVIII gene transfer via viral vectors:

Objectives

- From the previously developed piggyBac transposon vector carrying a codon-optimized B-domain deleted human FVIII gene from more than a decade ago (PB-coFVIII-BDD), we re-codon-optimized the FVIII gene (2023PB-coFVIII-BDD).
- We corrected a sequence with the Mulu restriction enzyme site (PB-coFVIII-BDD-MluI) and engineered the piggyBac vector to carry the full-length FVIII insert (PB-FLFVIII) as vehicles for FVIII gene transfer.
- We compare FVIII activity levels between PB-coFVIII-BDD and the modified vectors in Hemophilia A mice.

Hypotheses

- PB-FLFVIII: Although not required for FVIII coagulation functions, the FVIII B-domain plays crucial roles in decreasing ER stress, facilitating intracellular trafficking, and protecting against proteolysis. The inclusion of the B-domain may lead to higher FVIII gene transfer and increased activity.
- PB-coFVIII-BDD-MluI fix: PB-coFVIII-BDD has an introduced point mutation encoding for an Mulu site, which could affect intracellular cleavage and FVIII activation. We hypothesize that the reversion of the mutated sequence back to native sequence may lead to higher FVIII activity.
- 2023PB-coFVIII-BDD: Re-codon-optimization accommodates for up-to-date codon bias to further increase translational efficiency of the FVII gene; thus, we expect higher FVIII activity in comparison to the older PB-coFVIII-BDD vector.

Methods

Re-codon-Optimized Plasmid Construct

Site Directed Mutagenesis

Restriction Enzyme Ligation

Vector Construct

Viral Delivery

Class II Transposon Delivery

Genic Transfer Vectors

Benefits of transposition delivery over viral delivery for FVIII gene transfer.

Results: Vector Construction

✓ Vector plasmid sequences confirmed via NGS following vector construction.
✓ Successful site-directed mutagenesis to create PB-coFVIII-BDD-MluI fix.
✗ Unsuccessful creation of the PB-FLFVIII vector.

Results: FVIII Activity

- Delivery of PB-coFVIII-BDD + IP7 seems to increase FVIII activity levels in Hemophilia A mice back to normal, comparable to levels in wild-type mice.
- The old PB-coFVIII-BDD vector achieved greater FVIII activity than the newly modified vectors, suggesting that it confers the greatest FVIII gene transfer efficacy out of all tested vectors.

Conclusions

- Delivery of PB-coFVIII-BDD + IP7 may be a promising treatment avenue for Hemophilia A.
- Future Studies:
  - Conduct chromogenic FVIII activity assays over longer periods of time to evaluate the extent of FVIII expression in the long term.
  - Further study to improve the current vector delivery, which is hydrodynamic tail vein injection, to be more feasible for clinical use.

Acknowledgements

Thank you to the Staber Lab for your generous mentorship, and the SSTP summer program for facilitating the research experience.

All images were created by the student using BioRender.com or Canva. All graphs were created by the student using GraphPad Prism.

References

Electrochemical electrodeposition

Electrochemical Nitridation:

Etching:

Sonicating:

• In acidic media, two half reactions occur:
  - Hydrogen evolution reaction (HER): \(2H^+ + 2e^- \rightarrow H_2\)
  - Oxygen evolution reaction (OER): \(2H_2O \rightarrow O_2 + 4H^+ + 4e^-\)
  - Sluggish kinetics and the instability of available catalysts.
  - Highly oxidative environment for supports (i.e., Ti, C, ATO).

• Increases resistance.
• Lowers activity and stability.
• Substrate can be coated with Au, Pt, or Ir to improve electrocatalytic performance.
• Cost and availability of material is a concern.
• Electrochemical nitridation to coat Ti with TiN.
  - Good adhesion properties.
  - Lowers resistance.
  - Prevents TiO₂ formation.

Introduction

Water electrolysis (\(2H_2O \rightarrow 2H_2 + O_2\)) is highly regarded for its ability to transform renewable energy into green hydrogen fuel.

Water electrolysis (2H₂O → 2H₂ + O₂) is highly regarded for its ability to transform renewable energy into green hydrogen fuel. In acidic media, two half-cell reactions occur:

- Hydrogen evolution reaction (HER): \(2H^+ + 2e^- \rightarrow H_2\)
- Oxygen evolution reaction (OER): \(2H_2O \rightarrow O_2 + 4H^+ + 4e^-\)

Highly oxidative environment for supports (i.e., Ti, C, ATO).

This study aims to investigate the effect of electrochemical nitridation on the overall electrocatalytic performance of iridium-based water oxidation catalysts.

Purpose

Method

Sonicating:
1. Ti-felt was sonicated in C₂H₄O₂, CH₃OH, C₅H₇O₂ for 20 minutes to remove organic impurities.
2. Ti-felt was sonicated in ultra-pure water for 20 minutes to remove inorganic impurities.

Etching:
1. Ti-felt was etched in concentrated HNO₃ for 45 minutes.

Electrochemical Nitridation:
1. Etched Ti-felt was electrochemically nitridated in 0.1M HNO₃ + 0.5M KNO₃ for two hours.

Electrodeposition
1. Electrochemically deposited Ir onto the TiN

Electrochemical Testing Techniques
- PEIS, LSV, CV

Fig 1. TiN samples were made and analyzed using a three-electrode system with a Pt wire counter electrode and a Hg/HgCl reference electrode.

Results

Fig 2. Sample A is a bare Ti-felt. Sample B was etched for 45 min. in HNO₃ and nitridated for two hours. Sample C had the same conditions as Sample B, but it was deposited on it and tested using LSV and CV (25 cycles) at a scan rate of 20 mV/s.

Fig 3. EDX elemental analysis of sample B (Fig 2) at x100K magnification.

Fig 4. XPS of TiN formation at various nitridation periods (0.5, 2, 4, 10 h).

Fig 5. Polarization curves of IrOₓ/TiN samples etched in HNO₃ at different times (30, 45, 60, 90 min).

Fig 6. OER activity comparison of a IrOₓ/TiN catalyst and a commercially available IrO₂ catalyst.

Conclusions

• Samples etched for 45 and 90 minutes in concentrated HNO₃ performed similarly (Fig 5).
  - Higher activity and lower resistance.
  - Does not create enough roughness for effective Ir deposition.
• XPS of nitridated samples confirmed that two hours of nitridation formed the highest amount of TiN (Fig 4).
  - TiN converts to NH₄NO₃ as nitridation time increases.
  - EDX confirmed the formation of TiN via electrochemical nitridation (Fig 3).
• After 25 cycles of OER activity testing at a scan rate of 20 mV/s, indium begins to crack and fall off (Fig 2).
  - Indicates significant activity, but lack of stability.
  - The similar surface structure of sample A and B lacks nanoscopic roughness.
  - IrOₓ/TiN was found to be better in terms of electrochemical activity than commercially available IrO₂ catalysts (Fig 6).

Future Directions/Implications

• Etching Ti-felt in diluted HF or HCl may improve the electrochemical adhesion of the catalyst by creating more roughness.
• HNO₃ does not provide enough surface area for Ir deposition.
• Etching time in diluted HF and HCl must be explored.
• TiN is a robust material
  - Can be used to form dimensionally stable OER electrocatalysts under extreme oxidative conditions.

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References

The Role of B-Cells in Granuloma Formation \textit{in vitro}

Department of Internal Medicine, Roy J. and Lucille A. Carver College of Medicine, The University of Iowa

\textbf{Introduction:} Sarcoidosis is a granulomatous disease
- Highly challenging to diagnose and treat
- Due to inhalation exposure in a susceptible host
- Characterized by noncaseating granuloma formation
- Granulomas can be modeled with immune cells in blood from patients with latent tuberculosis infections (LTBI) and sarcoidosis
- Cell types and mechanisms involved in the formation of these granulomas is poorly understood

\textbf{Hypothesis:}
B-cell (CD19\textsuperscript{+}, CD20\textsuperscript{+}) depletion will cause a significant decrease in the granuloma formation observed in patients with LTBI

\textbf{Experimental Approach:}

\begin{itemize}
  \item Subjects
    \begin{itemize}
      \item PPD\textsuperscript{-}\textit{H}\textsubscript{L}\textsuperscript{-}n = 3
      \item PPD\textsuperscript{-}\textit{L}\textsubscript{L}\textsuperscript{-}n = 3
    \end{itemize}
  \item Human Whole Blood
  \item Centrifuged Blood Sample
  \item Peripheral Blood Mononuclear Cells (PBMCs)
  \item PPD (Un)coated Beads
  \item Flow Cytometry
  \item B - cell depletion using columns
  \item Incubate PBMCs with Beads
  \item Analyze/Score Results
\end{itemize}

\textbf{PBMCs from LTBI patients form granulomas \textit{in vitro}}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{In vitro granulomas after 7-day incubation with PPD-coated beads, healthy control vs. LTBI sample. LTBI sample has granuloma formation and significantly more cellular aggregation than healthy control sample. n = 1}
\end{figure}

\textbf{Freezing/Thawing does not affect granuloma formation in LTBI patients}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{Bar Graphs show the difference in Granuloma Score between No depletion, CD19\textsuperscript{−}, and CD20\textsuperscript{−} (D) and difference in number of granulomas present (E).}
\end{figure}

\textbf{B-cells are not essential for granuloma formation}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{No Depletion sample has a few large and robust granulomas (A). CD19\textsuperscript{−} sample has many more cellular aggregates that are generally smaller in size (B). CD20\textsuperscript{−} sample has similar frequency and size of cellular aggregates to CD20\textsuperscript{−} depletion (C).}
\end{figure}

\textbf{Summary/Conclusion}
- PBMCs from LTBI patients form robust granulomas when incubated with PPD coated beads
- Freezing and thawing process does not affect granuloma formation in model
- CD19 and CD20 B cells do not appear to be essential in LTBI granuloma formation \textit{in vitro}
- PBMCs from LTBI patients, in the absence of CD19 and CD20 B cells, form smaller and more numerous granulomas when exposed to PPD coated beads
- The addition of granuloma frequency to granuloma size scoring may provide further insight into the role B cells are playing in granuloma formation

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- Cystic Fibrosis Foundation K-box and Iowa ROP

\textbf{We thank our research subjects for participating and the Carver College of Medicine Cells and Tissue Core for excellent support.}
PARAMETRICALLY-GENERATED SOLAR CONCENTRATORS: METHODOLOGY, SIMULATION, AND TESTING

Contributors: Sebastian Hazlett, Reyna Alam, Dorothy Zhang, Leonard Maxwell. Research Mentors: Associate Professor Dr. Fatima Toor, Daniel Keefe, Rezwan Mohammed Sayeed.

Introduction:
Solar Concentrators found to increase solar cell efficiency by:
1. Reducing reflections in solar cell surface, busbars, and metal fingers.
2. Increasing distance traveled/absorbance for longer wavelengths without increasing solar cell thickness.
3. Suppressing radiative recombination (Hu et al., 2023).

The purpose of this study was:
- 1. To integrate the most up-to-date research on solar concentrator geometry, design, 3D printing, and reflective coating to construct an efficient small solar concentrator system within 5 weeks.
- 2. To refine previous scientific methodologies in doing so.

Methods:
OpenSCAD Scripting Details:
OpenSCAD is a programmatic CAD toolkit by which script code generates 3D models. Used math of Cooper et al. to generate polygonal parabolic compound concentrator (PPCC) 3D models via OpenSCAD scripting (Cooper et al., 2013). OpenSCAD scripts for each of the individual concentrator variations (see Fig. 1) automatically generated from template file via a shell script.

Optical Simulations of Concentrators Via Radiance:
We used an open-source command-line ray-tracing software called Radiance to simulate top-down (0° acceptance angle) sunlight hitting our concentrators (loaded into the program via STL models exported from OpenSCAD).

The ray-tracing scenarios thus described followed instructions in shell files executed by Radiance, with lux results in W/m² exported to High-Dynamic-Range (HDR) image files.

3D Prints & Reflectivity Testing:
3D-printed 12 concentrators listed in Fig. 2, chemically smoothed them w/XTC-3D coating. Metals sprayed on 3D-printed, smoothed flat pallets. Controls set as default smoothed pallets. Chromium most reflective, 70-77%. Sprayed our twelve concentrators in Chromium.

Solar simulator:
Tested concentrators under PV Measurements small-area solar simulator using Suntestytech 3.19" x 2.91" x 0.51" solar mini-module using setup below. Control solar cell current density (no concentrator, just 10-mm radius aperture) was 0.0345 mA/cm².

Results:

Analysis:
Cooper et al. vindicated by n→infinity superior light concentration performance for PPCCs. 5X and 10X Pentagonal PPCCs more effective than 5X and 10X square PPCCs, vindicating Radiance tests but contradicting Cooper et al.’s findings:
- Radiance tests have 2X pentagonal as lower-performing relative to 2X square PPCCs. Solar simulator results have opposite.
- Radiance also estimates circle performance incorrectly as lower than 8-sided PPCCs for 2X and 5X. However, Radiance correctly estimates superior 10X circular performance versus 8-sided PPCCs.

Finally, Radiance estimates a ring-shaped area of greatest luminosity within the concentrator apertures, whereas the solar simulator clearly shows a circle-area of greatest luminosity. Most likely surface imperfections not modeled in Radiance caused the light reflections to "diffuse" into this circle.

Conclusion:
Our tests confirmed the repeatability of much of Cooper et al.’s work. However, divergences between different modes of testing (digital and physical) and from literature suggest the desirability of a greater standardization and refinement of methodology than even the significant progress we have made in the pursuit of such.

Acknowledgements:
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References:
Unlocking the Cellular Gateway: Unraveling Superior Transfection Techniques

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Introduction

Multiple Myeloma (MM) is a type of B lymphocyte cancer. A common mutation (t(4;14)) occurs in around 25% of MM patients. NSD2 gene is highly expressed due to this mutation. Previous studies show that different sequences of NSD2 translocated can impact the mortality rate of MM patients. However, most of them were done by knocking out the gene instead of knocking in. Our project aims to study whether different sequences of NSD2 translocated impact the protein stability and patient mortality through gene insertion. Retrovirus is a type of virus that can integrate the DNA of its RNA into host cell genome and produce its own copy shown in figure 1. Retrovirus’s ability to modify gene permanen4 and efficiently makes it a common gene editing tool. Thus, we used Murine Stem Cell Virus (MSCV), a type of retrovirus, to insert different variants of NSD2 gene into B cells. For the establishment of methodology, we compared three transfection methods, lipofectamine, calcium phosphate, and PEI, shown in table 1, to find the most efficient method to produce MSCV.

Hypothesis

Lipofectamine will have the higher transfection efficiency for the transfection of MSCV IRES GFP NSD2 Full Length plasmid (10,824 bp) into HEK293T cells compared to Calcium Phosphate and PEI.

Methods

Table 1: Overview of transfection methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Virus</th>
<th>Bioactive</th>
<th>Microinjection</th>
<th>Lipofectamine (lipoinjection)</th>
<th>Calcium Phosphate</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Type</td>
<td>In vitro and vivo cells</td>
<td>In vitro and vivo cells</td>
<td>In vitro cells</td>
<td>In vitro and vivo cells</td>
<td>In vitro cells</td>
<td>Note: This table, conducted as a result of literature review, shows the common transfection methods.</td>
</tr>
<tr>
<td>Benefits</td>
<td>Stable transfection</td>
<td>Time efficient</td>
<td>High efficiency</td>
<td>High efficiency</td>
<td>High efficiency</td>
<td>Cost effective</td>
</tr>
<tr>
<td>Limitation</td>
<td>Possible Genotoxicity</td>
<td>High cost</td>
<td>Possible cell damage</td>
<td>Maximum of 100-200 cells</td>
<td>Limited cell types</td>
<td>Toxicity influenced by pH</td>
</tr>
</tbody>
</table>

Table 2: Comparison of transfection efficiency

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Time</th>
<th>GFP+ Cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipofectamine</td>
<td>6 hours</td>
<td>50%</td>
</tr>
<tr>
<td>Calcium Phosphate</td>
<td>24 hours</td>
<td>30%</td>
</tr>
<tr>
<td>PEI</td>
<td>48 hours</td>
<td>20%</td>
</tr>
</tbody>
</table>

Results

Figure 3: Cell viability and GFP+ percentage of HEK293T cells. (A) The cell viability is measured by light microscopy and trypan blue; the result is analyzed by one-way ANOVA followed by Bonferroni’s multiple comparisons test. (B) The GFP positive cells after 48 hours is measured by flow cytometry and analyzed by one-way ANOVA and Bonferroni’s multiple comparisons test.

Figure 4: NSD2 protein expression in Lipofectamine, C-Calcium phosphate, P-PEI. Protein was extracted from the 293T cells after 48 hours. The 20 µg of protein was run on western blot per each sample to quantify its expression. The expression level of NSD2 gene in 293T cells transplanted with different methods was analyzed by one-way ANOVA followed with Bonferroni’s multiple comparisons test.

Figure 5: GFP expression under fluorescent microscopy. The 3T3 cells were transduced by MSCV produced with Lipofectamine 3000 (n=3), Calcium Phosphate (n=3), and PEI (n=3). GFP positive cell was recorded by fluorescent microscopy and counted by ImageJ.

Conclusions

- HEK293T cells transplanted with MSCV IRES GFP NSD2 Full length plasmid by lipofectamine has the highest transfection efficiency.
- All three methods have low cytotoxicity to HEK293T cells.
- MSCV produced by lipofectamine has the highest infection and transduction efficiency.
- The transduction efficiency has a positive correlation with volume of viral supernatant used.
- Viral supernatant collected after 48 hours has a higher transduction efficiency.

Limitations

- The measurement of GFP+ cells by ImageJ can possibly produce imperfect results. Another cell counting software, CellProfiler developed by broad Institute will be used to improve the counting methods.
- The viral supernatant will only be collected after 48 hours to increase the viral concentration.
- The experiments will be repeated in a larger scale to gain more accurate results and in more cell types to check the commonality.

Acknowledgement

I would like to give my greatest thanks to Dr. Vasilyev, Dr. Ma, Dr. Tomasson, Dr. Bates, Dr. Vasileva, and rest members of IPG lab for offering me such a great learning experience. I would also thank SITP for this precious opportunity.
Integrating VR and GPT-4 AI Paradigms for Augmenting Hydroinformatics Education, Research, and Operation

Anish Jain, Yusuf Sermet, Ramteja Sajja, Ibrahim Demir

Motivation
- Leverage cutting-edge technologies to foster a more comprehensive learning experience for flood researchers and students
- Improve operational personnel’s capability to analyze data, monitor ongoing developments, and make informed decisions in real-time
- Provide a platform for seamless communication and knowledge sharing within the UIHI Lab

Introduction
Virtual Reality
Hydroinformatics Hub
Artificial Intelligence
Chatbot
Real-Time
Dynamic Data Feed

Methodology
- Utilize WebXR API to allow the development of the UIHI VR world using javascript
- Inference and implement a multimodal language model (GPT-4) for users to interact seamlessly using speech-to-text APIs
- Design functional hubs for Conferencing, Twitter Feeds, Research, and Brainstorming
- Optimize for commercial VR Headsets (e.g., Oculus, Holo Lens, etc.)

Preliminary Results/Prototype
Welcome Room - UIHI Engineering
Research Room - GPT-4 AI Assistant
Conferencing Room - IFIS Tracking
Twitter Room - Live Flood Updates

Outcomes/Discussion
- Streamline and improve the efficacy of Hydrology research
- Bridge gap between academia, research, and industry through a one-stop virtual hub
- Promote interdisciplinary research (Computer Engineering, Environmental Sciences, Hydroinformatics)
- Transcend traditional boundaries in education through technology
- Empower global research collaboration and environmental stewardship

Future Work
- Integrate multi-user functionality, facilitating collaborative learning for students
- Add an adaptive “VirtualITA” that could generate learning materials for hydrology and engineering students
- Create Research Rooms with interactive 3D models of the UIHI Lab’s latest technology
- Host Virtual Symposia in the Conferencing Center

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- Belin-Blank Center and STTP for providing the research opportunity
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- Canva for design interface/iconography - https://canva.com
Effects of Numerical and Nonnumerical Magnitudes on Number and Area Discrimination in Pigeons

Jonathan Jose¹, Francisca Diaz², Edward Wasserman, Ph.D²
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Introduction

Humans and animals alike use number to make complex decisions. Many theories aim to explain this fact. The Approximate Number System (ANS) proposes that organisms have evolved specialized mechanisms to process number (Brannon & Merritt, 2011). The Sensory-Integration model proposes that non-numerical magnitudes influence the behavioral control by number and that there is no specialized system to process number (Gebius, Kadosh, & Gevers, 2016).

To decide between these alternative theories, we trained pigeons in a discrimination task where size, area, and number were manipulated to see their differential impact on pigeon’s discrimination.

Methods

Pigeon subjects (n=2) were trained in an experimental box (Figure 2) to discriminate the S+ (center of grid array; 9a/12n) from S- (anything but the center). The pigeons had experience with unrelated experiments and were kept to 85% of their free-feeding body weight.

Figure 2. Experimental Pigeon Box

Figure 3. Trial Example

Procedures

Pigeons were trained in a 2-AFC discrimination task.

On each trial, a peck to the starting stimulus presented 2 response options on either side of the screen. Correct responses were reinforced with food pellets, but incorrect responses weren’t.

Stimulus Matrix

![Stimulus Matrix Image]

Figure 1. Full Matrix

The pigeons completed 160 trials per day, with the correct stimuli staying consistent as the center through the duration of the final experimental period. The x axis represents number, and the y-axis represents area. Hence, the middle of the 9x9 display would be 9 area by 12 number.

Results

Figure 4. Accuracy Density Chart: This density chart represents the accuracies to each of the S- compared to the S+. Darker colors represent lower accuracy as the birds had a harder time distinguishing those squares from the center. As expected, on average, the darker squares concentrate closer to the center, which indicates that the birds had a harder time distinguishing squares like the center than squares dissimilar from it.

Figure 5. Size, Area, and Number: The 3 distinct lines represent changes accuracy as a function of differences in area, number, and size between the S+ and S-. The steepest and clearest lines are size and area, followed by number (which has a very flat line), symbolizing that size and area (nonnumerical) are relatively the most important out of the 3 magnitudes.

Conclusion

Overall, we saw that nonnumerical magnitudes (size, area) have more of an impact on number discrimination than numerical magnitudes (number). Further research should be focused on how these magnitudes interact and their importance in other species, like humans (Lourenco & Aulet, 2023).

Reference


Examining Differences Between Self-reported and Collateral Reports of Depression in Patients with Brain Lesions

Seunghyeon Kim1, Amber Thomas, MA2, Aaron Boes, MD, PhD3,4,5,6, Daniel Tranel, PhD2,3
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Background
Diagnosing depression is often dependent upon a patient’s own report of their symptoms. Depression can also be measured by a collateral who knows the patient well, or a clinician. However, past studies have reported significant discrepancies between self and collateral reports of depression (Chopra et al., 2008). Particularly in patients with dementia, lower self-ratings in comparison to collateral and clinician ratings of depression was related to impaired insight (Ott et al., 1992, Burke et al., 1998). However, this difference has not been thoroughly examined in patients with brain damage.

Research Objective
The purpose of this study was to examine differences between self-reported and collateral reports of depression in patients with brain lesions and determine if insight plays a significant role in discrepant ratings. Patients with lower self-reported depression scores than collateral reports were hypothesized to have significantly impaired insight.

Methods
Participants were 138 patients from the Iowa Neurological Patient Registry. They were divided into four groups (Lowlow, Lowhigh, Highlow, Highhigh) based on their self-reported scores than their collateral reports of symptoms of depression (ex. Lowhigh group includes patients with low self-reported depression symptoms and high collateral reports)

1. Self-reported depression symptoms were measured with the Beck Depression Inventory (BDI)
   - Self-reported depression ratings were considered high when BDI was greater than 19.

2. Collateral reported depression and insight was measured with the Iowa Scales of Personality Change (ISPC)
   - Collateral rated depression and insight scores were considered high when ISPC ratings were greater than 4.

Results

![Proportion of Subjects with Impaired and Unimpaired Insight by Group](image)

Figure 1: Proportion of subjects with impaired and unimpaired insight by group

![Multivariate lesion symptom mapping was used to investigate the neuroanatomical correlates of impaired insight in this Lowhigh group. Patients in this group did not have brain damage that was significantly associated with their level of insight](image)

Figure 2: Lesion overlap map of patients in the Lowhigh group

Discussion

- In total, 30.43% of patients had discrepant self-report and collateral reports of depression (Lowhigh, Highlow), while 69.56% of patients had congruent BDI and ISPC depression now scores (Lowlow, Highhigh).
- Level of insight was significantly related to patients with brain lesions rating themselves low in depression while their collaterals rate them as highly depressed. Specifically, this group had a significantly higher proportion of patients with impaired insight compared to the other groups.
- Reliance on self-reports of depression in patients with impaired insight might undermine their severity of depression. In this context, the ISPC insight subscale can be used as an indicator of impaired insight, and thus give the clinician an idea of the reliability of patient-reported depression scales.

Limitations
- Time between lesion onset and date of ISPC rating (interval) may influence how collaterals report personality disturbances in patients.

ANOVA analysis showed that in our sample, there is no significant difference of interval in the 4 groups [F(3, 133) = 1.21, p=0.31].

- Sample size for Lesion Symptom Mapping was small (N=29).

Acknowledgments
I would like to thank Amber Thomas, Dr. Boes, Dr. Tranel, and the Tranel Lab for their guidance on this project. I would also like to thank the Belin-Blank Center for providing me with this opportunity.

References
Effects of Bone Density on Implant Stability in Total Ankle Replacement
Ruby Kolesar¹, Gabriel Clarke², Donald Anderson PhD²
¹Fiorello H. LaGuardia HS, New York City, NY, ²University of Iowa Department of Orthopedics and Rehabilitation, Iowa City, IA

Introduction
- Osteoarthritis is marked by the degeneration of an articular joint, which leads to disabling pain and loss of function.
- Total Ankle Replacement (TAR) is a surgical treatment for patients with end-stage osteoarthritis.
- TAR involves removing the damaged ends of the bones and cartilage from the ankle joint and replacing them with an implant.
- Success of contemporary TAR hinges on achieving early stability.

Objective
This study is based on the prediction that bone density around the implantation site influences tibial component stability. The goal is to use computed tomography (CT) scans to find bone density and simulate virtual implantation to determine how density affects the implant’s behavior and stability.

Structure
- Tibial component of TAR is implanted in the distal tibia (Figure 1)
- These prostheses are typically implanted with press-fit, relying upon elastic recoil of the bone to hold the implants more strongly and prevent early micromotion.
- Ability of bone to sustain press-fit is related to its density, which varies across individuals and can be compromised.
- Measuring bone density near where the tibial component is implanted provides a basis for evaluating how stable the implant will be following surgery.

Process
- CT scans provide a map of the radiodensity of tissues within a field of view, expressed in Hounsfield unit (HU) values.
- In prior research, mathematical equations have been derived that relate HU values to bone density (Figure 2).
- These equations are a basis for computing the mechanical response of bone models to applied loads (flowchart below).

Application
- Once the model has assigned properties, it can be put into ABAQUS, finite element analysis software.
- ABAQUS computes the mechanical response of a virtual implant in bone subjected to externally applied loads. Bones with varying density yield different results in implant-bone micromotion.
- Micromotion is an indicator of failure risk; when micromotions exceed 150 µm, fibrous ingrowth can occur instead of bony ingrowth, making it harder for the implant to succeed.

Conclusions
- Through testing the virtual implants and analyzing differences in micromotion, bone density was shown to influence implant stability.
- Bones with a larger elastic modulus are more stiff, which helps keep the implant in place and reduce movement. This means that having higher bone density is correlated with greater stability.

References

Acknowledgments
I would like to thank Gabriel Clarke for his guidance, Dr. Don Anderson for the opportunity to work in his lab, and the University of Iowa for the access provided by the SSTP program.

Graphical Illustration:
1. Graphical illustration of a total ankle replacement and an x-ray of the ankle following implantation.
2. Comparison of elastic modulus in 4 different patients. Cases 1-2 are healthy, cases 3-4 are osteoporotic.
3. Process flowchart:
   - Mimics: Create 3D model of bone from CT
   - 3-Matic: Optimize model for efficiency
   - Mimics: Apply density equation to prepare model for simulation
   - MATLAB: Generate code for ABAQUS

Diagrams:
1. Figure 1: Graphical illustration of a total ankle replacement and an x-ray of the ankle following implantation.
2. Figure 2: Comparison of elastic modulus in 4 different patients. Cases 1-2 are healthy, cases 3-4 are osteoporotic.
3. Figure 3: Comparison of elastic moduli in 4 different patients. Cases 1-2 are healthy, cases 3-4 are osteoporotic.
4. Figure 4: Elastic modulus values plotted in region of interest above tibial component of TAR.
5. Figure 5: Elastic moduli of implant contact surface in healthy and osteoporotic patients.
6. Figure 8: Transverse cross-section 2mm above baseplate displaying elastic modulus shows how lower bone density leads to higher micromotion.
Platelet Function in Ehlers-Danlos Syndrome

Michelle Lee¹, Mariia Kumskova², Gagan D. Flora², Anil Chauhan²

¹Henry M. Gunn High School, Palo Alto, CA; ²Department of Internal Medicine, University of Iowa, Iowa City, IA

Introduction

- Ehlers-Danlos Syndrome (EDS) is a heritable connective tissue disorder that often involves defects in collagen.
- There are 13 subtypes of EDS; most common types are hypermobile (hEDS) and classical (cEDS).
- Common symptoms: joint hypermobility, skin hyperelasticity, skin fragility, chronic pain.
- Easy bruising is a major criterion in four EDS types (classical-like, cardiac-valvular, dermatosparaxis, and mucoscutaneous) and a minor criterion in five EDS types (classical, vascular, arthrochalasia, kyphoscoliotic, and periodontal).

Hypothesis

The bleeding diathesis in EDS patients is due to dysfunction of platelet collagen receptors GPVI and integrin α2β1.

Methods

ISTH-BAT
- Screening tool used to assess 14 different bleeding symptoms on a scale of 0-4.
- Used to characterize bleeding symptoms in the human study population.

Light Transmission Platelet Aggregation
- Checks how well platelets clump together to form blood clots.
- Platelet-rich plasma sample with 2 x 108 platelets/mL.

Flow Cytometry
- Used to analyze the activation and function of the integrin αIIbβ3.
- Platelet-rich plasma sample with 2 x 108 platelets/mL.

Western Blotting
- Used to determine the level of protein phosphorylation in EDS subjects compared to healthy subjects.
- Washed platelets samples with 4 x 108 platelets/mL.

Human samples were excluded if subjects took medication with antiplatelet, anticoagulant, or prothrombotic effects within 7-10 days prior to the blood draw.

Results

Fig. 1 | ISTH-BAT of healthy and EDS subjects

Fig. 2 | Bleeding symptoms

Fig. 3 | Platelet aggregation and αIIbβ3 activation in EDS patients

Fig. 4 | Platelet aggregation and αIIbβ3 activation in COL5a1-deficient mice

Fig. 5 | Collagen-induced platelet signaling in EDS patients

Study Population

<table>
<thead>
<tr>
<th>Human cohort</th>
<th>EDS mouse model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>COL5a1+/−</td>
</tr>
<tr>
<td></td>
<td>COL5a1−/−</td>
</tr>
</tbody>
</table>

Wild type (WT) littermate control

eds classical type
- No known mutation of hEDS

Discussion & Conclusion

- EDS as a congenital connective tissue disorder that carries a high risk of hemorrhagic complications.
- Overall, 62% of patients with EDS demonstrated an abnormal bleeding score.
- The most frequent bleeding symptoms included bruising, muscle hematomas, menorrhagia, epistaxis, bleeding from the oral cavity, and bleeding after tooth extraction.
- Collagen-induced inside-out signaling and integrin αIIbβ3 activation are impaired in EDS patients.
- Platelet function impairment in COL5a1+/− mice mimics that in EDS patients.

Acknowledgements

I would like to thank Dr. Chauhan and the members of the Chauhan Lab for allowing me to have this opportunity, as well as Dr. Kumskova and Dr. Ghagte for their invaluable guidance.

References

Parametrically Generating and Testing \textit{n-sided} 3D-Printed Parabolic Solar Concentrators

Maxwell Leonard, Sebastian Hazelett, Dorothy Zheng, Reyna Alam, Daniel Keefe, Rezwan Sayeed, Fatima Toor

Introduction

3D-printed solar concentrators have the potential to make solar panels cheaper and easier to produce while potentially increasing the efficiency of solar panels by reducing recombination and surface reflection losses. Our research focused on expanding current work on 3D-printed parabolic solar concentrators, simulating and testing several hundred potential concentrator configurations to determine which were more efficient.

Process

We first characterized the reflectivity of several different metal-based paints in order to determine which paint would be used to coat the concentrators. Following the results shown in Figure 1, we chose a chromium-based paint and used its reflectivity to model a material in Radiance.

We then used OpenSCAD, a script-based CAD modeling application, to model 319 different solar concentrators, using the design and equations established in the Al-Shidhani et al. proceeding.

Using the results shown in Figure 5, we selected the 4 and 9X squareΔ concentration ratio for further testing. These models were 3D printed, chemically smoothed, and coated, before being tested in a solar simulator, netting the results shown in Figure 6.

Results

Concentration Efficiency (3-12 and 256 sides, 2-30X concentration)

Analysis

- Circular concentrators appear to be the most efficient in real-world scenarios.
- However, concentrators with lower numbers of sides more effectively disperse light rather than focusing it on the center.
- Real-world testing was limited in scope, and further research is needed to better understand how concentration ratio and shape affect photovoltaic power output.

Impact

Over the course of the project, we traced over 500 million individual photons and used around 95 hours of whole-processor CPU time. Given the power output of the processor at full load (80 watts) plus a rough estimate for cooling and other components, computing for this project likely emitted around

$$\text{11 kw} \times 95 \text{ hours} \times \frac{9477 \text{ lb CO}_2}{1 \text{ kw} \text{ hour}} \times \frac{1 \text{ MWh}}{1000 \text{ kw} \text{ hour}} = 9.90 \text{ lb CO}_2$$

While this may be negligible, we hope to establish a precedent for future projects; photon mapping is notoriously computationally expensive, and future projects may choose to take on a larger scope.

Acknowledgments

I’d like to thank my stellar research group for their work, Dan, Rezwan, Caleb, and Nick for their help and support in the lab, and, of course, Professor Fatima Toor.

References

How The American Civil War Impacted Migration Patterns

Kelvin Liu¹; Maryam Torkashvand²; Caglar Koylu, PhD²

Choate Rosemary Hall, Wallingford CT¹; Department of Geographical and Sustainability Sciences, University of Iowa²

Introduction

- Disruptive events substantially alter spatial and social interactions of humans.
- Although existing studies have thoroughly examined the volumetric, temporal, and spatial impact of disruptive events on human activities, the changes in structural patterns of human movement remain relatively unexplored.
- The American Civil War drastically changes the way people lived, worked, and interacted with one another, and had immediate and long-lasting impacts on the structure and functioning of social and spatial networks.
- Migration regions are groups of spatial units with a high degree of connection internally but low interaction with other subsystems.

Objective

- Investigate the American Civil War’s impact on human migration.
- Understand how to utilize the Louvain method.

Methods

- Utilized Known Node-Correspondence (KNC) to examine the changes in community structures in pre- and post-war networks.
- Employed Louvain algorithm to identify migration network regions across the continental United States. Used these regions within the US to examine the structural changes in spatial migration networks between pre- and post-war periods.
- Used a series of quantitative comparisons to quantify the similarity of regions between partitions of pre- and post-war periods.
- Undergo a series of quantitative comparisons to quantify the similarity of regions between partitions of pre- and post-war periods of each network including Adjusted Rand Index, Rand coefficient, Jaccard coefficient.

Results

(A) Migration Pre-War

(B) Migration Post-War

<table>
<thead>
<tr>
<th>Network</th>
<th>Pre-Period</th>
<th>Post-Period</th>
<th>z-Rand</th>
<th>Rand</th>
<th>Adj. Rand</th>
<th>Jaccard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family Tree</td>
<td>1840-1861</td>
<td>1865-1900</td>
<td>2.65</td>
<td>0.56</td>
<td>0.06</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Table 1 Partition quantified data of pre- and post-war migration network

- Regions increased from 3 to 4 in the post-period, with significant changes. All 4 regions in the post-period were substantial in size. Notably, Region 2, which originally consisted of the Virginias, expanded northwards.
- Modularity shifted from 0.374 in pre-war to 0.349 in post-war period. While similar modularity values suggest similar connectedness in migration networks, the post-war modularity indicates that states in that period were less densely connected in terms of migration flows, possibly due to the Settlement of the West and longer-distance moves.
- The z-Rand score of 2.65 is significant when compared with the z-Rand scores of 18.11 (for 1850-60 and 1860-70) and 13.85 (1860-70 and 1870-80) found in Koylu et al. [In Review], indicating dissimilarity between the pre- and post-war regions.
- The Jaccard coefficient of 0.20 indicates a significant overlap between the two partitions.

Conclusion

- This study demonstrates that the American Civil War led to a notable reduction in migration connections within regions while increasing long-distance migration flows between regions in the post-war period. Regardless of these differences, regions derived from migration flows generated a significantly similar regional structure in the US.
- The data used in this study accurately represents the native-born white population, but not others such as Blacks, Native-Americans, or Mexicans.

Acknowledgments

I would like to thank Dr. Caglar Koylu and Maryam Torkashvand for their mentorship and guidance in my research in the Geo-Social Lab at the University of Iowa. I would also like to thank the Secondary Student Training Program and Belin-Blank for giving me this unforgettable opportunity.

Selected References


References

Scan this QR Code to check out the full list of references!

Figure 1 Migration Regions in (A) Pre- and (B) Post-War Periods

<table>
<thead>
<tr>
<th>Network</th>
<th>Pre-Period</th>
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<td>0.20</td>
</tr>
</tbody>
</table>
Results: \(^1\)H NMR Spectroscopy, Powder X-ray Diffraction, & EPR Spectroscopy

[Figure 1: Left - Single crystals of (4,4\(^-\)bpe) (res) at 10x objective under a microscope. Middle – 3-D model representation of (4,4\(^-\)bpe) (res). Right – 3-D model representation of tpcb.]

[Figure 2: \(^1\)H NMR spectrum of (4,4\(^-\)bpe) (res).]

[Figure 3: \(^1\)H NMR spectrum of (4,4\(^-\)bpe) (res) after photoreaction forming tpcb.]

[Figure 4: PXRD pattern of (4,4\(^-\)bpe) (res).]

[Figure 5: PXRD diffractogram of (tpcb) (res).]

[Figure 6: EPR Spectroscopy of the dose study for (4,4\(^-\)bpe) (res). Carbon-centered radicals grow in as exposure to UV light increases.]
Differences in Knee Joint Space Width Distribution Between Flexed vs. Extended Weight Bearing CT Scans

Connor Meng,¹ Tyce C. Marquez,² Donald D. Anderson²
¹College of Education, ²Departments of Orthopedics & Rehabilitation and Biomedical Engineering

Introduction

- Joint space width (JSW) is the bone-to-bone distance across an articular joint
- JSW narrowing is a defining feature of post-traumatic osteoarthritis (PTOA) [1]
- Around 50% of patients with ACL injury develop PTOA of their knee within 10-20 years post-injury [2]
- Weight bearing CT (WBCT) evaluates joints in functional loaded positions, offering greater sensitivity and accuracy than radiographs [3]
- We believe the screw-home mechanism (SHM) causes JSW distribution in the knee joint to be different in flexed vs. extended pose

Methods

- WBCT scans of the knee acquired for 43 patients ≥ 14-years old
  - 34 flexed scans and 19 extended scans obtained three months post-ACLR
- 3D JSW maps and models of the articulating surfaces were generated using a fully-automated method (Figure 2) [1]
- Defined centroid of lowest 10% of JSW values as center of contact (COC)
- Measured the distance between COC in flexed vs. extended pose to assess the effect of SHM

Results

- In both compartments, COC is positioned more anteriorly in the extended than the flexed pose (Figures 3 and 4); it is placed more medially in the lateral compartment and vice versa
- In ACLR knees, the average distance between COC in flexed vs. extended pose is slightly larger than that of intact knees
- In ACLR knees, COC is in a slightly more anterior position than in intact knees (Figure 5)

Conclusion

- The difference in the location of COC is consistent with the tibia’s external rotation caused by SHM, meaning SHM likely changes where the narrowest JSW values occur in flexed vs. extended pose
- Observed difference between intact and ACLR knees is minimal and inconclusive, but this is at an early follow-up time point
- Follow-up is ongoing, and more WBCT scans will be obtained at one-year post-ACLR

Acknowledgements

This research was supported by a grant from the Arthritis Foundation (Award #851789).

References

Introduction

Neurodevelopmental syndromes can range from manifesting through things like ADHD, ASD, global developmental delay, and motor skill deficits. Consequently, they often worsen the quality of life for afflicted patients along with their families putting socioeconomic strain on them.

Methods and Results

Figure 7. Luminescence generated by luciferase upon stimulation with isoproterenol in hippocampal and cortical cells. R335W-V5 sh5 displays a severe reduction in transcriptional activity as compared to WT R1B-V5 sh5. N=1

Figure 8. Table containing the proportions of maximum excitatory response with different conditions when compared to WT in percentage form. All conditions except YC155 consistently display reduced maximum response relative to WT.

Figure 9. A, Luminescence generated by luciferase upon stimulation with isoproterenol in HEK394 R1A KO cells. R335W and R243C show a severe reduction in transcriptional activity relative to WT R1B. N=3. B, Luminescence generated by luciferase upon stimulation with isoproterenol in HEK394 R1A cells. Q167 and E196K show a moderate reduction in transcriptional activity relative to WT R1B. N=3.

Figure 10. Image of the hippocampal and cortical neuronal cell culture. This is stained with Gial Fibrillary Acidic Protein (GFAP), a glial marker, along with beta III tubulin as a neuronal marker. These were the only glia we found indicating that there were very few glia in our culture.

Objective

The objective is to investigate how different variations the PKA tetramer compare in transcriptional activity in order to learn more about PKA’s function and implications that changes to it can have. This information is to be expanded on a larger scale to better understand PKA’s role in neurodevelopmental disorders as a whole along with their mechanisms.

Hypothesis

Given PKA’s role in learning and memory along with the previously found presence of its variants in neurodevelopmental disorders, the hypothesis is that cells that are non-WT will display relatively reduced transcriptional activity in response to the isoproterenol.

Conclusions and Future Directions

Conclusions:
- The R1A KO cells and hippocampal neurons with the R335W have severely reduced transcriptional activity.
- The Q167L and E196K mutants display a moderate reduction in transcriptional activity in the R1A KO cells examined.

Future Directions:
- Assess if these results are reflective of smAKAPs ability to bind with R1B.
- Determine the underlying mechanism contributing to neurodevelopmental disorders in a mouse model of the conditions.

References


Acknowledgements

I would like to thank Dr. Strack, Mr. Glebov-McCloud, and everyone in the Strack lab for all of the mentorship, guidance, and support they graciously provided me throughout this project.
Envisioning the Coiled-Coil Domain on ANGPTL3
Sarah Park¹, Sydney Walker², Shwetha Shetty³, Kelli Sylvers-Davie², Brandon S. Davies²
¹Ames High School, IA; ²Department of Biochemistry and Molecular Biology, University of Iowa

Introduction

Lipoproteins: responsible for transporting such lipids like triglyceride and cholesterol in bloodstream
- HDL: carries cholesterol
- Chylomicrons/IDL: carries dietary TG

Lipases regulate lipoproteins through hydrolyzing free fatty acids into tissue
- Endothelial Lipase (EL): HDL
- Lipoprotein Lipase (LPL): triglycerides

Implications:
- High plasma TG levels and decreased HDL are risk factors in cardiovascular diseases.
- Low ANGPTL3 levels implicates additional cleavages.

ANGPTL3: inhibits EL and LPL, increasing plasma TG levels
- Forms complex with ANGPTL8 to inhibit LPL (Chen et al, 2020).
- A3 expression decreases HDL and increases chylomicron, VLDL

Objective

Identify the amino acid mutations on the coiled-coil domain of ANGPTL3 that are essential for EL and LPL binding and inhibition.
- Mutations L120A N121A (pA42), R139A L141A (pA51)
- Inward facing leucine

Methods

• Mutant Protein Expression
  - Site-Directed Mutagenesis of Plasmids
  - HEK293 Culturing, Transfections and Harvesting
  - SDS Page Gel Western Blots: quantify and visualize individual protein expression
  - EL Inhibition Assay: serially diluted protein media, EL, and EL substrate added to fluorescence plate reader
  - NanoBiT Luciferase EL Binding Assay: measure luminescence emitted from LgBiT tagged EL binding to SmBiT tagged proteins
  - Native Blue Gel Oligomerization Western Blot

SDS Page Western Blot

EL Inhibition Assay

Figure 1 (a) and (b). Conditioned cell media (left) and cell lysate (right) western blot of ANGPTL3 expression in green and ANGPTL8 expression in red. From left to right: pEB14 WT, R120A N121A (pA42), R139A L141A (pA51), ANGPTL8 control, all with ANGPTL8 on the right, positive control, protein ladder. Lower bands imply additional cleavages.

EL Binding Assay

Figure 2. EL activity measured by fluorescence emitted through hydrolysis of phospholipids on substrate with increasing concentrations of pEB14 WT and R139A L141A at 37 °C for 30 minutes. Given values then divided by EL control and multiplied by 100 for the percentages. R139A L141A cannot inhibit EL

Figure 3. Emitted luminescence from doubled samples of pEB14 WT and R139A L141A and 50% dilutions of both measured with plate reader under 37 °C for 30 minutes. Given similar values of R139A L141A (A3A51) compared to WT, it does seem to bind to EL.

SDS Page Western Blot

EL Binding Assay

Native Blue Gel Oligomerization Western Blot

EL Inhibition Assay

Figure 4. Conditioned cell media Native Blue Gel western blot of Poly A3 tagged ANGPTL3 mutant expression. From left to right: protein ladder, pEB14 WT, L120A N121A, R139A L141A. Top band represents trimers of full length, bands 2 and 3 represent trimers with 1 or 2 cleaved proteins respectively, bottom band represents monomers.

Conclusion

• ANGPTL3 mutant L120A N121A cannot express protein and thus cannot be assessed for EL and LPL binding and inhibition. However, mutant R139A L141A can bind to EL, though not inhibit.
• ANGPTL3 mutant R139A L141A cannot oligomerize.

Future Directions

• Perform RNA isolation and qPCR on L120A N121A and LPL Binding/Inhibition Assays on both mutants.
• Finish performing assays on the rest of the mutants on the alanine scan table.
• Generate a mutant mouse model to separating EL and LPL functions in a physiological context.

Acknowledgements

I would like to thank Dr. Davies and his lab for their mentorship and guidance. Special thanks to the Belin Blank Center and the University of Iowa Department of Biochemistry and Molecular Biology for this opportunity.

References


Figure 1 (a) and (b). Conditioned cell media (left) and cell lysate (right) western blot of ANGPTL3 expression (green) and ANGPTL8 expression (red). From left to right: pEB14 WT, R120A N121A (pA42), R139A L141A (pA51), ANGPTL8 control, all with ANGPTL8 on the right, positive control, protein ladder. Lower bands imply additional cleavages.

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The Effects of a Common Plastic Additive on Mating Behavior

Nadia Patel1, Yiyi Tu2, Bryan Guevara3, Maurine Neiman4
1Cedar Falls High School, 2The Bishop School, 3Department of Biology University of Iowa, Iowa City, IA

How do plastic additives affect behavior?

- Our environment is filled with chemical additives that could plausibly influence health and behavior.
- New Zealand Mud Snail (Potamopyrgus antipodarum) are very sensitive to water environments and are thus a powerful aquatic ecotoxicology model system.
- Dimethyl Phthalate (DMP), a chemical reagent of phthalates, is common in variety of household items. It is also a known endocrine disruptor.

New Zealand Mud Snails offer great models for studying ecotoxicology

Using a snail model to assess plastic toxicity

- How does DMP (Dimethyl Phthalate) affect the reproductive behavior of New Zealand Mud Snails?
- Relevant to human health concerns as well as ecosystem health.
- Use experimental approach to expose P. antipodarum to varying levels of DMP and assess reproductive behavior.

Hypothesis:
DMP negatively affects male reproduction because it represses androgen production, decreasing sexual behavior.

Prediction:
Frequency and duration of mating attempts by males will decrease with increased DMP concentration.

Quantifying DMP effects on behavior

- Experimental Design:
  - Males: Male (M) placed equidistant from brooding (B) female and non-brooding (NB) female.
  - Snails are given 2 hours to mate within the 4" diameter petri dish. The frequency of mating attempts and the mating duration are calculated per 2-hour interval.

- Results:
  - DMP negatively affects mating behavior in P. antipodarum; effects increase with dose.
  - There could be consequence of DMP exposure for reproductive behavior in other organisms such as humans.

Reproduction is influenced by a plastic behavior additive

- Males preferred mating with brooding over non-brooding females, and they mated for longer durations with the former.
- Why is unclear but could be linked to higher fertility of brooding females and/or greater propensity of breeding females to mate.

Future Directions

- How would male snail reproductive behavior change at even higher concentrations of DMP?
- Will reproductive behavior in brooding vs. non brooding snails be differentially affected by DMP? What about embryos produced after DMP exposure?
- How do other reagents of phthalates affect reproductive behavior?
- Could DMP affect humans? How?

Acknowledgements

Special thanks to Bryan Guevara for actively mentoring and supporting me through this project, Maurine Neiman for guiding me through this research journey, and Yiyi Tu for her moral support. We also thank the Belin Blank Center for this incredible research opportunity and funding.

References


Fig 1. The New Zealand mud snail (Potamopyrgus antipodarum) relative to a US dime. (A) Lateral view of mud snail. (B) Multiple mud snails surrounding a US dime.

Fig 2. Snail Sexes and Embryo Brooding (A) Male mud snail rotating head left revealing penis—highlighted by the white arrow. (B) Brooding female snail with embryos visible from exterior of shell. Embryos are highlighted inside the white circle. (C) Non-brooding female with no embryos visible from exterior of shell.

Fig 3. Model for Assessing Male Reproductive Behavior Post-DMP Exposure. Male (M) is placed equidistant from brooding (B) female and non-brooding (NB) female. The snails are given 2 hours to mate within the 4" diameter petri dish. The frequency of mating attempts and the mating duration are calculated per 2-hour interval.

Fig 4. Closer Look at the Mating of New Zealand Mud Snails. The male snail moves his aperture in alignment with the aperture of the female; mating takes place under the shell.

Fig 5. Photos of the 5-week exposure of DMP for New Zealand Mud Snail Males, with four treatment groups containing eight sexual snails each.

Fig 6. DMP Effects on Mating Behavior. (A) There was significantly more mating in the no-exposure (negative control) group relative to the medium and high groups. * = p < 0.05, ** = p < 0.005. (B) There was a trend towards decreased mating duration as DMP dose increased.

Fig 7. Male Preference During Mating Trials. (A) Males had the ability to choose between mating with a non-brooding or brooding female. Males preferred to mate with brooding vs. non-brooding females. (B) Males mated with brooding vs. non-brooding females for significantly longer durations.
Top2A is a Novel Progesterone Receptor Repressor in Endometrial Cancer

Aarthi Raghavan1; Xiangbing Meng, PhD2; Shujie Yang, PhD2
1American High School, CA; 2Department of Pathology, University of Iowa

I. Background

Progesterone Receptor (PR) Expression

- Endometrial cancer is located in the uterus (Figure 1)
- Estrogen promotes endometrial cancer cell proliferation
- Progestosterone is another hormone
- Progestosterone negatively regulates estrogen-driven tumor growth and is an ultimate tumor suppressor in endometrial cancer
- MYC is a proto-oncogene and reported as a PR downstream gene

PR expression is significantly downregulated in endometrial cancer patients

II. Objectives

#1 Analyze PR expression trend in Top2A knockdown (kd) cells

#2 Inhibit Top2A activity and then measure PR expression

#3 Measure the cell growth in the Top2A kd cells

III. Methods

Knockdown Top2A using siRNA & shRNA
- siRNA: transfected twice with shRNA: lentivirus transfection - passage to T100 - wait 48-72 hours

Use Top2A inhibitors on cells
- used idarubicin and Mitoxantrone - tested both MYC and PR expression

BCA assay to determine the loading volumes
- 25 ml total in each well - standards (25 µL), water (25 µL), samples (2.5 µL)

WB and capturing the final images
- used both 7.5% and 12% gel - transfer ON - use filter paper and the NC membranes

IV. Results (Continued)

- The Top2A siRNA and siRNA3 knockdown Top2A well – it’s barely visible (Figure 7)
- Clear increase in PR expression for Top2A siRNA1 and siRNA3 when compared to the negative control (Figure 7)

- Top2A siRNA1 and siRNA3 knockdown Top2A in Ishikawa (Figure 8)
- All Top2A siRNAs knock down Top2A in ECI1 (Figure 8)
- There is a clear increase in PR expression for the above samples

- Both Top2A inhibitors idarubicin and Mitoxantrone increase PR expression
- At the same time, MYC expression clearly reduces (Figure 9)

- Top2A is a Novel Progesterone Receptor Repressor in Endometrial Cancer (Figure 5)
- The brown mass depicts the tumor.

IV. Conclusion/Future Directions

- Top2A knockdown increases PR expression in siRNA1 and siRNA3 in Ishikawa and all siRNA in ECI1
- Top2A inhibitors idarubicin and Mitoxantrone increase in PR expression
- The knockdown of Top2A in Ishikawa reduces cell growth
- It is likely that Top2A is a bona fide PR repressor in endometrial cancer cells
- Future studies should determine the mechanism for Top2A repressing PR
- Future experiments could involve Top2A inhibition and knockdown in mice endometrial cancer cell lines
- Our data overall suggests idarubicin and Mitoxantrone can be potential treatments for endometrial cancer patients based on Top2A inhibition

V. Acknowledgements

I would like to extend my gratitude to the Belin Blank Center for providing this incredible opportunity and to Dr. Meng and Dr. Yang for their valuable guidance and mentorship in these five weeks. This project was supported by NIH R37-CA228724 (SY) and the Department of Pathology Start-Up Fund (SY).

VI. References

Endocannabinoid Receptor 1 in Sensory Neurons Affects Body Weight and May Contribute to Bariatric Surgery Outcome in Mice

Sana Rajesh \(^1\), Yi Chu, PhD \(^2\), Mohamad Mokadem, MD, PhD \(^2\)

1. Gretchen Whitney High School, Cerritos, CA
2. Department of Internal Medicine, Division of Gastroenterology and Hepatology, University of Iowa, Iowa City

**BACKGROUND**

This study focuses on the endocannabinoid receptor 1 (CB1), a key regulator of energy signals along the gut-brain axis located in both the central nervous system (CNS) and peripheral nervous system (PNS), and its effects on metabolism. The goal is to understand the effects of CB1 receptors in sensory neurons of mice fed with a high-fat diet (western diet) and how this receptor may determine the outcome of RYGB surgery.

**METHODS**

We used Wildtype (WT) & Knockout (KO) mice to explore fluctuations in Body Weight (BW) and Food Intake (FI) after high-fat diet (HFD) feeding over a span of 20 days.

Breeding Schematic:

- **Figure 1.** When breeding, looking for Nav1.8-Cre\(^{+}\) CB1\(^{-}\) as “knock-out” for the CB1 gene while the rest are used as control during experimentation.

**RESULTS**

1. We were able to successfully breed sensory neuron-specific endocannabinoid receptor 1 “knock-out” mice, (Nav1.8-Cre\(^{+}\) CB1\(^{-}\)) which we were able to utilize in experiments with control mice to observe the impact of this receptor.
2. Preliminary findings of the Rate of Change of Body Weight Experiment/Food Intake Experiment: Male KO mice had a significantly less increase of body weight during the experiment than Control. Female KO mice had similar rates to Control, both resistant to HFD confirmed when compared with Male Control.

**CONCLUSION**

1. **Future Work:**
   - Increase n to obtain a more accurate statistical significance
   - After mice weigh ≥ 40g, RYGB will be performed and Rimonabant, a CB1 antagonist drug, will be applied to mice to conclude whether sensory neuron CB1 is fully or partially responsible for the previous findings that CB1 receptor does have an influence on gastric behavior as it leads to an increase in food intake which is not present in the KO mice.

**ACKNOWLEDGEMENTS**

I would like to thank Dr. Yi Chu for his mentorship and guidance, Dr. Mohamad Mokadem for the opportunity to conduct research in his lab, as well as the entire Mokadem Lab, and the Belin-Blank Center for making this opportunity possible.

**REFERENCES**
Mutations of the ANGPTL3 Coiled-coil Domain and their Impacts on Oligomerization and EL/LPL Binding and Inhibition

Param Sampat¹, Sydney Walker², Shwetha Shetty², Kelli Sylvers-Davie PhD², Brandon Davies PhD²
¹Cedar Falls High School, ²Department of Biochemistry and Molecular Biology, University of Iowa

Background

Lipids are essential to the human body:
- Hormone precursors
- Digestive aids
- Energy stores
- Metabolic fuels
- Components of Cell Membrane

Relevant classes of lipoproteins:
- Chylomicrons/Very low-density lipoproteins (VLDLs)
  - Transport fats in bloodstream to tissues
- HDL (High density lipoproteins)
  - “Good” cholesterol
  - Scavenges excess cholesterol back to liver

ANGPTL3
- Expressed by liver
- Inhibits EL and LPL
- Forms complex with ANGPTL8 to efficiently inhibit GPIHBP1 bound LPL
- Humans lacking functional ANGPTL3 have:
  - Hypolipidemia
  - Protection from cardiovascular disease
  - Protection from type-2 diabetes

Objective of Study

Mutate ANGPTL3 proteins and analyze impact of said mutations on EL and LPL binding and inhibition to deduce regional function

Methodology

- Protein Expression:
  - Culture cells
  - Transient transfection
  - Nucleic acids artificially introduced into cells to produce proteins
  - Protein harvesting
  - Cells dislodged/lysed & media and lysate collected
  - Western Blotting (SDS & Native-page)
  - Protein separated using GE
  - Separated proteins then transferred to membrane
  - Antibodies added and membrane imaged

- Functional analysis:
  - EL Inhibition Assay
  - Various concentrations of ANGPTL3 prepared
  - EL substrate added
  - Machine measures fluorescence
  - Increased fluorescence = Increased activity
  - Same as EL inhibition assay except with LPL

Western Blot Results

EL and LPL Inhibition Assay Results

EL Binding Assay Results

Conclusions

- ANGPTL3 Mutant G66A Q67A
  - Retained ability to inhibit LPL and EL
  - Adequately bound to LPL
  - Retained trimer

Future Directions

- Perform LPL Binding Assays
- Continue analyzing different mutants within coiled-coil domain to expand scope of understanding
- Utilize KO drugs to analyze ANGPTL3 mutant impacts

Broader Implications

- Step in the correct direction for Type-2 Diabetes and CVD sufferers.
- This research coupled with advancements later on may allow for specific mutagenic targeting of ANGPTL3 in order to decrease EL and LPL levels in a person to varying degrees.

Acknowledgements

I'd like to thank Dr. Davies and his lab, The Department of Biochemistry and Molecular Biology, and the University of Iowa

References


The New England Journal of Medicine


Journal of Lipid Research


Journal of Biomedical Research


American Public University


Journal of Biomedical Research


The New England Journal of Medicine


References
Development of ESP-8266 IoT device for efficient and low-cost transmission of hydrological data

Satvik Sandru¹, Yusuf Sermet², PhD, Muhammed Sit, PhD², Ibrahim Demir², PhD
¹American High School, ²University of Iowa, Department of Hydroinformatics

Introduction:

- Hydroinformatics is a field of informatics that encompasses hydrology and decision support systems
- IoT devices connect to the internet or other services & transmit or obtain data

Motivation:

- Limited efficiency in communicating hydrological information to researchers/workers
- Insufficient coverage of ESP 8266 board in the hydroinformatics field and K-12 setting
- Current general smart assistants can not comfortably provide specific hydrological data such as stream height data at a particular location

Outcome/Result:

- Successfully developed basic prototype that is appealing to K-12, & relays flood alert level with live time data streaming
- Utilized Node/Express.js in order to communicate information from National Weather Service website (NWS) & United States Geological Survey webservice (USGS) & effectively display this information on low-cost IoT device

Prototyping/Developmental Process & Future:

What promise does the implementation of Internet of Things (IoT) technology demonstrate in the domain of Hydrology and as an educational tool in order to expose K-12 to hydroinformatics?

Future Goals:

- Develop a more advanced ESP-8266 device with more hydrological data output capabilities, and voice input integration for researchers/workers
- Construct a simple IoT kit that will educate K-12 about IoT technology/hydroinformatics in a beginner friendly manner

Methodology

- ESP-8266
- HTTP GET Request & Response
- Node.js Application
- Relaying location and alert level info to ESP-8266
- USGS Webservice
- HTTP GET RESTful Request & Response
- NWS Webpage
- HTTP connection for webpage

References

- Successfully developed basic prototype that is appealing to K-12, & relays flood alert level with live time data streaming
- Utilized Node/Express.js in order to communicate information from National Weather Service website (NWS) & United States Geological Survey webservice (USGS) & effectively display this information on low-cost IoT device

Future example of user communication + ai capabilities

This screenshot provides information gathered by the Node.js server about live flood alert data and stream height values

ESP-8266 Block Diagram

(Dachyar et al., 2019)

(Mesquita et al., 2018, pp. 784-791)

Special Thanks To:

- SSTP and the Belin-Blank center for this opportunity
- Dr. Ibrahim Demir and the UIHI Lab for close mentorship
- Yusuf Sermet and Muhammed Sit for assisting me with innumerable technical issues

https://docs.google.com/document/d/1xCqCM5ym2nbfSiudJ-chYNEOBjDHZggT0HADigU5ik/edit?usp=sharing/
Synthesis and Characterization of a Series of Polymers with Conjugated -NS- and -NSS- Backbones
Atman Shah1, Jolene Cao2, Shanari Wickremsinghage3, Ned B. Bowden, Ph.D.3

1Archbishop Mitty High School, 2Smithtown High School East, 3Department of Chemistry, University of Iowa

Introduction
Polythiazyl, first synthesized in 1910, is an inorganic polymer composed entirely of alternating nitrogen and sulfur atoms. Its characteristics include superconductivity at low temperatures (critical point of 0.9K) and a conjugated backbone. However, polythiazyl is also liable to decomposition in air (McDermid et al., 1979). Previous work has shown that modifications to the poly(NS) backbone yield more stable polymers. The polymerization of anilines to yield poly[N,N- amino(thiazoyl)]polymers revealed that the color depended on the conjugated backbone (Pauleau et al., 2023). Additionally, our lab has reported the synthesis of polythiazyl, first synthesized in 1910, is an inorganic polymer composed entirely of alternating nitrogen and sulfur atoms. Polythiazyl is also liable to decomposition in air (McDermid et al., 1979).

Methods
Vacuum Filtration
Extraction
Rotovap
Final Product

Fig. 2: H₂S release promotes crop growth (Grace et al., 2021).
Fig. 3: DMF is used to convert SCl₂ into SC₇, before the amine is added dropwise to create the polymer.

Fig. 8: From left to right, urea, 1,1-dimethylurea, butyl carbamate, phenyl carbamate changes color on polymerization. The colors of these polymers arise from energy band gaps in the conjugated backbone.

NMR Spectra

Fig. 14: NMR spectra of butyl carbamate monomer. Peaks are clearly defined, and the amine singlet and alkyl chain multiplets are visible.

Fig. 15: NMR spectra of butyl carbamate polymer. Peak broadening is observed. Solvent (DMF) is also present.

Fig. 12: Workflow for 2D Printing through rapid polymerization of anilines in the presence of SCl₂.

Rapid Polymerization Enables 2D Printing

Synthesizing polycyclic polythiazyl derivatives enables rapid 2D printing.

Fig. 11: General diaminodisulfide polymerization scheme.

Fig. 13: -NSS- polymers synthesized from the following monomers (a) 2,3,5,6-Tetramethyl-1,4-phenylenediamine (b) 4,4'-Dioxysulfanilimine (c) 4,4'-sulfanilimine (d) 1,5-Diaminonaphthalimine.

Fig. 9: Butyl carbamate polymer changes color within five minutes of KOH addition.

Fig. 10: From left to right, 0.92, 0.95, and 0.97 equivalences of butyl carbamate.

Fig. 1: Resonance structure of polythiazyl.

Fig. 5: Spectroscopy enables the characterization of the structure, color, and size of our polymers.

NMR Spectra

Fig. 14: NMR spectra of butyl carbamate monomer. Peaks are clearly defined, and the amine singlet and alkyl chain multiplets are visible.

Fig. 15: NMR spectra of butyl carbamate polymer. Peak broadening is observed. Solvent (DMF) is also present.

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Future Work

• Cleaving off R-groups from the -NS- backbone
• Quantifying the rate of hydrogen sulfide release of the polymers
• Doping the polymers with oxidants (e.g., Br₂) and testing electrical conductivity.
• Synthesizing polycyclic polythiazyl derivatives

Acknowledgements

I would like to thank Professor Bowden and Shanari for their mentorship during this program. I also thank the University of Iowa and the SSTP program for giving me this opportunity, as well as the other members of the Bowden Group for their support.

References

Environmental and hydrological sciences have been enriched by hardware and software research output over the past decades. New technologies and developments making significant impacts every year.

Technology such as sensors and physical modeling have been used for centuries to analyze river flow, landslides, and remote sensing. However, the recent boom in computing, artificial intelligence, and other innovations just in the last decade has caused significant changes in research methodologies and led to novel solutions to modern problems. Especially with the alarming rise in climate change, rise in sea levels, and conflict over water scarcity, it is more important than ever for hydrology research to constantly look for new options, as well as analyze the successes and failures of past research.

Editors of various hydrological journals allow us to efficiently obtain article, journal, and author metadata through the use of APIs and automated data mining.

| Fig 1.1: Satellite used for hydrological scanning and mapping |
| Fig 1.2: Drone employed in remote sensing and aerial data collection |
| Fig 1.3: A 3-D surface model and simulation of watershed river flow |

By discovering connections between specific technology and which hydrological fields they are employed, our research hopes to uncover potential uses of technology in fields that have not yet used them to their full potential. We also hope to use contextualize popular technologies that are currently being explored with their past employment.

**References & Acknowledgements**

I would like to thank the Belin-Blank Center and SSTP Program for providing this research opportunity for me, as well as Carlos Ramirez, Yusuf Sermet, and Professor Demir for guiding me on my five-week experience.


The trends over the past five years have reflected recent technological developments. For example, Artificial intelligence and big data have remained popular throughout the years. Modeling and Web Applications have likely remained stable over the past decade. Among the most popular hydrological subfields include groundwater and rainfall modeling, as well as chemical hydrology. These results are important because it reveals new technologies, like biotechnology, that one might not have considered to be applicable to hydrology research but are actually prevalent. Although it is not used as often as things like AI and modeling, it is nonetheless worth consideration for further investigation into its implications.

In the future, we would like to repeat the same study to see how the field of hydrology and its subfields have further evolved, as well as testing other classification algorithms while using a more comprehensive list of buzzwords.
The Effect of Circadian Rhythm Disruptions on Serotonin Neurons and Time-of-day Dependent Serotonergic Chemosensitivity

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1Horace Greeley High School, Chappaqua, NY, USA; 2Secondary Student Training Program; 3Medical Scientific Training Program; 4Interdisciplinary Graduate Program in Neuroscience; 5Iowa Neuroscience Institute; 6Department of Neurology, University of Iowa Carver College of Medicine, Iowa City, IA, USA

Introduction

- Epilepsy is a neurological disease associated with spontaneous seizures.
- 1 in 26 people will develop epilepsy within their lifetime.
- Sudden unexpected death in epilepsy, or SUDEP, is a phenomenon where seizures result in death.
- SUDEP occurs more frequently during the night.
- Nocturnal mouse models of seizure-associated death are also more likely to die during the night.
- The mechanism driving nighttime risk of death in SUDEP is unknown.
- The neurotransmitter serotonin (5-HT) is a compelling target of study, due to its known daily fluctuations in the brain, relationship with seizure mortality and severity, and role in CO2 chemosensitivity.

Hypotheses

1. Disruption of the circadian rhythm (viral ablation, electrolytic lesion, and genetic deletion) will result in fewer serotonin neurons.
2. 5-HT-associated CO2 chemosensitivity (CO2 arousal and the hypocapnic ventilatory response, HCVR) is time-of-day-dependent with the lowest response during the night in wild-type animals and low regardless of time of day in mice lacking 5-HT neurons in the brain.

Materials and Methods

Experiment #1 – Neuroanatomy

- Lmx1b+/f/f mice
- Electrolytic disruption of brain target
- SUDEP
- Spontaneous Epilepsy
- Chemosensitivity
- Neurotransmitter
- 5-HT

Experiment #2 – Development of an Open-Loop Trigger and Serotonin Physiology

- Open-loop system
- Day/night
- CO2
- Ventilation
- Brainstem

Graphical Abstract

Results

Discussion/Conclusion

Neuroanatomy: Electrolytic lesioned mice have more DRN 5-HT neurons than sham lesioned & dual viral ablation mice.

Open-Loop System: reduce experimental confounds and improve time-of-day-dependent experiments in the future.

CO2 arousal and HCVR: wild-type (Lmx1b+/f/f) mice demonstrate time-of-day-dependent variability in CO2 arousal and HCVR.

In the future, chronotherapeutic strategies that influence serotonergic physiology could be leveraged to reduce the nighttime risk of death for people living with epilepsy.

Future Directions

1. Find time-of-day-dependent regulation of 5-HT-associated genes (tryptophan hydroxylase, TPH & serotonin transporter proteins).
2. Study how seizures at different times of day affect serotonergic physiology (induce seizures followed by an automatic gas challenge).
3. Investigate the serotonergic physiology (CO2 arousal and HCVR in Lmx1b+/f/f (5-HT knock-out) animals.
4. Explore alternative serotonin physiologies (autoresuscitation & post-ictal generalized electroencephalography suppression)

Acknowledgments

This work was supported by the NIH/NIGMS T32 GM007337 (to Iowa MSTRP), NIH/NINDS R01 NS056842 (to GFB), NIH/NINDS R01 NS13209722 (to GFB), Cure Epilepsy Award - The Joanna Sophia Foundation (to GFB), and the Beth L. Tross Epilepsy Professorship (to GFB).

References


Figure 1. Fluorescent IHC was used to label TPH2+ 5-HT neurons in the DRN. A. A zoomed out image of a representative coronal section containing the DRN. B. Comparable zoomed in images from just ventral to the cerebral aqueduct used for cell counting experiments. C. TPH2+ positive neurons were counted and secondarily verified by another scientist.

Figure 2. Number of TPH2+ neurons in the DRN following lesion. Preliminary cell counting studies demonstrate more TPH2+ neurons following electrolytic lesioning compared to sham and viral ablation groups.

Figure 3. Actograms from each lesion strategy. Motion sensors were used to capture locomotor activity. Electrolytic-lesioning, but not attempted viral ablation, resulted in arrhythmic locomotor activity in constant darkness.

Figure 4. A novel open-loop system was developed to trigger gas challenges at specific times of the day automatically. A. A flow chart that shows the design of the system. Gas switches were controlled by a programmable microcontroller (Arduino Uno) interfacing with a real-time clock using the open-loop system. B. The graphical demonstration of the system set-up with a newly created Plethysmography chamber where Mice were placed in a novel plethysmography chamber with access to food, water, and bedding, which allows for overnight experiments.

Figure 5. Time-of-day-dependent rhythm in hypercapnic ventilatory response (HCVR) will be quantified by comparing ventilation (volume of air moved through lungs) under CO2 versus room air conditions. A. Bar graph demonstrating the difference of awake versus RA and CO2. B. The difference between the percentage of awake in RA and CO2.

Figure 6. Time-of-day-dependent rhythm in hypercapnic ventilatory response (HCVR) will be quantified by comparing ventilation (volume of air moved through lungs) under CO2 versus room air conditions. A. Bar graph demonstrating the difference of awake versus RA and CO2. B. The difference between the percentage of awake in RA and CO2.
Hemophilia A (Factor VIII deficiency) is a bleeding disorder caused by defective or missing Factor VIII, a blood clotting protein. Hemophilia A is associated with neurophenotypic differences including increased cerebral microbleeds, mental health disorders, and decreased brain volumes in hemophilia patients (Al-Hunti et al., 2019, 2020). Staber lab has found significant differences in select neuro-inflammatory marker expression between human hemophilia and healthy patients.

**Research Objectives**

1. Measure the relative gene expression of pro-inflammatory and pro-repair markers in 6-week FVIII deficient (hemophilia) mice.
2. Examine anxiety-like behaviors in hemophilia mice compared to wild type behavior test data.
3. Determine if 6-week hemophilia mice express similar neurocognitive and behavioral differences observed in 8- to 12-month-old mice and humans.

**Methods**

**Behavioral Tests**

<table>
<thead>
<tr>
<th>Type of Behavioral Test</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevated Zero Maze</td>
<td>Measures anxiety-like behavior in mice by analyzing time spent in the open (higher for anxiety-like) or closed (lower for anxiety-like) arm of the maze.</td>
</tr>
<tr>
<td>Open Field Tests</td>
<td>Measures anxiety-like behavior in mice by analyzing time spent in the open (higher for anxiety-like) or closed (lower for anxiety-like) arm of the maze.</td>
</tr>
<tr>
<td>Tail Suspension</td>
<td>Measures depression-like behavior in mice by analyzing time immobile (higher for depression-like) or mobile while hanging by the tail.</td>
</tr>
<tr>
<td>Fear Conditioning</td>
<td>Assesses learning and memory by delivering a shock to a tone while immobile (higher for depression-like) or mobile while hanging by the tail.</td>
</tr>
</tbody>
</table>

**RT-qPCR Relative Gene Expression**

- **A** Cortex
- **B** Hippocampus
- **C** Cerebellum
- **D** Brain Stem

**Results**

**Future Directions**

1. Increased sample size – use a power test to determine the number of mice needed to produce statistically significant results.
2. Continue expanding the age range of mice studied in order to reveal more about the relationship between neuro-inflammation and hemophilia.
3. Utilize knowledge about the neuro-cognitive component of FVIII deficiency to improve treatment for Hemophilia A patients.

**References**


**Acknowledgements**

I would like to thank Dr. Staber for welcoming me into her lab and giving me the opportunity to contribute to her research. Special thanks to Danielle York for her generous mentorship this summer, as well as Kevin Gabner for his help with qPCR and date analysis. I would also like to thank the SSTP program and Blank Blank Center for curating this summer research experience. Images created with Biorender. PRISM Graphpad was used for graph generation and data analysis.
Introduction

- Sea Spray Aerosols (SSAs) are generated from the air bubbles entrained from the breaking of sea waves.
- SSAs can influence Earth’s radiative budget both directly and indirectly.
- SSAs are highly variable and unpredictable, so we need to examine them on an individual particle level to see their effects on the climate.
- The Atomic Force Microscopy (AFM) has been proven to be an effective way to analyze individual SSA particles.
- SSAs have different morphologies and phase states under different relative humidity (RH).
- The wind speed of 1600 rpm generated by a fan simulates a wind speed of 19.1 m/s at 10 m height above the ocean surface.

Objective

Investigating the morphologies and phase states of SSA particles sized from ~70 to 1200 nm under the wind speed of 19 m/s.

Instrumentation

1. Fill the tank with collected seawater and use a fan to simulate a wind speed of 1600 rpm (approximately 19.1 m/s).
2. Deposit SSA particles onto the hydrophilically coated silicon substrates in the MOUDI.
3. Get the particle scans and force plots using the AFM instrument.

Methodology

I. Determine the morphologies of each particle using the images scanned by the Atomic Force Microscope (AFM).
II. Determine if a particle is a liquid using the force plots and the Relative Indentation Force (RID) formula:
   i. Measure the indentations at 20 nN on the force plots of the particle
   ii. Use the Height image scanned by the AFM to determine the particle height
   iii. RID = Indentation / Particle Height
      (Larger RID value = softer particle; smaller RID value = stiffer particle)
   iv. If RID > 0.95, the particle is in liquid state; otherwise, it is either a solid or semisolid
III. Determine if a particle is a solid or a semisolid using the force plots and the Viscoelastic Response Distance (VRD) formula:
   i. Smooth the force plots to ensure that the noise during the experiment did not affect the results measured at a particular RH
   ii. Measure the distance (in nm) between the approach and retract curves at 0 nN, and this value is the VRD
   iii. If VRD < 0.5, the particle is a solid; otherwise, it is a semisolid (only if its RID < 0.95)

Results

Core-shell shaped SSA particles’ phase state distribution at 20% and 60% RH (measured at their shells):
- At 20% RH, ~94% were solids or semisolids.
- At 60% RH, ~97% were semisolids or liquids.

Sea Spray Aerosols’ Morphologies and Phase States under the Wind Speed of ~19 m/s

Mengnan Sun, Chamika K. Madawala, Alexei V. Tivanski

Sea Spray Aerosol Particles’ Morphologies and Phase States under the Wind Speed of ~19 m/s

Conclusion

These findings show a significant variability in SSA morphology and phase state with respect to a particular wind speed. Thus, the variability observed by the current findings suggests the importance of investigating the dynamic nature of SSAs’ morphology and phase state as a function of wind speed to accurately predict their climate-related effects.

Acknowledgments

Special thanks to Chamika K. Madawala, Alexei V. Tivanski, and everyone in the Tivanski group for the help on this project. Huge thanks also to the Department of Chemistry at the University of Iowa and the SSTR program for providing the opportunity to do this research.

References

Assessing Effects of a Phthalate on Sperm Morphology in a freshwater snail ecotoxicology model

Yiyi Tu¹, Nadia Patel², Bryan Guevara³, Maurine Neiman³

¹The Bishop’s School, CA; ²Cedar Falls High School, IA; ³Department of Biology, University of Iowa, IA

Do plastic additives affect reproduction?

- Phthalates are a series of endocrine-disrupting chemicals often found in plastics and common commodities (Wang & Qian 2021).
- This study analyzes the influence of DMP on reproduction in the New Zealand mud snail (Potamopyrgus antipodarum).
- We hypothesize that DMP will negatively affect male sperm, predicting that these sperm would have different and potentially abnormal phenotypes relative to unexposed males, and with these consequences increasing with DMP dose.

Quantifying Sperm Traits

Fig 1. Dissection of P. antipodarum sperm duct under a dissecting microscope (Fig 1A and 1B at 30x; 1C at 40x). (A) Snail held with forceps. (B) Removed from shell. (C) Sperm duct.

Future Directions

- More sperm per snail are needed to adequately quantify abnormalities, which occur at fairly low (<<10%) frequency in normal sperm (Jalinsky et al. 2020).
- Increased DMP dosage might increase our ability to detect consequences in sperm.
- As P. antipodarum are a worldwide invasive species, a study comparing sperm in snails from different environments with different pollutant exposures could also be illuminating.
**I. Introduction**

- **Endometrial cancer (EC)** is the most common gynecologic cancer.
- The incidence (66,200 new cases/year) and death (13,030 death/year) are on the rise.
- **SETDB1**, a histone methyltransferase which regulates gene silencing, is overexpressed in EC and predicts worse survival.
- Knockout SETDB1 in EC cells slows down tumor growth and prolongs survival in mice.
- High expression of FLNA and CD47 predicts proliferation and immune evasion in EC.
- **SETDB1** promotes tumorigenesis by enhancing growth and decreases survival in EC patients and the high expression of ZNF266, ZNF841, and MT-CO1 predicts favorable survival in EC patients.

**What are the mechanisms that SETDB1 promote tumorigenesis in EC?**

**II. Purpose and Hypothesis**

- The purpose is to understand the oncogenic function of SETDB1 gene in EC.
- We hypothesize that SETDB1 can promote oncogene expression and repress tumor suppressor gene expression in EC.

**III. Procedure**

- **RT q-PCR**
  - Design primer using primer bank or IDT
  - Verify primer specificity using PCR
  - Run q-PCR to quantify mRNA expression
- **Western Blot**
  - Collect cells from cell plates
  - Extract protein from cells
  - Run Western blot to check protein expression
- **CHIP assay**
  - Find SETDB1 binding peak on the target gene
  - Design gDNA primer
  - CHIP assay
  - Run PCR and q-PCR to verify the binding

**IV. Method**

1. **PCR test**
   - Use PCR machine and Agarose gel
2. **RT q-PCR**
   - Use q-PCR machine (2 hrs)
3. **Extract protein**
   - Use agarose gel to extract proteins
4. **Western Blot**
   - Use Western Blot to check protein expression

**V. Results and Data**

**A.**

- **Cluster Heat map of SETDB1 and regulated genes**
  - POLR2A, FLNB, MKI67, CD47: high expression in NT1 cells, but low in SETDB1 knockout.
  - ZNF841, MT-CO1, ZNF268, ZNF84, ZNF583, CCR4, ZNF555: low expression in NT1 cells, but high in SETDB1 knockout.
- **Mitochondria super activity.**

**B.**

- **Activity test for MT-CO1 in NT1 and SETDB1 knockout**
  - Knockout SETDB1 reduces binding of SETDB1 and H3K9me3 on ZNF268 and ZNF841.

**VI. Conclusion**

- **Knockout SETDB1 greatly decreases POLR2A, FLNA, and increases ZNF268, ZNF841 and MT-CO1.**
- Depletion of SETDB1 decreases FLNA and CD47 expression at protein level.
- Depletion of SETDB1 enhances mitochondria super complex IV activity.
- SETDB1 directly binds on the promoter regions of ZNF268 and ZNF841, thus repressing their expressions through H3K9 trimethylation.

**VII. Discussion**

- **Understand how SETDB1 regulates POLR2A, MT-CO1, and SETDB1 itself.**
- For those genes that SETDB1 promotes, how SETDB1 promotes them in EC.
- Does SETDB1 trigger a chain of event that activate some other genes, thus resulting in promoting those genes?
- Does SETDB1 itself activate them?
- After we testified binding ability in ISH cell, can we generalize to all the cell lines?
- Test the function of downstream genes through either overexpression or knocking down the genes.
- Investigating the functional implication of the gene in tumor growth.

**VIII. Acknowledgement**

The project was supported by NIH R37-C2A38274(SY), the Department of Pathology Start-Up Fund(SY) and Belin-Blank Center SSTP.

**IX. Reference**

3D-Printed Silk Scaffolds for an In Vitro Lung-on-a-Chip Model

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PROBLEM ADDRESSED
- Drug discovery research involves the use of various models to predict drug effects in humans.
- Traditional 2D (i.e. Petri dish), 3D (i.e. hydrogel scaffold), and in vivo (animal) models have often proven to be oversimplified, expensive, and/or irrelevant.
- Such drawbacks have slowed research and resulted in higher drug prices (Cadeo et al., 2017).
- This could be addressed by a tissue model that can accurately, conveniently, and repeatable model human organs and organ systems.

PROJECT OBJECTIVES
- One recent concept to replace traditional models, the organ-on-a-chip (OoC), aims to replicate tissues via a careful combination of biocompatible scaffolds, microfluidic channels to maintain a flow of culture media, and physiologically relevant mechanical factors (Huh et al., 2012).
- This concept has been expanded with recent advancements in 3D printing, which enables customizable, efficient, and high-throughput manufacturing of monolithic proteinaceous scaffold materials (Mu et al., 2021).
- This study aims to evaluate lung cell growth on silk-based 3D printed scaffolds processed with different bioinspired solvents. Via optical density imaging to determine transparency and confocal microscopy to determine cell proliferation, we explore various salt ion effects on the ability of monolithic silk substrates to support lung alveoli cells in a lung-on-a-chip model.

We explored salt ion effects for manufacturing silk substrates to support lung alveoli cells in a 3D lung-on-a-chip model.

EXPERIMENTAL DESIGN
- Blood-air barrier
- Alveolar epithelial cells
- Proteinaceous basement membrane (BM)
- Vascular endothelial cells

REFERENCES

RESULTS

CONCLUSION & DISCUSSION
- **(NH₄)₂SO₄** scaffolds featured high cytocompatibility with a larger observed cell population and larger aggregates after five days of incubation.
- **K₂HPO₄** scaffolds featured high optical transparency, comparable with the PDMS control, for 3 days incubation.
- **NaCl** scaffolds featured the least observed cell population, but have previously demonstrated superior mechanical performance via higher structural beta-sheet concentration, which may be relevant for stresses exerted by integration into a lung-on-a-chip (Mu et al., 2023).

Future work includes investigation of the exact nature of special ion effects on silk protein molecular assembly, as well as optimization to produce the most biocompatible and experimentally viable scaffolds.

ACKNOWLEDGEMENTS

This work was supported by the National Science Foundation Graduate Research Fellowship and the Roy J. Carver Department of Biomedical Engineering at the University of Iowa. We would like to acknowledge the assistance of Mr. Jacob Olsen, Mr. Reynold Tawiah-Quashie, and the rest of the SSTP and Belin-Blank staff.

Fig. 1. Solid film prints (8x10.05 mm) were post-processed in three salt baths which were derived from the in vivo silk-spinning conditions of Bombyx mori. Each treatment solution results in unique optical, mechanical, and bioactive properties. Higher optical transparency allows for better imaging while a porous surface results in better cytocompatibility. Scanning electron microscopy was performed to characterize film surfaces at 2kV and 10,000x magnification.

Fig. 2. Experimental design was guided by the testing of three post-processing salt baths: NaCl, (NH₄)₂SO₄, and K₂HPO₄. 1. Silk was harvested and titrated (200 mL NaCl, 200 mL (NH₄)₂SO₄, and 200 mL K₂HPO₄) and dialyzed and concentrated. 2. Silk films were printed on a CELLINK Inkredible printer. 3. Prints were processed in various salt baths. 4. Mammalian lung cells were seeded on top of the prints and growth was measured via cell immunostaining and confocal microscopy after incubation at physiological conditions.

Fig. 3. In-vitro modeling via a two-sample t-test assuming unequal variance. NS: p ≤ 1.00, *: 0.01 < p ≤ 0.05, **: 0.001 < p ≤ 0.01, ***: 0.0001 < p ≤ 0.001, ****: p ≤ 0.0001. P-values were calculated using GraphPad Prism.

Fig. 4. Confocal microscopy of H1299 cancerous lung cells immunostained with DAPI (405 nm, shown in blue) and phalloidin (488 nm, shown in green), which indicate cell nuclei and cytoskeletons, respectively. Silk background autoflouresces (seen as blue) due to amino acids and disulfide present in the silk protein.

Fig. 5. Left-to-right: 3D stack reconstructions of confluent aggregates on **(NH₄)₂SO₄**, and **K₂HPO₄**, after 3 days of static incubation, respectively. Large aggregates were observed as opposed to the expected monolayer, likely due to procedural difficulties.

Fig. 6. Mean percent optical transmittance of various post-processing methods on wet and dry silk substrates as compared to PDMS. ns: p ≤ 1.00, *: 0.01 < p ≤ 0.05, **: 0.001 < p ≤ 0.01, ***: 0.0001 < p ≤ 0.001, ****: p ≤ 0.0001. P-values were calculated via a two-sample t-test assuming unequal variance.
Effect of Early Life Stress on Microglia in the Prefrontal Cortex of Mice

Gloria Wu, Sara B. Mitchell, Rainbo Hultman, PhD, Hanna E. Stevens, PhD

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Background

- Microglia are the brain’s resident immune cells. 1
- Microglia are impacted by early life stress (ELS), 2
  - Microglia are lastingly impacted in the human brain after childhood abuse and could lead to increased vulnerability to psychiatric disorders.
- The prefrontal cortex (PFC) is one of the last structures to develop, making it more vulnerable to the effects of ELS. 3
- Maternal separation leads to a decrease in microglia in the infralimbic PFC (IL) compared to the prelimbic PFC (PL) in male mice. 4
- Women are more susceptible to the effects of ELS. 5

Hypothesis: ELS causes a decrease in microglia density and soma size in the PFC of adolescent female mice.

Methods

- Brain tissue of 11 adolescent (P30) female mice were immunostained for Iba1, a marker for microglia.
  - Control group (N=5), ELS group (N=6)
- Slides were cover-slipped with VECTASHIELD with DAPI to visualize cell count.
- Pictures were taken using a fluorescent microscope.
  - Three sections containing the PFC per brain (35 µm sections).
  - Four fields per section (two per hemisphere); two in the PL, two in the IL.
  - Two focal planes per image field.
  - One Iba1 + one DAPI picture per focal plane.
- Microglia density per field and soma sizes were recorded using ImageJ’s measurement tool.
- GraphPad Prism was utilized for statistical analysis.

Results

- There is a trending decrease (p=.06) in microglia density in the PFC between the control group (M=0.0015) and ELS group (M=0.0012), but no significant difference between the PL and IL.
- There is no statistically significant difference between the soma sizes of microglia in the control group (M=725.5) and ELS group (M=716).

Conclusions

- ELS causes a trending decrease in microglia density in the PFC of adolescent female mice but no significant difference in soma size.
- ELS does not seem to have a differing impact on microglia density or size in the PL vs. the IL.
- A decrease in microglia density could potentially impact their ability to form and wire neuronal circuits, however more research is needed.

Future Directions

- Differences in microglia morphology.
- Sex differences in microglia density, size, and morphology.
  - A previous study has shown that ELS causes an increase in microglia density in the PFC of adolescent male mice. 6
  - Long-term impact of ELS on microglia.
  - Impact of ELS on microglia in different regions of the brain.
  - Impact of ELS on the density of different brain cells.

Acknowledgements

Special thanks to the Hultman Lab, Stevens Lab, and especially my mentor, Sara Mitchell, for their continued support throughout the course of this project. I would also like to thank SSTP and the Belin-Blank Center for this opportunity.


References

Exploring Vocal Acoustic Features as a Marker for Depression and Anxiety Status with TMS Treatment

Background:
- Approximately 280 million people around the globe struggle with depressive disorder, and approximately 8.4% of the US population are suffer from Major Depressive Disorder (MDD) in 2020. Those numbers continue to increase. (World Health Organization, 2020)
- Of those with depression, almost one-third are simultaneously treatment-resistant (World Health Organization, 2020)
- Anxiety disorders dominates ~20% of the US. (Lépine et al., 2002)
- TMS (transcranial magnetic stimulation) helps improve treatment-resistant depression by using series of magnetic pulses to stimulate nerves in the areas associated with depression. Thus, altering depression via brain wave stimulation. (UC San Diego Health)
- TMS can help anxiety by activating brain cells regulating mood. (UC San Diego Health)
- Vocal features can act as markers for one’s depression because they are difficult to hide; jitter and shimmer score have abnormalities in those with depression. (Weintraub et al., 2023)
- Previous studies show that pitch and volume decreases with one’s depression scores, (Weintraub et al., 2023) while their hoarseness increases (Jia et al., 2019).

Objective:
- Identify vocal biomarkers of depression and anxiety in a sample undergoing TMS treatment for MDD or other severities of depression.

Research Question:
- How significant of a correlation does acoustics have with one’s depression and anxiety status before and after TMS treatment?
- Can vocal acoustics (e.g., loudness) predict depression and anxiety scores?
- Can these features predict who will respond best to TMS treatment?

Methods:
- Speech samples from 20 patients with either MDD or other forms of depressive disorders were collected in the University of Iowa Clinic
- Quantitative measurements of depression and anxiety were collected weekly from the PHQ 9 (Patient Health Questionnaire) and GAD 7 (Generalized Anxiety Disorder Assessment) scores.
- Weekly speech samples were extracted from each patient during every TMS treatment.
- Acoustic features such as jitter scores, shimmer scores, mean pitch, HNR (Harmonic to Noise Ratio), standard deviation of pitch, and loudness were extracted using Surfboard, a Python tool. and their difference scores were calculated.
- Correlation tests (TTests, R correlation tests, p values) were used to compute levels of association between acoustic features and PHQ 9 and GAD 7 scores in the R script.

PHQ 9 and GAD 7 Score Comparison:

Mental Health Scores and Acoustic Scores Correlation:

Acoustic Features Predictive of Treatment Response:

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>Beta Estimate</th>
<th>P Value</th>
<th>R²</th>
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<td>GAD 7 Response Score</td>
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<td>PHQ 9 Response Score</td>
<td>Loudness Before Treatment</td>
<td>-0.45</td>
<td>0.346</td>
<td>6%</td>
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</tbody>
</table>

Conclusion:
- TMS is an effective treatment for depression and anxiety.
- Anxiety is significantly correlated with vocal acoustics.
- Vocal acoustics can predict TMS treatment response
- This study has some limitations including a small sample size, no placebo treatment, and treatment duration inconsistency.
- Future directions for this study would be to see if vocal acoustics in treatment responses have correlations with other psychiatric disorders, and to identify variables associated with non-responsive TMS patients.

References

Acknowledgements
We are grateful to all the individuals who participated in this study. Thank you to Aaron Bode MD, PHD and Nick Trapp MD for administering the TMS treatment to the patients. Importantly, special thanks to everyone in the Michaelson lab for mentoring me and the Belin Blank center for providing me with this research opportunity.

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Physical and Computational Analysis of Metal Complexes to Better Understand Metal-Ligand Bonding

Alan Xu1, Dhruba R Paudel2, Aditi Bhattacharjee, Ph.D.2

Background and Objectives
A coordination complex is a chemical compound that consists of a central atom, often a metal, and various surrounding molecules known as ligands. Metal-ligand bonding is an interesting topic in that there are very many unique ways in which a ligand can bond to a metal in a complex.

A cyclopentadienyl anion (C5H5- or commonly Cp-), is a common organic ligand. Cp- can bond to a large set of different metals to form interesting coordination complexes with various unique properties.

Metal-ligand bonding is an especially interesting topic considering the way Metal-ligand interactions can occur on a spectrum of covalence. Not only that, these interactions mirror acid-base reactions concerning electron donation during bonding. Ligands can also coordinate through multiple contiguous atoms. Almost all complexes with cyclopentadienyl have a hapticity of 5, meaning all five carbons in the cyclopentadienyl ring are bound to the metal ion.

The overall objective boils down to a single question:
How exactly do metal-ligand bonds work between cyclopentadienyl and metal ions
This question involve many smaller questions as well:
How exactly are electrons shared in these bonds? Are there any differences between this any other bonds at hapticity one? How does electron-sharing work in higher hapticities?

Methodology
Complex molecules are first modeled with Gaussview, where bond distances and energies are left ambiguous.

The files are then packaged into data files, and computer calculations are run to find exact bond energies, bond lengths, and to correct atomic positions.

Then, UV-vis spectroscopy is run on the substance while considering expected results.

Results

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<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>Fe   0.845350</td>
</tr>
<tr>
<td>2 C   -0.312803</td>
</tr>
<tr>
<td>3 H   0.228876</td>
</tr>
<tr>
<td>4 C   -0.313154</td>
</tr>
<tr>
<td>5 C   -0.313154</td>
</tr>
<tr>
<td>6 H   0.228824</td>
</tr>
<tr>
<td>7 C   -0.313901</td>
</tr>
<tr>
<td>8 H   0.228824</td>
</tr>
<tr>
<td>9 C   -0.313901</td>
</tr>
<tr>
<td>10 H  0.228856</td>
</tr>
<tr>
<td>11 H  0.228856</td>
</tr>
<tr>
<td>12 C  -0.312803</td>
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<tr>
<td>20 H  0.228856</td>
</tr>
<tr>
<td>21 H  0.228856</td>
</tr>
</tbody>
</table>

Absorbance of Ferrocene vs Wavelength (nm)

Implications
Most of these results simply confirm what we already knew or suspected:
- Shared equal charges among carbons in cyclopentadienyl complexes (with a hapticity of five)
- Expected ultraviolet absorbance at around 200 nm along with expected absorbance at around 400 nm

Ultimately, these results help set up deeper research involving more advanced research techniques.

Conclusion
Although the results were not necessarily interesting, they set us up for further research into these molecules, and potential to find interesting interactions with different wavelengths of light.

Acknowledgements and References


Most of these results simply confirm what we already knew or suspected:
- Shared equal charges among carbons in cyclopentadienyl complexes (with a hapticity of five)
- Expected ultraviolet absorbance at around 200 nm along with expected absorbance at around 400 nm

Ultimately, these results help set up deeper research involving more advanced research techniques.

Acknowledgements and References


Thank you to the Aditi Bhattacharjee, Dhruba R. Paudel, Caleb H. DeWitt, Belin-Blank Center, and the University of Iowa
Identifying Brain Networks Critical for Working Memory

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Introduction

Working memory is a brain system that provides temporary storage and manipulation of information necessary for such complex cognitive tasks such as language comprehension, learning, and reasoning (Baddeley, 1992).

- Comprised of three parts
  - Central Executive – main processing unit
  - Phonological Loop – temporary storage of auditory information
  - Visuospatial Sketch Pad – temporary storage of visual and spatial information

Working memory can be measured in many ways including neuropsychological tests such as the digit span. Working memory is a brain system that provides temporary storage and manipulation of information necessary for such complex cognitive tasks such as language comprehension, learning, and reasoning (Baddeley, 1992).

Purpose and Hypothesis

We aimed to determine specific regions of the brain that influence working memory. We predicted the lateral prefrontal cortex in the left hemisphere to have the most influence due to previous research indicating its importance in the processing of words (Pisoni et al., 2019). The lateral prefrontal cortex has also been shown to house the central executive which is the impaired system in this experiment.

Methods

- Identified patients with lesions and working memory impairment
  - LDSF - LDSB ≥ 3
- Created heat maps which layered lesions of patients to help identify areas of concentration
- Generated T-tests comparing lesion location, specifically in the superior longitudinal fasciculus and the rest of the brain

Results

Figure A: 2D Heat maps of patients in different locations. Warmer colors represent higher lesion overlap

Figure B: 3D heat maps of patients. Warmer colors represent higher lesion overlap

Figure C: T-test comparing patients with SLF damage to those without

Conclusion

- The greatest overlap of the lesions appeared in the intersection between the parietal and occipital lobe in the right hemisphere
- A small, less significant, population of lesions also appeared in the lateral prefrontal cortex on the left hemisphere
- T-test revealed significantly more patients had lesions within the SLF along with an average lower LDSB hinting at the SLF’s role in working memory.

Future Work

- Collect data for all patients in the registry
- Utilize different tests that measure working memory
- Create data collection standards that more strongly correlate to and measure working memory impairments.
  - Low LDSB score
  - LDSF-LDSB 3 and low LDSB score
- Generate voxel-based lesion-symptom mapping

Acknowledgments

Special thanks to thank Dr. Bowren and Dr. Tranel for all their guidance throughout this research experience. Thank you to the University of Iowa and the SSTP program for this amazing opportunity.

References

Effect of Interface Geometry on Dielectric Properties of Ceramic-Polymer Composites

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Background

Piezoelectricity is the property of certain materials that have a spontaneous electric polarization that enables the generation of a surface charge, in response to the application of an external mechanical stress on the material. Conventional piezoelectric materials, such as ferroelectric ceramics and piezoelectric polymers, have limitations in terms of energy conversion efficiency and brittleness. However, bi-continuous piezocomposites, which combines a ceramic phase and a flexible polymer phase, demonstrates both mechanical flexibility and piezoelectricity.

Study has shown that 3D printed all-dielectric structures could offer a convenient method to move towards the manufacturing of structures with metamaterial electromagnetic properties and tunable operational frequencies. We've also proven that the geometry of the interface between the ceramic and polymer does impact the capacitance of the composite. Under the same volume fraction of ceramics, when the interface has a larger surface area and volume, the interface geometries does not apply and might produce inconsistent outcome. Therefore, Analogdiscovery2 is used for measurement.

Methods

The purpose of this project was to validate our actual test results on permittivity of the integrated part by verifying the correct simulation parameters, based on the study of the correlation between the interface geometry and the capacitance of bi-continuous piezocomposites through comparison of data from virtual simulation and actual testing.

Objective

The study has shown that 3D printed all-dielectric structures could offer a convenient method to move towards the manufacturing of structures with metamaterial electromagnetic properties and tunable operational frequencies. The reason why the simulated capacitance in the first set of experiment is far off from actual value is because the additive manufacturing process for our BTO is not widely used, from the ingredient to heat treatment process. Thus, even though the permittivity of this material could be obtained, the literature value available does not match with the permittivity of the material that's manufactured under our procedure.

Discussion

• The reason why the simulated capacitance in the first set of experiment is far off from actual value is because the additive manufacturing process for our BTO is not widely used, from the ingredient to heat treatment process. Thus, even though the permittivity of this material could be obtained, the literature value available does not match with the permittivity of the material that's manufactured under our procedure.

• Measuring the capacitance for this specific application is very difficult, in that BTO is a very small and fragile part, so traditional method of measurement, like gold press, does not apply and might produce inconsistent outcome. Therefore, Analogdiscovery2 is used for measurement.

• Given that most segment of simulated capacitance in second trial is higher than that of the actual, the yielded result confirms our previous concern, because simulated capacitance is in an ideal condition. The smaller deviation, which is around 5% to 10%, also enhances the accuracy of the simulation.

Acknowledgements

I would like to give thanks Jake Atzen for his guidance and mentorship throughout my research experience at SSTP program, as well as for Dr. Xuan Song for his advice. I would also like to thank other members in this lab for all the help and support, and I wish the best luck for them in the future. This work is based on materials supported by the National Science Foundation Award No. 1825962.


References
Increasing Solar Panel Efficiency
Contributors: Dorothy Zhang, Sebastian Hazlett, Reyna Alam, Maxwell Leonard, Mentors: Dr. Fatima Toor, Dan Keefe, Rezwan Mohammad Sayeed

Introduction
Photovoltaics is a powerful source of energy; however, standard solar panels are approximately 20% efficient, due to recombination and surface reflection losses (PV Education). Solar concentrators reduce surface reflections, increase absorbance, and suppress radiative recombination (Van Dijk, 2015). Sun trackers maintain the constrained angle of incidence light from the concentrator. The purpose of our research is to increase the efficiency of solar panels by developing a solar system. Our research questions thus are:

1. What is the optimal geometric concentrator shape, and how can we generate standardized models and digitally test the lux of each?
2. What metallic coat on the concentrator inside can have best reflective properties?
3. How can we implement a sun tracker system either through sensor or data to best take advantage of the concentrator?

Based on previous research done, our hypothesis came to be:

An aluminum coated 8x circular parabolic concentrator will provide the optimal optical properties.

Methods

SOLAR TRACKER DEVELOPMENT – HARDCODED & PROGRAMMED

Approach 1: We created a 3D printed dual axis sun tracker inspired by online research. Servo motors continuously rotate until the adjacent photoreceptor input differences into the Arduino are within a certain range.

Approach 2: We developed a stepper motor tracker following the sun movements based on the SolTrack library given a time and location.

Wrote an OpenSCAD script to parametrically generate a matrix of 2x through 10x magnification, 3 through 12 n-side polygon parabolic concentrators, with dimensions based on Al-Shidhani’s research.

Rendered the concentrators in Radiance, a ray tracing software, to digitally simulate the effects of sunlight at a 0% acceptance angle (straight above) on the renders with mirror material.

Processed the luminance HDR (high dynamic range) images in Matlab to calculate the amount of lux (w/m^2) fallen on the bottom aperture of the solar cell.

Characterized the reflectivity of various flat pieces spray with chromium, aluminum, control, copper, nickel material. Using Ocean Optics spectrometer, we found chromium to have optimal reflectivity.

Polished using XTC-3D Print Coating, a combination of two basic chemicals which dissolves and redistributes the texture surface and coated the polished concentrator with chromium spray paint.

Used PV Education solar simulator and 3D print holder to test efficiency (short circuit current density) of concentrator on a standard solar cell.

Results

RADIANCE FINDINGS
MATLAB analyses of ray-traced Radiance renders found the highest optical efficiency in the circular 13x concentrator (height = 60cm, bottom radius=10mm, half-acceptance angle = 37 degrees, n-sides = 256).

SOLAR SIMULATOR FINDINGS
Highest non-control short circuit current density (Jsc) was the circular 10x concentrator. An increase in sides showed clear increase in efficiency, but concentration ratios didn’t correspond. This confirms Thomas Cooper’s previous work on parabolic solar concentrators, as well as the shape aspect of our original hypothesis.

Acknowledgments
Thank you for your guidance, Dr. Toor, Dan, and Rezwan. I could not have done this work without you. Thank you to my stellar research group, Maxipad the computer, Sebas the cyborg, and Reyna the Rebya, my family for the summer. And Nick you’re a real one. Caleb you’re cool too.

References

The Impact of CO₂ on EEG and Breathing Before and After Induced Seizure in an Amygdala-Kindled Mouse

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¹The Governor’s Academy, Byfield, MA, USA; ²Iowa Neuroscience Institute, ³Department of Neurology, Carver College of Medicine, Iowa City, IA, USA; ⁴Interdisciplinary Graduate Program in Neuroscience

Introduction

- Sudden unexpected death in epilepsy (SUDEP) ranks second only to stroke in years of potential life lost among all neurological diseases¹.
- SUDEP tends to follow a generalized tonic-clonic seizure which can cause hypercapnia².
- Respiratory dysfunctions have been implicated in the etiology of SUDEP³.
- Promoting signaling from the neurons in charge of the hypercapnic response can reduce the length of a SUDEP risk marker⁴ and modulate post-ictal breathing⁵.
- Therefore, the objective of the current study is to examine the impact of CO₂ on EEG and breathing before and after an induced seizure.

Hypothesis: We hypothesized that the impact of CO₂ on EEG and breathing may differ before and after an induced seizure

Methods

An EEG/EMG headmount was surgically implanted in a C57BL/6J mouse along with a bipolar electrode inserted into the right amygdala. After recovery, the mouse was exposed to a small current determined by afterdischarge threshold every day until it produced consistent afterdischarges. A custom MATLAB script was used to record EEG/EMG data. When RMS values of the EEG data exceeded a predetermined threshold, the script automatically initiated the gas valve to allow for the infusion of CO₂ for 6 minutes.

Figure 1. Schematic (A) and example traces (B) recorded using the closed-loop system of an amygdala kindled mouse of closed-loop system. The horizontal bars in (B) and (b1-3) indicate 30 sec and 1 sec, respectively.

Results

Figure 2. Changes of EEG activity in response to 7% CO₂ challenge pre and post an induced seizure. (A-D) Heatmaps (A and C) of averaged EEG power changes of all trials in response to elevated CO₂ concentration (indicated by the overlaid magenta curve) before (A) and after (C) an induced seizure. Mean values across 1-30 Hz frequency band were extracted and summarized in (B and D). Changes in different frequency bands of EEG activity were analyzed. (E and F) for delta band, (G and H) for theta band, (I and J) for alpha band, and (K and L) for beta band. Solid colored bar graphs indicate pre-seizure CO₂ challenge, while shaded colored bar graphs indicate post-seizure CO₂ challenge. One-way ANOVA was used for (B and D), and two-way ANOVA was used for (F, H, J, and L). * indicates p < 0.05.

Figure 3. Comparison of breathing patterns in response to CO₂ before (top) and after (bottom) induced seizure.

Conclusion and Future Directions

- CO₂ suppressed EEG activity in both pre- and post-seizure settings.
- The delta band power of the EEG data are notably less suppressed by CO₂.
- In the future, more detailed analysis on breathing data is required to fully decode the effect of CO₂ on breathing patterns.
- We would also investigate the interaction between CO₂ and seizure in the context of the serotonergic (5-HT) system.

References


Acknowledgements

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Effects of Stimulant Medication on Social Behavior for Three Children with ADHD

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Introduction

• ADHD is one of the most diagnosed neurodevelopmental disorders in children1
• 90% of diagnosed children are treated with stimulant medications2
• While the efficacy of these medications on reducing challenging behaviors is well documented, little is known about the side effects, particularly on social play2

Objective: Determine the effect of stimulant medication on decreasing social behavior in 3 children with ADHD

Participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Diagnosis</th>
<th>Medications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ross</td>
<td>ADHD, ODD, dyslexia, dysgraphia, anxiety, chronic motor tic disorder</td>
<td>15 mg Ritalin (MPH-IR) 2x daily</td>
</tr>
<tr>
<td>Chandler</td>
<td>ADHD</td>
<td>27 mg Concerta (MPH-ER) every morning 5 mg Ritalin (MPH-IR) as needed</td>
</tr>
<tr>
<td>Joey</td>
<td>ADHD</td>
<td>30 mg Vyvanse (Lisdexamfetamine-ER) every morning</td>
</tr>
</tbody>
</table>

Methods

• Observed seven-14 free play sessions on and off meds during functional analysis (FA) or free operant preference assessment (FOPA)
• 5-minute sessions were coded by a primary and reliability coder for the following behaviors:
  - Frequency:
    • Verbal, gestural, physical initiation & reciprocation
  - Therapist initiation and reciprocation
  - Duration:
    • Interactive play
    • Solitary play
    • Orienting towards
    • Orienting away

Results

Fig. 1: Ross Rates of Initiation/Reciprocation
Fig. 2: Ross % Engagement
Fig. 3: Chandler Rates of Initiation/Reciprocation
Fig. 4: Chandler % Engagement
Fig. 5: Joey Rates of Initiation/Reciprocation
Fig. 6: Joey % Engagement

Discussion

• Results support hypothesis that stimulants cause decrease in socialization in kids with ADHD, with some nuances

<table>
<thead>
<tr>
<th></th>
<th>Initiation/ reciprocation</th>
<th>Play</th>
<th>Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ross</td>
<td>Considerable increase in initiation/ reciprocation off meds</td>
<td>Higher % of session interactive/no % solitary off meds</td>
<td>Higher % of session towards/less away off meds</td>
</tr>
<tr>
<td>Chandler</td>
<td>Considerable increase in initiation/ reciprocation off meds</td>
<td>Minimal levels of interactive regardless, overlap of solitary %</td>
<td>Minimal levels of towards regardless, higher % away off meds</td>
</tr>
<tr>
<td>Joey</td>
<td>Negligible increase in initiation/ reciprocation off meds</td>
<td>Negligible % of increase of interactive on meds, solitary off meds</td>
<td>Higher % of session towards/less away off meds</td>
</tr>
</tbody>
</table>

Conclusion

• Overall, averages of initiation/reciprocation rates of all three individuals show considerable increase off medications
• Negligible differences in play may indicate less of marker for social behavior
• Slight difference in orientation
• Limited sample size, correlation between social play and stimulants should be studied more in depth
• Help inform doctors, patient, and family about side effects of medication

References