Constraining Tropical Rainfall Changes from Sparse Networks of Paleoclimate Data

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Overview

A band of heavy precipitation spanning the deep tropics is an essential feature of the climate system that diverse ecosystems and billions of people around the globe depend on. It is well known that this rainbelt, called the Intertropical Convergence Zone (ITCZ), when averaged across all longitudes, shifts north and south in response to heating or cooling the atmosphere in one hemisphere more than the other[1,2]; this framework has been widely applied to past tropical rainfall changes under differing climate states. Though the energetic framework of the zonal mean ITCZ has been widely used to assess mechanisms of change in the tropical rainbelt on seasonal to orbital timescales, it obscures the inherently regional nature of tropical rainfall and it is not clear to what degree proxy data documenting regional shifts in rainfall can be extrapolated to infer similar shifts at other longitudes.

In this study, I use a large suite of coupled climate model simulations to demonstrate that large zonal variations exist in the tropical precipitation response to forcing. I assess the zonal structure of meridional shifts in tropical rainfall in a compilation of climate models under a range of past and future climate forcings. Some forcings are characterized by strong hemispheric asymmetry (e.g. meltwater forcing in the North Atlantic Ocean, extratropical volcanic eruptions, and Last Glacial Maximum orography and albedo), while others are characterized by weak hemispheric asymmetry (e.g. quadrupling of atmospheric CO_2 and mid-Holocene orbital and greenhouse gas forcing).

Change in tropical precipitation under different climate forcings

Figure 1. *For each set of simulations, the total ΔP (top), zonally-symmetric component of ΔP ([ΔP]; middle) and zonally-asymmetric component of ΔP (ΔP*; bottom) is plotted (colors). The numbers in the top-left of the bottom two subpanels of each forcing indicate the fractional change in the root mean square error (RMSE) associated with the zonally-symmetric and zonally-asymmetric components of ΔP, respectively. The climatological multi-model mean precipitation for each set of control simulations is shown by the unfilled contours. Stippling in the top subplots indicate where 80% of the models agree on the sign of total ΔP (from Atwood et al., in press).*

Quantifying shifts of the ITCZ

Meridional shifts in tropical rainfall are characterized in terms of the mean annual tropical precipitation centroid, P_C (the latitude at which the mean annual area-weighted tropical rainfall to the north equals that to the south, within the bounds 20°N to 20°S). P_C is calculated at each longitude. I decompose forced changes in P_C (ΔP_C; defined as the difference between a forced simulation and a control simulation) in the following way:

$$\Delta P_C = [\Delta P_C] + \Delta P_C{}^* , \qquad (1)$$

where $[\Delta P_C]$ is the zonal mean change (i.e. ΔP_C averaged over all longitudes) and ΔP_C* denotes the deviation from the zonal mean. For each set of forcings, I compare the change in the zonal mean precipitation centroid $[\Delta P_C]$ to the change in the zonal variation of ΔP_C* (i.e. the 'waviness' of ΔP_C), quantifying the latter by the standard deviation of ΔP_C across longitudes (j).

$$\sigma_{Pc} = \left(\frac{1}{N-1} \sum_{j=1}^{N} (\Delta P_C - [\Delta P_C])^2 \right)^{1/2} = \left(\frac{1}{N-1} \sum_{j=1}^{N} (\Delta P_C{}^*)^2 \right)^{1/2} , \qquad (2)$$

The zonal mean precipitation centroid $[\Delta P_C]$ is compared to the change in the zonal variation of ΔP_C* in Table 1.. The results demonstrate that all forcings produce robust regional meridional shifts that are much greater than (and not always in the same direction as) the zonal mean shift.

Next Steps

Future work will focus on comparing the models output to proxy data, targeting two key periods: the Last Glacial Maximum (~21,000 years ago) and the most recent abrupt meltwater forcing event 8,200 yr ago. The target outcome is the design of an optimal proxy network for the purposes of inferring changes in the large-scale circulation patterns of the tropical atmosphere.
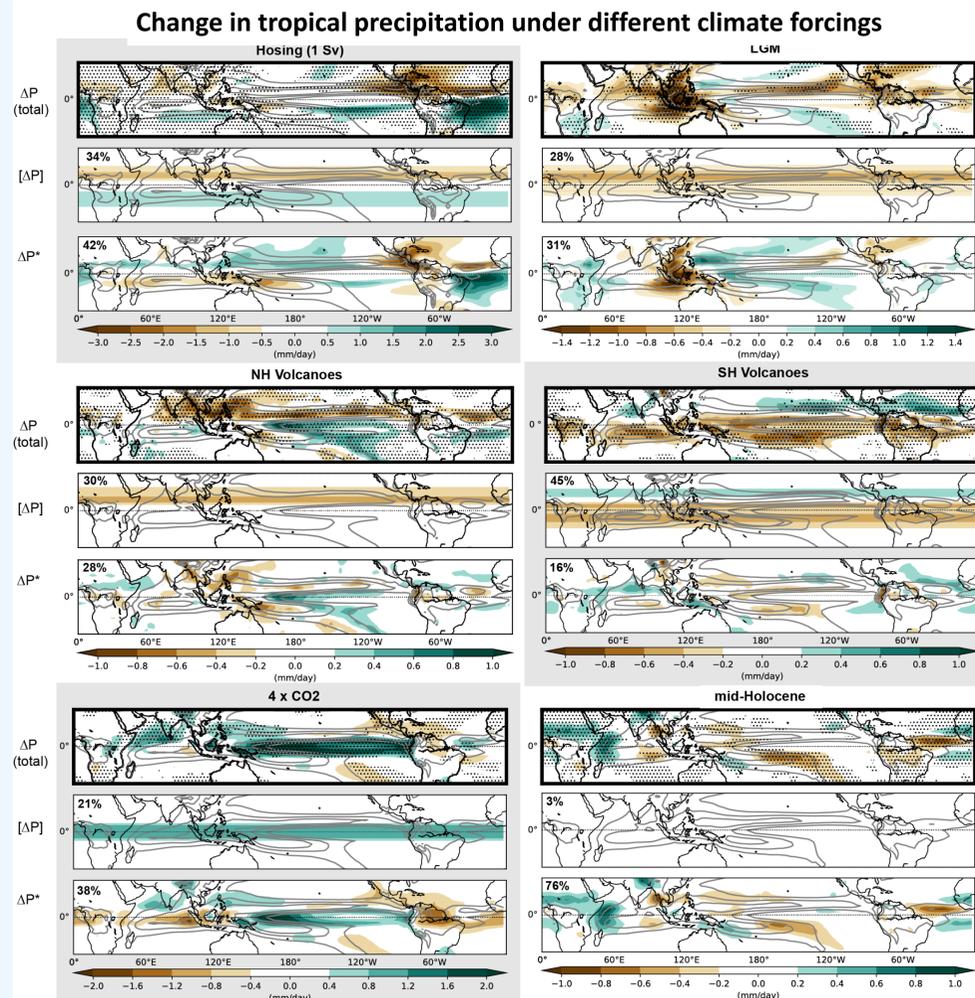
Outcomes

o In this project, I demonstrate that the energetic framework of the zonal mean ITCZ is not useful for characterizing shifts of the rainbelt at regional scales, regardless of the characteristics of the forcing. Shifts of the rainbelt vary from place to place and thus data documenting north or south shifts in one location can't be used to infer similar shifts at other longitudes.

o Forcings with large hemispheric asymmetry such as extratropical volcanic forcing and meltwater forcing give rise to robust zonal mean shifts of the rainbelt, but the direction and magnitude of the shift varies strongly as a function of longitude (Table 1). Even the Pacific rainband doesn't shift uniformly under any forcing considered (Fig. 1). Forcings with weak hemispheric asymmetry such as CO_2 and mid-Holocene forcing give rise to zonal mean shifts that are small or absent, but the rainbelt does shift regionally in coherent ways across models that may have important dynamical consequences.

o These findings demonstrate the zonal complexity inherent in changes in tropical rainfall and caution against the practice of inferring large-scale changes in tropical rainfall based on paleoclimate data from a limited spatial domain. These results are presented in Atwood et al. (in press).

Selected References: [1]**Kang et al.** (2008) The response of the ITCZ to extratropical thermal forcing: Idealized slab-ocean experiments with a GCM. *Journal of Climate*; [2]**Donohoe et al.** (2013) The Relationship between ITCZ Location and Cross-Equatorial Atmospheric Heat Transport: From the Seasonal Cycle to the Last Glacial Maximum, *Journal of Climate.*; [3]**Atwood et al.** (in press) Robust longitudinally-variable responses of the ITCZ to a myriad of climate forcings, *Geophysical Research Letters.*

Table 1. Zonal mean and zonal variation in meridional shifts of the precipitation centroid under different forcings

Centroid metrics	Forcing type						
	Volcanic (NH)	Volcanic (SH)	Hosed (1 Sv)	Hosed (0.1 Sv)	LGM	mid-Hol	4 x CO2
[ΔPc] (multi-model mean ± standard error)*	-0.72 ± 0.10	0.59 ± 0.09	-2.48 ± 0.02	-0.23 ± 0.03	-0.53 ± 0.15	0.27 ± 0.08	-0.07 ± 0.12
σPc (multi-model mean ± standard error)*	0.77 ± 0.07	0.71 ± 0.10	2.45 ± 0.18	0.23 ± 0.02	1.84 ± 0.20	0.82 ± 0.10	1.61 ± 0.13
# models with northward shift of [ΔPc]	0/12	9/9	0/13	0/4	1/13	8/10	9/18
# models with southward shift of [ΔPc]	12/12	0/9	13/13	4/4	12/13	2/10	9/18

Differentially Private Bayesian Model Validation

Andrés Felipe Barrientos

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1. Problem statement

Data stewards from a variety of settings, including national statistical agencies, survey organizations, health systems, and private companies, must protect individuals' private information. They also seek to grant access to their data to researchers and the broader public. Often times, researches only need to perform statistical analyses on the data rather than to access individuals' information.

One of the goals of data privacy is to provide tools that allow researches to perform statistical analysis while protecting private information. To protect individuals' confidentiality, statistical methods have to be designed to satisfy **differential privacy**: a popular and formal privacy property that enables data stewards to bound the potential information leakage in each analysis. There is a vast literature on differentially private statistical methods, which rely on specific modeling assumptions that need to be verified. Violations of any of those assumptions might lead to erroneous inferences and conclusions. Model validation approaches have to be designed to satisfy differential privacy. There are very few contributions at the intersection of model validation and differential privacy.

Long term goal: To develop differentially private methods for model validation for several types of statistical analyses.
Short term goal: To develop differentially private methods for model validation for regression analysis. Regression analysis is one of the most common statistical methods available to examine how a variable of interest (response) relates to other variables (predictors).

2. Differential privacy and statistical analysis

Statistical analyses rely on summaries of the data. To perform statistical analyses, researchers do not need to have access to individuals' information but to the corresponding summaries. Unfortunately, summaries of the data can also reveal information about specific individuals in the confidential dataset.

Assume that a researcher (or employee) does not have access to individual records but can query how many associate professors in a public university are HIV-positive. The researcher found out that, by the end of July 2020, out of 501 associate professors, 23 are HIV-positive. Bob, an associate professor and colleague of the researcher, decided to leave the institution at the beginning of August 2020. As soon as Bob left the public university, the researcher asked for the same summaries again and found that out of 500 associate professors, 22 are HIV-positive. The researcher now knows that Bob is HIV-positive.

Differential privacy protects individuals' confidential information by releasing a noisy version of the summaries of interest. We define differentially private methods for model validation using the same trick, i.e., by adding noise to the summaries defining the method.

3. Validation server
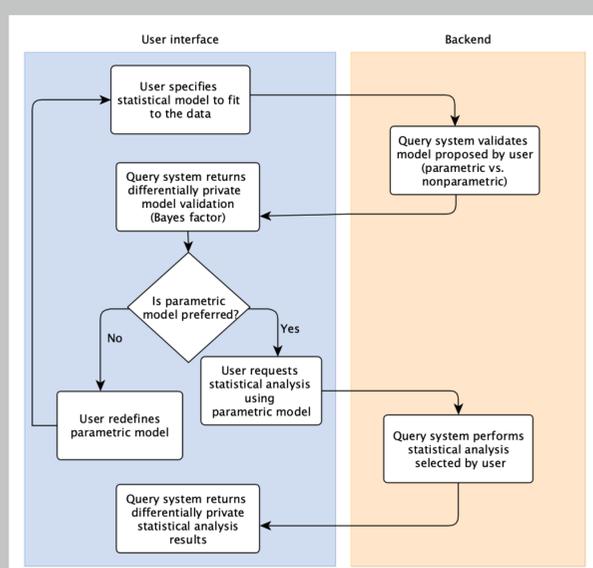
Model validation is performed through a server which houses the confidential dataset. Model validation consists of determining whether or not a model has been correctly specified (i.e., the assumptions have been met). A key quantity in model validation is the **probability that the model has been correctly specified given the available data**. By adopting a Bayesian approach, we are able to compute this quantity while accounting for both the randomness associated with the data and the noise added to make it differentially private. **Bayesian statistics** allow researchers to update their prior beliefs regarding this probability using newly acquired data.

## 4. Universal residuals for regression analysis

For any regression analysis, we can compute the universal residuals by means of Rosenblatt's transformation. If the model is correctly specified, the universal residuals meet two properties: i) they are uniformly distributed and ii) they are independent of the predictors. We develop **two differentially private algorithms** for model validation to verify the uniformity and independence of the residuals.
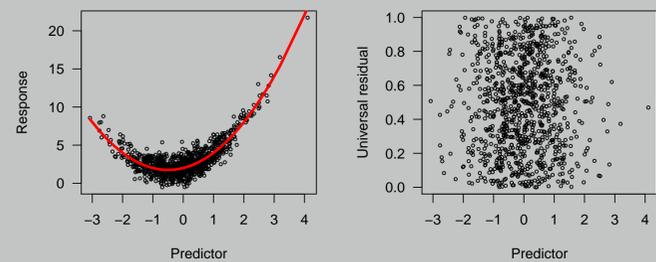
Algorithm 1: Binned residuals

Strengths: fast, scalable, and works with small sample sizes.
Limitations: only able to verify the uniformity of the residuals and sensitive to the number of bins.
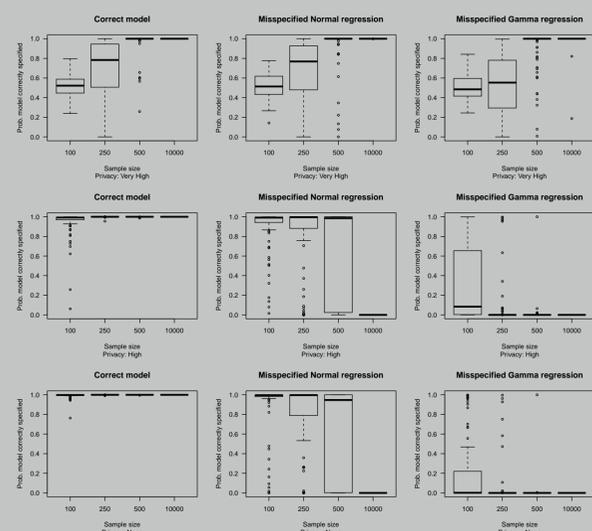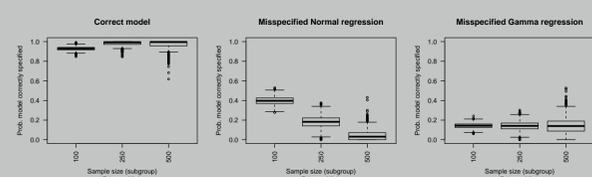

This figure displays results for different privacy levels and using simulated data.

Algorithm 2: Sub-sample and aggregate method

Strengths: fully nonparametric and able to verify the uniformity and independence.
Limitations: computationally expensive and requires large sample sizes (a commonly assumed scenario in differential privacy) .

This figure displays results for a high privacy level using simulated data and assuming a sample size equals 10,000.

Future work

Calibrate and find a default set up for Algorithms 1 and 2.

Keep developing differentially private methods for model validation for different types of statistical analysis other than univariate regression.

Add developed methods to the validation server that will be constructed under an initiative at Urban Institute (housing data from the IRS) and with potential funding from Sloan Foundation and NSF. Dr. Barrientos is currently collaborating in this initiative.

Contact information

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EXPANDED CINEMA LAB

COVID-19 Fallout
My summer research plans were compromised as a direct result of the limitations generated by the pandemic. The Florida Prize Competition at the Orlando Museum of Art was postponed. Turning the setback into an opportunity, I chose to develop a platform for interdisciplinary

We are in the process of founding a **New Media Festival** here in Tallahassee. We plan to bring in national-level artists to produce projects in collaboration with local talent from FSU, TCC, FAMU, and the broader arts community. Our doors are open to all friendly people, regardless of previous experience.

Research Goals Reached
1. Through the generosity of Scott Balog (Executive Director at the TCC Center for Innovation), we secured a unique 5,000 square foot space in which to base our lab. The size of the space makes safe experiential collaboration feasible.
2. Gained Faculty Affiliates from the FSU Innovation Hub, and from the Departments of Dance, Theatre, Film, Communications, and Music.
3. Confirmed Senior Advisors and Board Members from 7 other research universities.
4. Built a VR Cave.
5. Construction of an electric hybrid harp/guitar (Bharptar) using a salvaged car door. We will continue on to build an electric orchestra out of salvaged auto parts -- the Car Crash Orchestra.
6. Completion of a 43x12' neon wall installation

Future and Ongoing Research at the lab and through remote lab affiliates includes work into the fields of artifical intelligence, interactive installations, automated authorship, creative coding, hacktivism, pirate radio, tech-augmented dance and performing arts, light art, DMX, OSC, ArtNet, and MIDI protocols, mobile guerrilla projection, drones and machine vision, VR, AR, MR, internet art, 3D animation, 3D scanning, 3D bio-printing, and electronic music.

ExCineLab Exhibitions will be maintained virtually, IRL in our physical space at the Center for Innovation, and at pop-up locations to be announced.

Our **Virtual Artist-in-Residence Program** is set to kick-off in the fall with Ryan Rassmuson, Assistant Professor of Sculpture at Georgia State University. The Virtual Artist in Residence Program will include artist lectures, free community workshops, and will culminate in an exhibition built in collaboration with lab members.

Community Outreach is central to the lab's mission. We offer this in the form of free new media workshops for underserved youth, free artist lectures, the generation of free online instructional videos, open access We build databases to empower artists and collaborate with local non-profits to reach a broader public. New Media History and Theory reading groups as well as access to equipment and instruction on how to use it are avaialble through the lab. We are in the process of founding a New Media Festival here in Tallahasse. For it we plan to bring in national-level artists to produce projects in collaboration with local talent from FSU, TCC, FAMU, and the broader arts community. Our doors are open to all friendly people, regardless of previous experience.

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Black Bandes Dessinées : African Comics in French

Background

Both France and Belgium exported *bandes dessinées* (comics) to their colonial territories in tandem with their respective civilizing missions. As many argue, *bandes dessinées* contributed to an imperial visual culture of stereotypes that regularly cast non-white figures as less civilized than their European colonizers. In his groundbreaking 1952 anti-colonial text *Black Skin, White Masks*, Frantz Fanon exposes their damaging psychological impact on colonized subjects who identified with the white, European explorer and adventurer protagonists. Yet, since the 1960s, cartoonists from francophone Africa and the diaspora have adopted and adapted *bandes dessinées* to tell their own stories such as the groundbreaking international success of *Aya* by Franco-Ivorian Marguerite Abouet and French Clément Oubrerie.

Translation: "Should we ban *Tintin in the Congo*?" "Yes, in the Congo! Not in Gabon" (Pahé)

Research Project & Impact

My interdisciplinary book-length project provides the crucial sociohistorical, political, and economic context of the cultural field of what I term *black bandes dessinées* and critically examines cartoonists' visual, verbal, and material strategies to demonstrate their innovative use of image-text spaces for theorizing identity, representation, and justice in the 20th and 21st centuries. In addition to bringing this extensive and relatively unknown corpus to many disciplines, this research investigates the ways in which *black bandes dessinées* engage with and theorize current questions of postcolonialism, race and racism, gender and sexuality, migration, restitution, ecocriticism, and the role of social media in everyday life.

Comics about colonial soldiers in WWII

Outcomes

The **FYAP** provided time to finalize the manuscript's structure and the book proposal, contact academic presses, submit related publications, and conduct new research:

- Submission of chapter on African women cartoonists to peer-reviewed anthology to be published by the Ohio State University Press
- Submission of article on comics about African soldiers in World Wars I & II to the peer-reviewed journal *Francosphères*
- Participation in workshops for the exhibition and colloquium "Afropolitan Comics" sponsored by the French government and the South African Institut Français

Aya de Yopougon, Marguerite Abouet & Clément Oubrerie

Next Steps

After sending out my book proposal this fall, I will continue to revise chapters to submit the full manuscript by the end of the 2020-2021 academic year. Then, in the summer of 2021, I will build upon research I started on cartoonists' use of *bandes dessinées* as forms of archive, memory, and history to pivot towards my second book project while waiting for manuscript reviews.

To assist in completing the manuscript and continuing new research, I will also spend this fall semester applying for external funding:

- National Endowment for the Humanities Fellowship
- Multi-Country Fellowship from the Council of American Overseas Research Centers
- Camargo Core Interdisciplinary Fellowship Program in southern France
- American Council of Learned Societies Fellowship

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Assessing the Indirect Pathway of Adverse Childhood Experiences on Criminal Offending in Early Adulthood

Erin D. Castro, Ph.D.

Background and Objectives

Background

In 1998, Felitti found that children who were exposed to sustained poverty, divorce, parental substance use, parental incarceration, violence in the home, and child abuse were more likely to experience issues related to mental health (Fox et al. 2015), cognitive development (Anda et al., 2006), and behavior outcomes (Bellis et al., 2014). One particularly concerning outcome is the relationship between ACEs and criminal offending (Craig et al., 2017). While previous research has attempted to understand the direct and indirect effects of ACEs on behavior few studies have attempted to examine the mediating effects of depressive moods, low self-control, and stressful life events.

Award Accomplishments

Data

To date, a final multilevel sample that includes parental and child adolescent information from the RYDS and RIGS (respectively) has been created. In total there are 3,624 variable observations and 459 parent-child dyads. Variables include repeated observations in the variety of offending from the ages of 18 to 22, depressive symptoms, and peer deviance from 17 to 21 years old. Static measures of ACEs, low self-control, stressful life events, gender, and race are also included. Table 1 displays the between individual descriptive statistics.

Preliminary Results

The preliminary results from the mixed effects multilevel regression models show a significant direct effect of increase ACE exposures on increased likelihood of delinquency engagement from 18 to 22 years old. In addition, children who had higher ACEs and more stressful life events were marginally more likely to engage in a wider variety of offending when aged 18 to 22. Table 2 displays these preliminary results.

Objectives

To address these gaps, the objective of this awarded project was to construct a multilevel, longitudinal, and intergenerational dataset from the Rochester Youth Development Study (RYDS) and the Rochester Intergenerational Study (RIGS). With this dataset, three broad research questions are to be answered:

(1) Do ACEs increase the likelihood that children will have lower levels of self-control, greater depressive symptoms, and engage in more chronic criminal offending?

(2) Do ACEs increase the likelihood that children will react to stressful life events with depressive symptoms or be influenced by their low self-control development to engage in criminal offending during late adolescence?

(3) Does the intergenerational transmission of ACEs help to explain continuity in criminal offending?

Table 1. Sample Descriptives by Parent-Child Dyads

	N	Mean/%	S.D.	Min	Max
Offending (variety score)	412	.146	.354	0	2.485
ACEs	457	2.086	1.390	0	7
Low Self-Control	311	1.349	.406	.167	2.556
Depressive Moods	459	1.280	.577	0	3
Stressful Life Events	453	.251	.124	0	.722
Peer Deviance	459	1.367	.391	1	4
Parental Attachment	432	2.408	.463	.273	3
Black	310	67.44%	-	-	-
Hispanic	78	17.11%	-	-	-
Other	71	15.45%	-	-	-
Male	459	49.14%	.500	0	1

Table 2. Multilevel Mixed Effect of ACEs on Young Adult Offending

	M1 B	M1 S.D.	M2 B	M2 S.D.	M3 B	M3 S.D.
ACEs	-	-	.029***	.008	.012	.019
Low Self-Control	.085**	.028	.082**	.027	.073*	.030
Depressive Moods	.002	.018	.006	.018	.014	.020
Stressful Life Events	.310***	.088	.246**	.087	.073	.156
ACEs X Stressful Events	-	-	-	-	.110+	.068
Peer Deviance	.101***	.024	.103***	.023	.126***	.027
Parental Attachment	.028	.020	.041*	.020	.056*	.023
Race (black=0)						
Hispanic	-.003	.027	.005	.026	.020	.029
Other	-.018	.027	-.013	.026	-.019	.029
Male	-.007	.021	-.006	.020	.009	.022
Age	.079	.077	.072	.077	.116	.203
Age Squared	-.002	.002	-.002	.002	-.003	.005

Note: $p<.1$+, $p<.05$*, $p<.01$**, $p<.001$***

Future Research

Moving forward there three main steps. First, will be to assess the direct effect of ACEs on low self-control, depressive symptoms, and stressful life events. Second will be to conduct a group-based trajectory model to examine whether ACEs can predict different types of offenders. Lastly, will be to conduct a cross-lagged panel model to more appropriately test for mediation.

When and why does increased host biodiversity lead to more disease?

Michael Cortez, Department of Biological Science, FSU
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Motivation

Biological communities are changing globally, due to the introduction and extirpation of species. Gains and losses of host species (i.e., changes in host biodiversity) in host-pathogen communities affect the size and severity of disease outbreaks. We have a limited understanding of how disease dynamics change as host species are gained or lost, because we currently lack strong mathematical theory for multi-host-pathogen communities.

I developed new analytical theory for host-pathogen communities with many host species. I used the theory to predict what factors determine how disease levels change in response to gains or losses of host species.

Background

Higher host biodiversity (more host species present) can lead to higher or lower levels of disease in a focal host.

Amplification: Higher host biodiversity causes an <u>increase</u> in disease

Dilution: Higher host biodiversity causes a <u>decrease</u> in disease
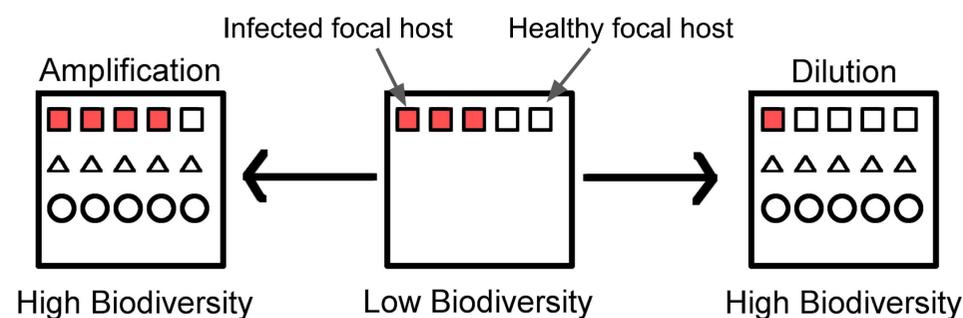
Factors influencing amplification versus dilution:

Competence: How well a species spreads the disease

Competition: How well a species competes for and acquires food, space and other resources

Transmission: The mechanism of pathogen spread

Results

Competence: High competence hosts promote amplification, unless they are strong interspecific competitors
Translation: Hosts that are better spreaders of disease cause larger outbreaks, unless they are better at acquiring resources than other hosts

Competition: Strong interspecific competitors promote dilution, unless they have high excretion rates
Translation: Hosts that are good at acquiring resources cause smaller outbreaks, unless they are massive spreaders of infectious propagules

Transmission: Density-dependent direct transmission amplifies disease more than frequency-dependent direct transmission when interspecific competition is weak and hosts have lower competence. Environmental transmission is always intermediate to density-dependent and frequency-dependent direct transmission
Translation: Pathogens whose spread is more limited by contacts with hosts have smaller outbreaks, so long as different host species use different resources and most hosts are not good at spreading the disease

Impact and Future Work

This theory greatly extends and unifies existing theory on amplification/dilution of disease. It provides general predictions about how host and pathogen characteristics shape patterns of amplification and dilution.

In the future, I will apply these predictions to empirical systems in order to help explain why some real-world communities show amplification of disease while others show dilution. I will also extend the theory by relaxing some of the assumptions built into the mathematical model.

Multi-host-pathogen Mathematical Model

We model a biological community made up of n host species and an environmentally transmitted pathogen that is spread via infectious propagules (e.g., spores or viruses) released into the environment. Examples of such diseases include cholera and giardia in humans, whirling disease in fish, and chytrid fungus in amphibians. The model describes the changes in the abundances of healthy (H_j) and infected (I_j) individuals in each population and infectious propagules in the environment (P).

Changes in healthy hosts
$$\frac{dH_j}{dt} = \overbrace{F_j(H_1,..,H_n,I_1,...,I_n)}^{\text{host reproduction and competition}} - \overbrace{\beta_j H_j P}^{\text{transmission}}$$

Changes in infected hosts
$$\frac{dI_j}{dt} = \overbrace{\beta_j H_j P}^{\text{transmission}} - \overbrace{m_j I_j}^{\text{mortality}}$$
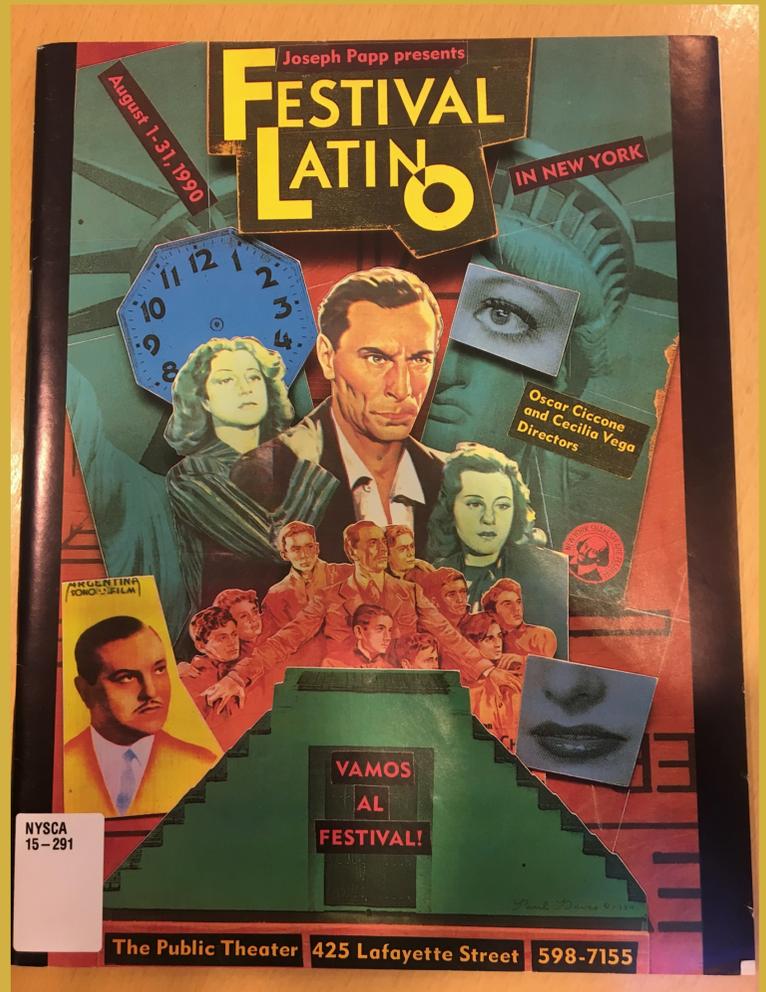
Changes in infectious propagules
$$\frac{dP}{dt} = \overbrace{\sum_j \chi_j I_j}^{\text{excretion}} - \overbrace{UP - \delta P}^{\text{uptake and degradation}}$$

Technical details:
- We assume no recovery from infection (i.e., infection is lethal)
- The model can be converted into a direct transmission model, making it applicable to direct transmission diseases like ebola and rabies
- Results are for disease prevalence at endemic equilibria

The Festival Latino: Joe Papp and el Teatro de las Américas

- Ran ten times between 1976-1991

- Brought together Latinx, Central, and South American theatre, film, and dance

- Prompted satellite festivals in in the Americas

Advanced Latinx aesthetics, bilingual theatre, Spanish-language theatre and film, South American actors and companies, and Shakespeare in Spanish and Portuguese

This project will document the festival in its entirety and highlight watershed productions and the financial structures that shaped theatre in the Americas in the late twentieth century.

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Re-modularization of Constrained Horn Clauses

Grigory Fedyukovich, CS Department

Software is buggy

Building software is tedious and error-prone

- *Rapid growth of software complexity*
- *High demand for human resources*

Testing, profiling, analyzing software is difficult

- *Computationally expensive tasks*
- *Also requires user interaction*

Need tools which at the same time

- *Provide checkable guarantees*
- *Fully automatic and reasonably easy to use*
- *Scale to practical applications*

Automated Reasoning about Software

Inspired by methods in applied science

E.g., physicists in 17-19th centuries

Logic-based verification and synthesis

- *A user provides a program and a desired specification*
- *A tool automatically constructs a model of the program*
- *Use decision procedures to reason about formulas*

Automated Reasoning Today

Automated verification with SMT solvers

- *Scale to large industrial applications*

Constrained Horn Clauses (CHC):

- *Symbolic representation of programs*
- *And safety specifications (assertions)*

Verification = CHC translation + CHC solving

- *E.g., SeaHorn + Spacer, JayHorn + Eldarica, or Mu2CHC + HoIce*

Successful techniques are based on simple ideas

- *Property Directed Reachability / IC3*
- *Probabilistic / Syntax-Guided methods*
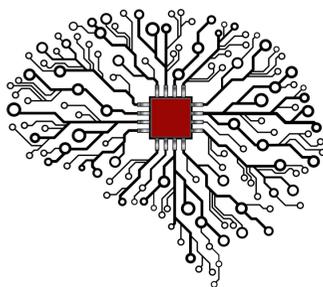
CHC: Constrained Horn Clauses

Formula in first order logic: $\quad \varphi \wedge p_1(V) \wedge \ldots \wedge p_k(V) \implies H$

- where A is a constraint language (e.g., (non-)linear arithmetic, arrays, bit-vectors, etc.)
- φ is a constraint in A
- $p_1 \ldots p_k$ are uninterpreted relation symbols
- each $p_i(V)$ is an application of the predicate to variables
- H is either some application $p_i(V)$ or $false$

System of CHCs

- Only one CHC with $H = false$
- Has a solution if there exists an interpretation for each p_i making each CHC valid

Example

Program in C

```
int j, m, N = nondetInt();
int *A = nondetArray(N);
int i = 0;

while (i < N) {
  if (m < A[i]) m = A[i];
  i++;
}

assume(0 ≤ j < N);
assert(m ≥ A[j]);
```

CHC-encoding

$$i = 0 \implies inv(A, i, m, N)$$

Uninterpeted predicate

$$inv(A, i, m, N) \wedge i < N \wedge$$
$$m' = ite(m < A[i], A[i], m) \wedge$$
$$i' = i + 1 \implies inv(A, i', m', N)$$

Symbolic execution (via *static single assignment* transformation)

$$inv(A, i, m, N) \wedge i \geq N \wedge$$
$$0 \leq j < N \wedge \neg(m \geq A[j]) \implies \bot$$

Solutions for CHCs

Inductive invariant:

- *Describes all initial states*
- *If it describes a state from where a transition starts, then it describes a state where the transition ends*
- *Describes no bad states*

Example:

$$inv \mapsto \forall j \, . \, 0 \leq j < i \implies m \geq A[j]$$

$$i' = 0 \implies inv(A', i', m', N')$$
$$inv(A, i, m, N) \wedge i < N \wedge m' = ite(m < A[i], A[i], m) \wedge i' = i + 1 \implies inv(A, i', m', N)$$
$$inv(A, i, m, N) \wedge i \geq N \wedge 0 \leq j < N \wedge \neg(m \leq A[j]) \implies \bot$$
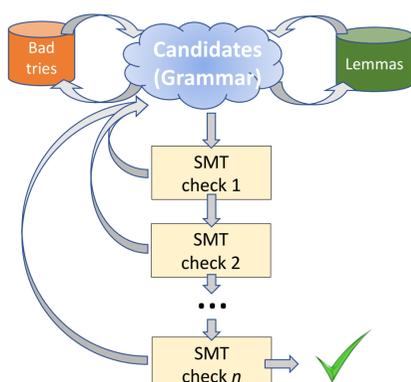
Our Tool: FreqHorn

High-level view:
- Loop between a candidate generator and an SMT-solver

Candidate generator
- **Syntax-Guided Synthesis (SyGuS)**
- Learning from positive / negative candidates

SMT-based decision maker
- Off-the-shelf SMT solvers (for termination, non-termination, safety, etc...)

Bad tries

Candidates (Grammar)

Lemmas

SMT check 1

SMT check 2

• • •

SMT check *n*

Re-modularization of CHCs

FreqHorn implements various features to accelerate convergence:

- Merging consequent non-inductive CHCs

  Such that individual invariants are no longer needed

- Fairness heuristics for picking a relation to be considered in the synthesis

  Such that each relation is eventually considered

- Candidate propagation between relations

  Allows for synthesizing an invariant for one relation and re-using it for other relations

Reducing incidence and prevalence of diarrheal illnesses in rural Honduras

Charles Fleischer M.D., Jared Wainwright[1], BS, Lethia Wainwright[1], BS, Leah Genn[2], BS

[1] Second Year Medical Student, [2] Third Year Medical Student at the Florida State University College of Medicine

Background

In 2017, the fourth leading cause of death and disability in Honduras was due to diarrheal illnesses. On a global scale, there are more than 2.2 million lives lost each year due to these infections. The primary objective of this study is to reduce the morbidity and mortality of diarrheal illness in rural Honduras by addressing the underlying causes of diarrheal illnesses. Our multidimensional interventions, which were created after careful and thorough review of current available literature, will focus on removing the antagonists to diarrheal disease (health hazards) by implementing culturally acceptable, scalable, and sustainable preventative measures. Some of the interventions include hand and oral hygiene campaigns, establishing clean drinking water, proper disposal of human waste via latrine construction, health education and the training of Village Health Workers.

Village: Gracias a Dios, Honduras

During previous work with the Rotary International, my team was informed that the Honduran Health Ministry in Honduras identified a geographical area in the surrounding villages of Olanchito that represented the highest levels of diarrheal incidence. In these communities, local initiatives were unable to address the severity of the diarrheal incidence due to extremely limited local and governmental resources. Therefore, Rotary members from both the US and Olanchito met with village leadership to discuss projects that could be beneficial, including objectives and village responsibilities for implementation and sustainability. Village leadership reviewed project proposals, provided additional insights, and committed to active leadership and participation which is a critical component to help avoid causing future mistrust. I have chosen to work in Gracias a Dios based on their high level of water contamination per water analysis reports.

Current Project Accomplishments

❑ Assembled a diverse and multi-level research team
❑ Completed a thorough literature review on diarrheal illness specific to rural Honduras
❑ Administered a pre-interventional community health needs survey which is currently being analyzed
❑ Conducted water and geological analysis surveys
❑ Appointed two Village Health Workers
   ▪ Compiled a VHW training manual and identified Honduran medical doctors to train them
❑ Partnered with Honduran medical and dental professionals in addition to engineers, professors, and rural village leadership


Results
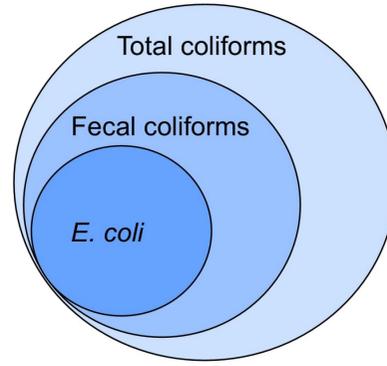
Measuring fecal coliforms is an indicator of fecal contamination in water supplies that includes E. Coli and other potentially pathogenic bacteria. EPA standards mandate that potable water be "less than 1 colony total coliform with *E. coli* absent per 100 mL" and for water to meet guidelines for recreational use it is required to be less than **125 CFU/100mL**. Our water analysis of their primary drinking water shows **62,000 CFU/mL**. Further more, a water sample obtained from the original source of the stream from the top of the mountain showed **0 CFU/mL**. This shows their water supply is being contaminated before reaching the village.
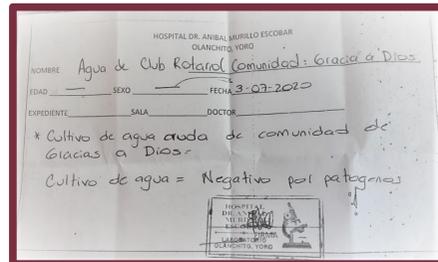
0 CFU/mL from original mountain source
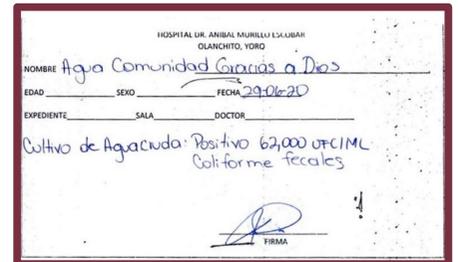
62,000 CFU/mL from primary water source

Teaching Through Collaborative Research

Through the FYAP award, I have been able to create a project that allows for the collaboration of physicians, dentists, medical students, graduate students, undergraduate students, and Honduran medical professionals. This unparalleled opportunity supports and encourages each of these groups to apply their shared passion for global health and unique skill sets to best serve the people of Gracias a Dios, Honduras.

Future Work

In the upcoming weeks, construction of latrines and installation of water filters will be completed. Village Health Workers, in close partnership with the local hospital and medical doctors, will be trained to treat common ailments, survey for and refer chronic illness, and provide monthly health education to the villagers. In partnership with Honduran dentists, toothbrushes, toothpaste and dental hygiene education will be provided and children will receive fluoride varnishes.

We will further administer post-interventional surveys to assess for a reduction in the incidence and prevalence of diarrheal illnesses. In addition, continued support will be provided to the VHW's in the form of salary, medications, medical supplies, and training. We will analyze the collected data and submit our findings for publication. In the future, we will utilize the multidimensional interventions that were proven to be effective and create a model which can be utilized in similar rural and underserved villages in Central and South America to further improve health outcomes.

Contact

Charles Fleischer, MD: Assistant Professor - Department of Family Medicine and Rural Health
Assistant Director for the Center on Global Health
Florida State University College of Medicine - Charles.Fleischer@med.fsu.edu

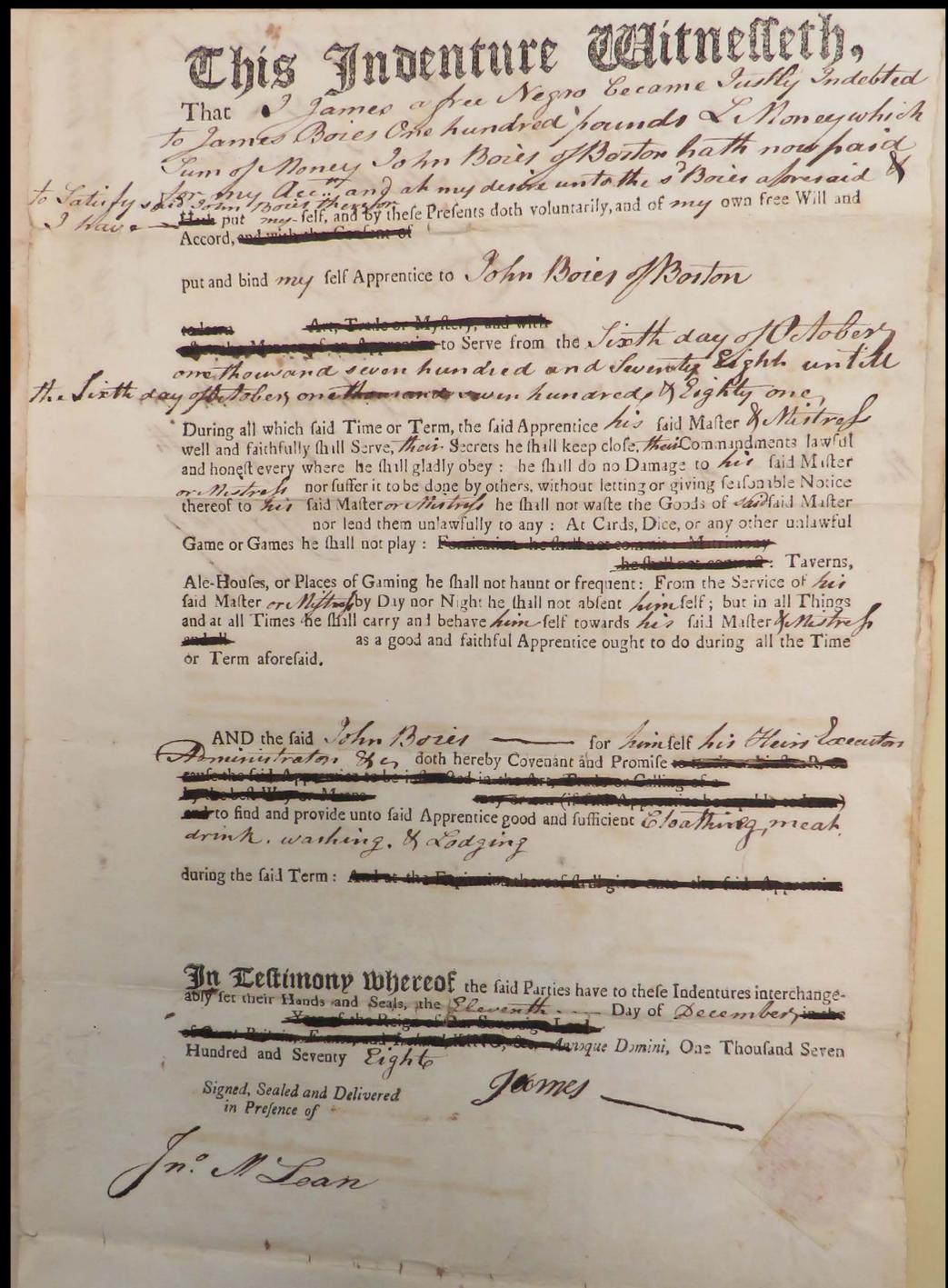# Without Order: Booksellers and the Failures of the Early American Book Trade, 1670-1825

- Debt and economic failure was endemic to all facets of the early American book trade.

- The business records and financial documents from printing, publishing, and papermaking reveal the presence of enslaved and indebted African-American men and women who contributed to the rise of print culture in eighteenth-century North America.

Pictured above: Signed indenture form of James Moody, a free black man who manufactured paper near Boston during the American Revolution. Moody was trapped in debt, and later ran away from a paper mill to fight in the Revolutionary War.

John J. Garcia

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BLACK LIVES MATTER

Makers of the Sensible: The Evangelical Book and Its Readers in Antebellum America

Fig. 1. ATS tract *Christ the Only Refuge* (c. 1830). American Antiquarian Society.
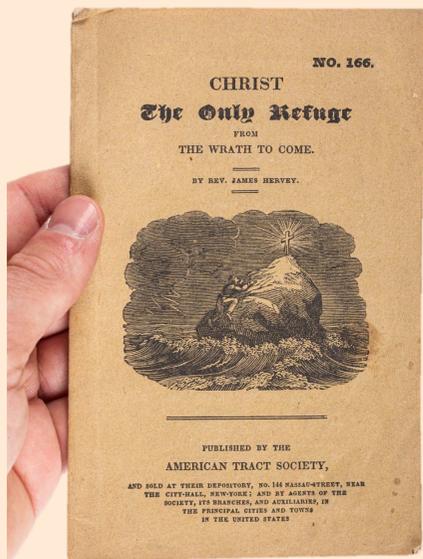
Background: This book project focuses on the cultural work of the American Tract Society (ATS), the major evangelical publishing company, during a key stage in the history of mass reproduction. Between its founding in New York in 1825 and 1861, the ATS circulated *5.3 billion* printed pages throughout the United States. These were mostly tracts (Fig. 1) and books. Society leaders planned for this surge of publications to convert the nation to evangelical Protestantism. In an image decorating an ATS certificate (Fig. 2), we see this ambition on full display: angels draw tracts hot from the presses and fling them through the air to eager readers.

Fig. 2. Asher Durand, engraved vignette on ATS membership certificate (c. 1825). Library Company of Philadelphia.

Questions and argument: Two questions drive my project. One, what was the impact of printed media on readers? Two, what does evangelical engagement with mass media show us about the power, characteristics, and functions of evangelical Christianity? The book argues that antebellum evangelicals were "makers of the sensible." The ATS did not merely print religious texts and hope for the best. The ATS approached reading as a full-body sensible experience. The institution labored to shape the experiences of ordinary readers using five techniques that correspond to the book's five single-word chapters: Thing, Value, Circulation, Ritual, and Commodity.

Intervention: While *Makers of the Sensible* is an interdisciplinary project that will speak to conversations in book history, media studies, and material culture, its main intervention is in American religious history. Historical consensus has regarded evangelicalism—the dominant religion in the antebellum US—as a democratizing force, emboldening ordinary people to think for themselves. The book contributes to a revisionist literature about evangelicalism's authoritarian side. What has not yet been examined are the techniques evangelicals used to win mass conversions and rise to power. *Makers of the Sensible* establishes how evangelicals exerted power by shaping reader experience on a bodily, material, and emotional level.

Fig. 3. Tract used as an ink blotter (c. 1830). FSU Special Collections.

Methods: The book analyzes archival evidence that I collected from over a dozen repositories in the US and the UK. Among textual sources, I analyze the publisher's proceedings, newspaper accounts, and handwritten diaries and letters. Just as crucially, I examine the materiality of printed objects themselves. Objects offer a window on the world of reader reception in the forms of marginalia, wear, and other "traces of use." For instance, a tract used as an ink blotter (Fig. 3) reveals the low status of the tract for the middle-class Pensacola minister who owned it.

FYAP work and future plans: During the FYAP period, I substantially revised three of my five chapters. For an example, my revised chapter on ritual draws on ritual theory to analyze the efforts of the ATS's itinerant distributors (Fig. 4). The chapter reconstructs the rituals that distributors staged in ordinary people's homes. Far from simply peddling tracts, they followed a script to conduct emotionally-charged inquisitions intended to make readers cry. Only then, at the culmination of the ritual arc, could the tract be conveyed. My plan is to revise the final two chapters and submit the entire manuscript to a university press by May 2021.

Fig. 4. Jerome Thompson, *The Tract Distributor* (c. 1835). Boston Athenaeum.

## Sonia Hazard (shazard@fsu.edu)

Background: Blackface minstrelsy has long been imagined to be distinctively American. Yet, blackface performance predates the formation of the United States and has always traveled broadly. It was the also most popular performance form throughout the 18th- and 19th-century British Empire. My current monograph project, *Transoceanic Blackface: Performance, Race, Empire*, maps the the traffic of blackface minstrel performers, songs, troupes, and scripts in order to consider how this popular performance form contributed to global conceptions of race. The final chapter of this monograph, "Recurrent Tides; or, Blackface Backwash," traces the influence of blackface performance on 20th-century Anglophone theatre & film and how the form continues to popular cultural forms and transnational performances of race.

Results: This chapter focuses on the following case studies (images clockwise from below left):
- Brownface in *The Cingalee*, first performed in London (1904);
- Blackface in *Helena's Hope, Ltd.*, first performed in Cape Town (1910);
- Blackface in the long-running BBC radio show, *The Kentucky Minstrels* (1933-1950); the BBC TV show, *The Black and White Minstrel Show* (1957-1973); and its South African theatrical imitations, *Minstrel Scandals* (1967-68) and *Non-Stop Minstrel Scandals* (1970);
- Blackvoice in Australian pop star Iggy Azalea's chart-topping hip hop song, "Fancy" (2014); and,
- Blackface, brownface, and yellowface in popular social events, such as Canadian Prime Minister Justin Trudeau's infamous brownface costume (2001; background image).
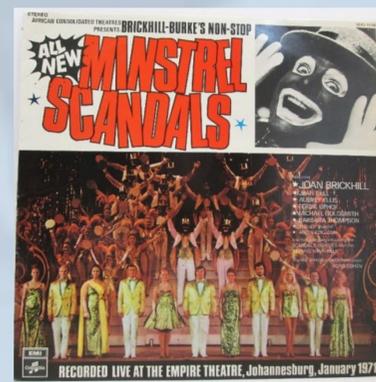

British actor Huntley Wright in brownface as "Chambuddy Ram" in *The Cingalee* (1904)
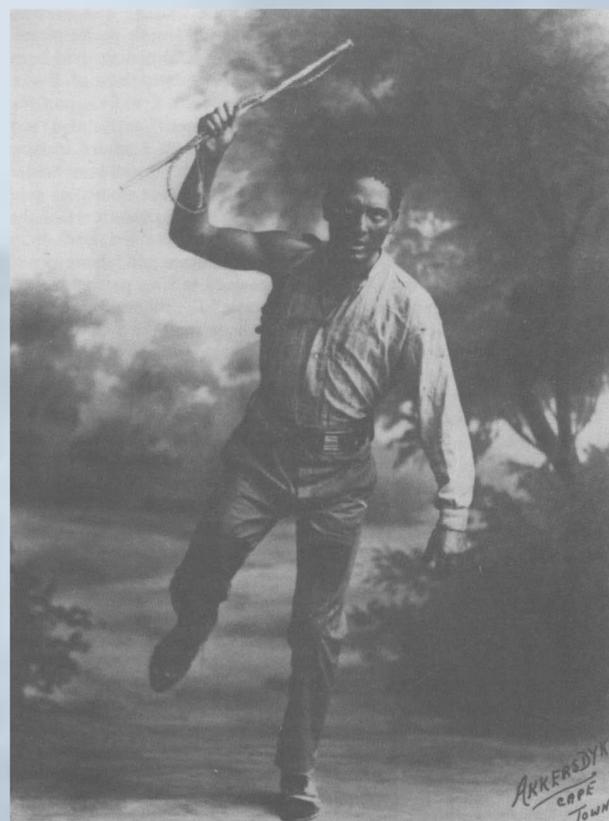
South African playwright and actor Stephen Black in blackface as "Jeremiah Luke Mbene" in *Helena's Hope, Ltd.* (1910)

Australian pop star Iggy Azalea, *Fancy* (2014)

South African theatremakers Joan Brickhill and Louis Burke, *Non-Stop Minstrel Scandals* (1970)

Discussion: Far from functioning as a US American national cultural form exported elsewhere, Anglophone artists regularly adapted blackface to stage imperial racial anxieties (*The Cingalee*); to embody nascent nationalist racial imaginaries (*Helena's Hope, Ltd.*); to imitate popular racial tropes for local audiences (*Minstrel Scandals)*; to capitalize on white investments in Black popular music (*Fancy*); and, to play with racial difference as a mode of "fun" (Justin Trudeau). The ubiquity of blackface and related forms of racialized performance throughout the 20th- and 21st-century Anglophone world demonstrates how blackface functioned as the default mode for imaging race across the globe.

Future Research: I have begun working with Professor Douglas A. Jones, Jr. (Rutgers University) to organize a conference on the global traffics of blackface minstrelsy. This conference will result in an edited collection of essays drawing together new, interdisciplinary research on this topic while also affording me the opportunity to develop material that exceeded the scope of my monograph – especially, performances of Black American minstrel troupes in the British Empire.

Background image: Canadian Prime Minister Justin Trudeau in dark brownface at an "Arabian Nights" party at West Point Grey Academy (2001)

Shape Regression and Its Applications in Heterogeneous Medical Image Data

GEO-FARM: Geodesic Factor Regression Model for Misaligned Pre-shape Responses in Statistical Shape Analysis

Introduction

Shape is broadly defined to be a characteristic that is left after certain undesired (nuisance) transformations have been removed. It is of great importance to understand shapes of objects in biological systems, for example, the largest white matter region, corpus callosum (Fig 1).

Challenge:
1. heterogeneity caused by image <u>misalignment</u>
2. <u>curse of dimensionality</u> in shape space

Goal: establish geodesic regression model to investigate the relationship between shape and clinical information (e.g., age, gender, and diagnostic status).
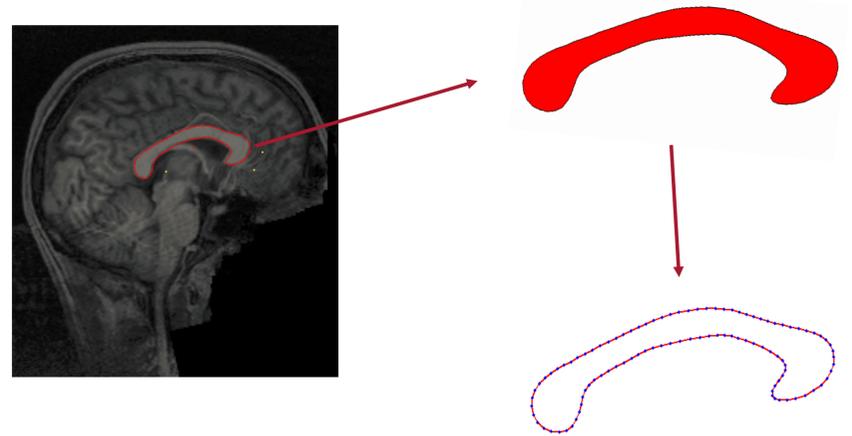
Fig 1. segmentation and shape information extraction of corpus callosum from brain image.

Method

GEO-FARM

$$f(y_i * g_i) \mid x_i, z_i \sim \mathrm{RN}\left(\mathrm{Exp}(f(\mu), Bx_i + \Lambda z_i), \sigma \mathrm{I}_m\right), \; z_i \sim \mathrm{N}(0, \mathrm{I}_q)$$

$$f(y_i * g_i) = \mathrm{Exp}(\nu_i, \epsilon_i), \; \nu_i = \mathrm{Exp}(f(\mu), \xi_i)$$

$$\xi_i = x_{i1}\beta_1 + x_{i2}\beta_2 + z_{i1}\alpha_1 + z_{i2}\alpha_2$$

$f: S_2^k \to \mathbb{S}^{m-1}, m = 2k - 2$

$y_i \in S_2^k$: pre-shape response

$g_i \in OS(2)$: nuisance transformation

$\epsilon_i \in T_{\nu_i}\mathbb{S}^{m-1}$: stochastic error term

$f([\mu])$: base point

$\beta_1, \beta_2, \alpha_1, \alpha_2 \in T_{f(\mu)}\mathbb{S}^{m-1}$

x_{i1}, x_{i2} : covariates of interest (e.g., age, disease status)
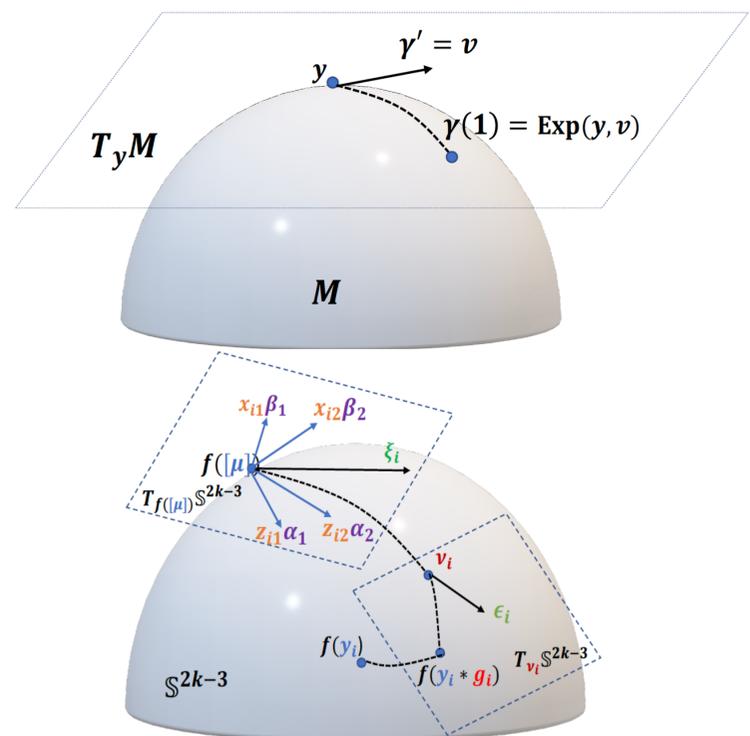
z_{i1}, z_{i2} : latent factors

Fig 2. Graphical illustration of Exp-map on Riemannian manifold and GEO-FARM.

Algorithm

Data: pre-shape data $\{y_i\}_{i=1}^n$ and covariates of interest $\{x_i\}_{i=1}^n$

Result: estimates including $\hat{\mu}, \hat{B}, \hat{\Lambda}, \hat{\sigma}$, and $\hat{G}$

Initialization: $\mu^{(0)} = \mu_0, B^{(0)} = B_0, \Lambda^{(0)} = \Lambda_0, \sigma^{(t)} = \sigma_0, G^{(t)} = G_0, t = 0$;

while stopping criterion not satisfied **do**

    Monte Carlo E-step;

    Sample $z_i^j, i = 1, \ldots, n, j = 1, \ldots, n_z$ via HMC method;

    Calculate the approximated Q-function $\tilde{Q}(\Theta, \sigma, G \mid \Theta^{(t)}, \sigma^{(t)}, G^{(t)})$ in (11);

    M-step;

    Update $\mu^{(t+1)}, B^{(t+1)}$, and $\Lambda^{(t+1)}$ by Algorithm 1;

    Update $G^{(t+1)}$ by minimizing the objective function in (18);

    Update $\sigma^{(t+1)}$ by minimizing the objective function in (19);

    Set $t = t + 1$;

Output: $\hat{\mu} = \mu^{(t)}, \hat{B} = B^{(t)}, \hat{\Lambda} = \Lambda^{(t)}, \hat{\sigma} = \sigma^{(t)}$, and $\hat{G} = G^{(t)}$;
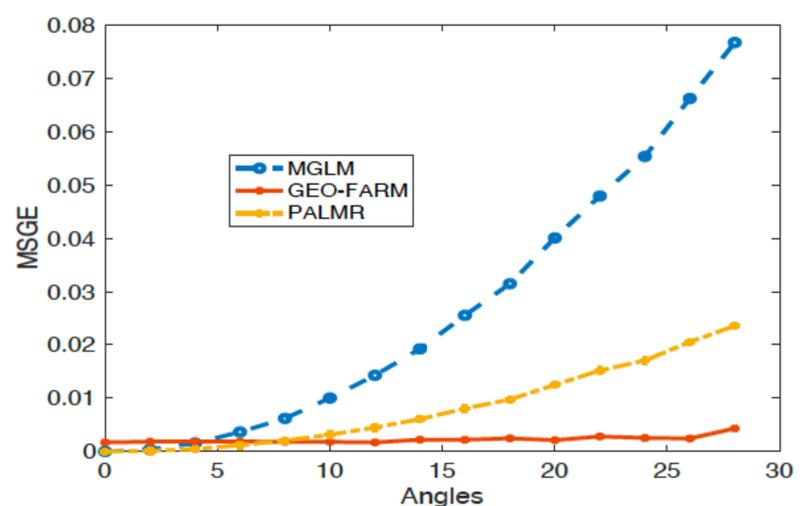

Fig 3. Estimation error in comparison with existing methods.

Future work

1. Generalization to shape information of 3D object
2. Applications to large-scale biomedical studies
3. Address the shape heterogeneity at the group level

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THINKING AND FEELING WITH FRANCOPHONE LITERATURE

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PROJECT SUMMARY:

My second book project, **Thinking and Feeling with Francophone Literature** engages in the work of cognitive criticism of a range of experimental Francophone texts from the African world and its diasporas.

A cognitive approach illuminates the ways in which these aesthetic forms invite us to *think and feel along with* Francophone African films and novels. I argue that readers and viewers engage in three difficult imaginative acts that are central to postcolonial world-making:

1. **envisioning** the relationship between tradition and modernity in the postcolonial state
2. **tracking and engaging** with double consciousness as understood by Africana phenomenology
3. **cultivating human emotion** against the threat of nonbeing , exile or violence.

MAIN CONTRIBUTIONS TO FIELD:

Reframe postcolonial studies; move away from psychoanalysis and towards cognitive accounts of perspective-taking, imagination and emotion

Examine Francophone African texts as complex aesthetic objects (not only political/anthropological/mimetic accounts)

OUTCOMES:

The FYAP grant allowed me the time to:

1) revise my existing article on Sony Labou Tansi and Djibril Diop Mambety for the book.

2) map the remaining chapters of *Thinking and Feeling with Francophone Literature* and plan the research for those chapters.

3) Draft an article on visualization, gender, and diaspora for a forthcoming peer-reviewed issue of *Modern Fiction Studies*.

NEXT STEPS:

-Present work in progress in February as conference organizer on "Cognitive Decoloniality; Two Cultures and Transcultural Literature" through the Winthrop King Center with Director Martin Munro

-Apply for NEH fellowship to complete research on remaining chapters

-Apply for fellowship at American Library in Paris to continue researching and sharing the transcultural aspect of this project

Image: Djibril Diop Mambety, *Touki Bouki* (1973)

Large-scale real estate developments:
Is there a mismatch between theories and case studies?

Minjee Kim, Department of Urban and Regional Planning, m.kim@fsu.edu

Background

- Planning scholars are in agreement that existing theories on the causes, processes, and outcomes of large-scale real estate development are largely unhelpful.
- On the other hand, a huge repository of academic research based on in-depth case studies exists

Questions

- To what extent have theories on large-scale real estate developments informed case study based research?
- To what extent are theories helpful in explaining the causes, processes, and outcomes of large-scale real estate developments as observed in case studies?
- Is there an opportunity for developing alternative theoretical framework?

Classifying existing theories

Neoliberal Urbanization	Regime theory/ urban politics	Institutional approach

Analyzing case study research

- Existing case studies can be classified into three categories: 1) theory-driven; 2) topic/theme driven; 3) practice-oriented
- Many case studies don't apply the dominant theoretical narratives
- Theoretical explanations don't actually match what's been observed in the cases

Conclusion

- There is a mismatch between theories and case studies
- A large group of case study research employs an institutional approach that critically analyses the goals, values, and interests of the key actors involved in building large-scale real estate developments
- This instituional approach should be better defined as a theoretical framework to advance scholarship on large-scale developments

Fast Evolutionary Algorithms for Submodular Maximization

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Motivation and Problem Definition

- Discrete optimization of weakly submodular functions is relevant to many learning problems. Examples: training set reduction, influence maximization, determinantal point processes.

  Problem. Given $f : 2^U \to \mathbb{R}_+$, and budget constraint k, determine

  $$\arg\max_{S \subseteq U : |S| \leq k} f(S).$$

  Submodularity. Let $\gamma \in (0, 1]$. Then f is γ-weakly submodular iff for all $S, T \subseteq U$,

  $$\gamma(f(S \cup T) - f(S)) \leq \sum_{x \in T \setminus S} f(S \cup \{x\}) - f(S).$$

- Greedy algorithms have nice theoretical properties, but

  − How to further improve a greedy solution?

The Evolutionary Algorithm BLPO

- Maintain a population of sets $\mathcal{P} = \{S_0, S_1, \ldots, S_{2k}\}$, such that $|S_i| = i$.
- Each timestep, select a set S_i in $\mathcal{P}$ from a probability distribution. Uniformly randomly add an element from U or delete an element from S_i to obtain S_i'.

  If S_i' has higher f value than the set in $\mathcal{P}$ of the same cardinality, replace that set with S_i'.
- At termination, return feasible set in population with highest f value.
- BLPO+: Additional heuristics.

Future Directions

- **More generalized constraints.** So far we have considered cardinality constraint k only. Cardinality → knapsack, matroids, independence systems
- **Streaming algorithms.** Modern datasets have grown too large to fit in main memory → need for algorithms that can analyze the data in one or more sequential passes

Contributions

Two evolutionary algorithms: BLPO and BLPO+. The algorithm BLPO

- converges to an approximately good solution in linear time, as summarized by the theorem below; and
- the approximation ratio is nearly optimal.

Theorem (Informal). *Suppose we run our evolutionary algorithm BLPO for $T \geq \Omega(n)$ timesteps. Then*

$$\mathbb{E}[f(A)] \geq (1 - 1/n)\left(1 - e^{-\gamma} - \epsilon\right) \text{OPT},$$

where A is the set returned at completion, and γ is the submodularity ratio of f.

Empirical Results

Application. variants of the influence maximization problem in social networks, which is to select the k most influential users in the network given some diffusion model.

Competitors. We compared BLPO, BLPO+ with

- SG: Stochastic greedy algorithm
- SG+LS: Greedy algorithm followed by local search
- PO: evolutionary algorithm
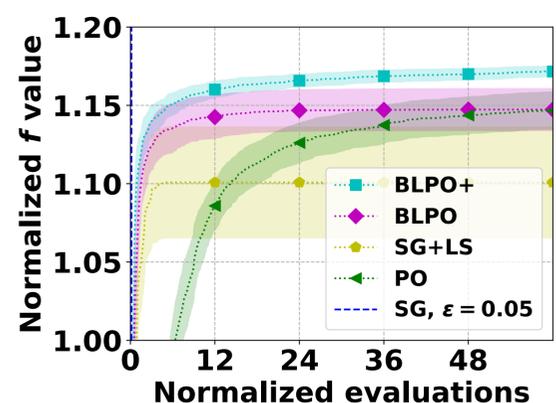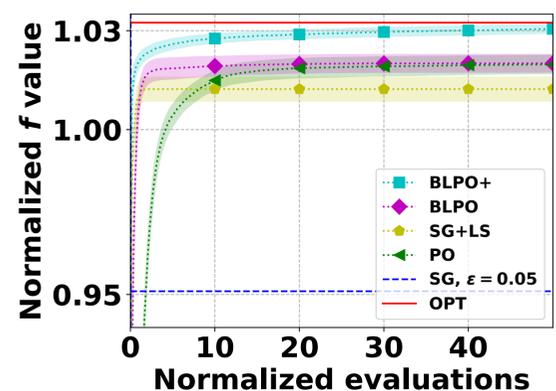
Solution value normalized by the standard greedy value vs. time measured in function evaluations.

Melody, Movement, and Oral Poetry in Western Crete

- Background: *Syrtos*, the dominant traditional music and dance of the westernmost province of the Greek island of Crete, is the site of complex improvisatory interaction across three parallel domains: violin and lute music, highly personalized solo dance steps, and the singing of extemporaneous rhyming couplets. Though there is much scholarship on the sociopolitical and affective dimensions of this practice, there has been little analysis of the specific bodily techniques involved.

- Hypothesis: Through real-time and video-based analysis of performances drawing on recent work in super linguistic and gestural analysis and interviews with practitioners, this project seeks to develop a theoretical model for understanding how the three domains of syrtos performance function on a structural level, and how these spatial relationships between bodies and ideas about them constitute interventions in a changing narrative about Cretan masculinity in crisis-era Greece.

- Preliminary results: Due to travel restrictions, this portion of the project focused on collaborative analysis of previously-recorded performances with practitioners via Zoom and phone. The clearest emergent thread of discourse so far suggests that practitioners interpret particular melodies, and the danced and sung improvisations that they prompt on a given occasion, as markers at highly specific points in time and space that enable them to construct personalized chronotopic narratives of localized belonging.

Syrtos dancers, musicians, and onlookers in Agios Myronas (L) and Lousakies (R), Chania province, Crete, Greece

Next steps: In the summer of 2021, I plan to travel to western Crete in order to conduct further fieldwork among a wider set of practitioners, as well as evaluate my own subjective experiences as a performer of Cretan music and dance. I have begun drafting an article exploring the syrtos genre through the lens of Mikhail Bakhtin's formulation of the chronotope, and will attend the annual super linguistics summer school at the University of Crete in order to workshop other techniques of gestural analysis that I can use to nuance my ethnographic interpretations. Ultimately, I hope to use this investigation as impetus to produce either an edited collection or special issue of a journal focusing on unified structural and ethnographic analyses of traditional Greek music and dance.

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Dynamics of Political Polarization

Motivation: Platforms of Democratic and Republican politicians increasingly polarized. Voters becoming more partisan as well (see figures). Connection between the two phenomena not well-understood.

Goal: Propose a (formal) theory of the evolution of polarization of the political elite and of the mass.

Main findings: Elite and mass polarizations are mutually sustaining and evolve in the same direction but eventually reach a stable state. Both high and low polarization stable states exist. Temporary external shocks such as war, economic depression can lead to a permanent change from one stable state to another.

Implications: End of the Cold War a trigger for the increased political polarization? Results also suggest a small increase in the polarization of the electorate can lead to drastic changes in the elite's policy positions.

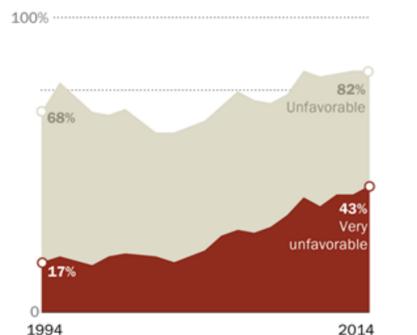**Limitations:** Model relies on several simplifying assumptions.
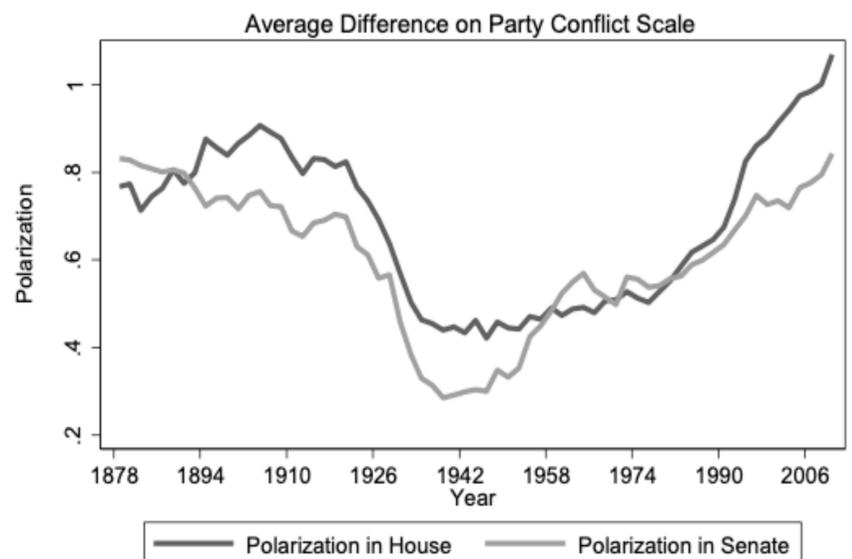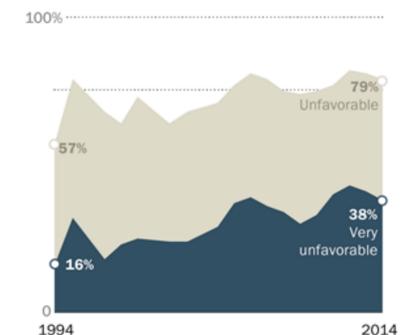
Outline of the Model:

Voters identify as either Democrat or Republican. The intensity of partisanship determines voter turnout.

Parties choose policy to maximize the chance of wining elections.

A voter's partisan leaning increases if the party's policy is more aligned with their own ideology.

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"Results" - An Exhibition of Expanded Printmaking

Exhibition of a body of artwork on view at Hair and Nails gallery in Minneapolis on view July through August 2020.

The development of a handmade artist book entitled "Hidey Hole" to be published in 2021 on Random Man Editions.

"Lab Work (Easter Candy) - Foamcore, Resin, Ink, Xerox Labcorp Blood and Urine Analysist
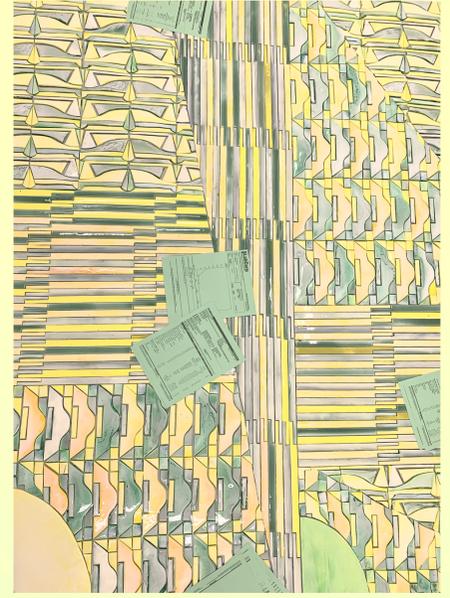
The body of work include sculptures, installations and artist book that showcase found medical related media to illustrate how illness and medical messaging affect how we understand mortality and our own bodies.
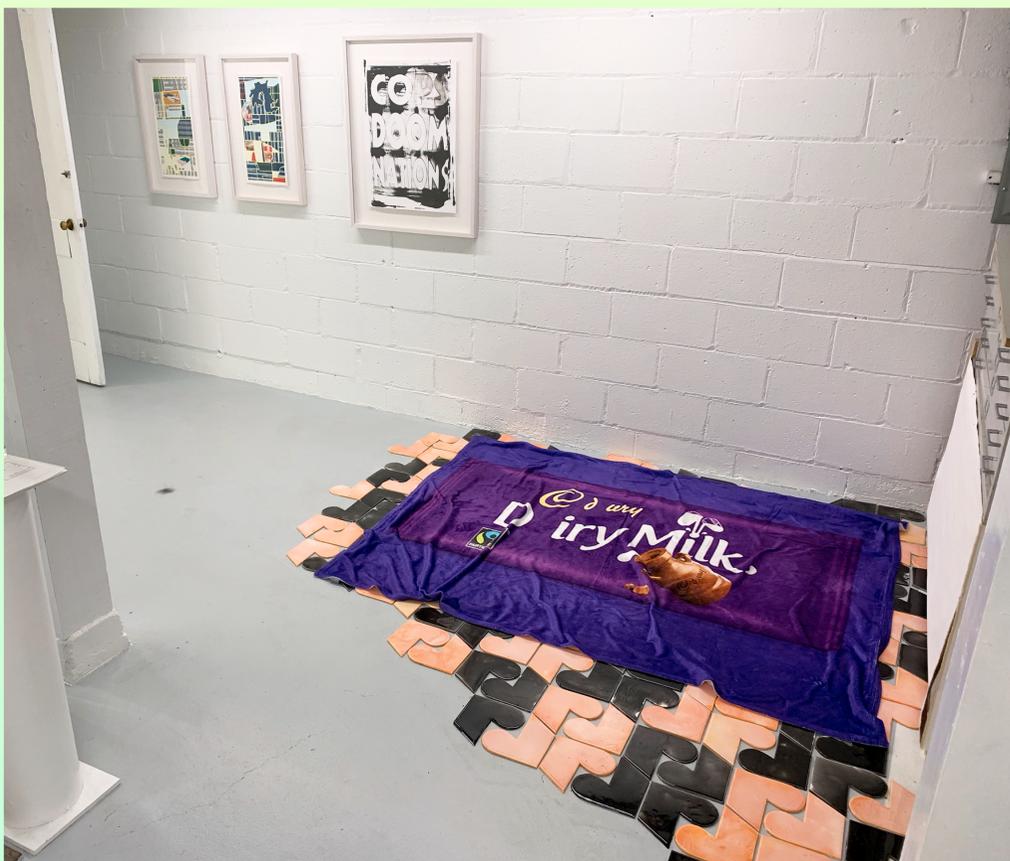
"RESULTS" - Exhibition View, Hair and Nails Gallery Minneapolis, MN

COVID IMPACTS - Portions of this body of work were to be in the exhibition "Print +: Sameness and Otherness in Contemporary Printmedia" at the Hunterdon Art Museum and at the 2020 Southern Graphics Council International printmaking conference in Puerto Rico. Both presentations were postponed until 2021.

The FYAP award assisted with research, development, supplies, production and travel costs associated with the exhibition and future iterations of this body of work.

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"This One Weird Trick" - Lithograph, Screen Print, Digital Print Collage