

## evaluation

- **Participation: 20%.**
  - class discussion, everybody reads and discusses every paper
  - engagement in class, including online
- **Paper Presentation and Discussion: 20%**
  - All students are assigned to a Reading and Discussion Group
  - **SSIE501** students in group present and discuss papers
    - all students are supposed to read and participate in discussion of every paper.
    - *section 01 groups* present in class, *section 20 groups* present via zoom or send a video
  - Presenter group prepares short summary of assigned paper (15 minutes)
    - no formal presentations or PowerPoint unless figures are indispensable.
  - Summary should:
    - 1) Identify the key goals of the paper (not go in detail over every section)
    - 2) What discussant liked and did not like
    - 3) What authors achieved and did not
    - 4) Any other relevant connections to other class readings and beyond.
  - **ISE440** students in group participate as lead discussants
    - not to present the paper, but to comment on points 2-3) above
  - Class discussion is opened to all
    - lead discussant ensures important paper contributions and failures are addressed
  - Post presentation 1-2 page report uploaded to Brightspace
    - 1-4) plus 5) statement of individual contributions
- **Black Box: 60%**
  - Group Project (2 parts)
    - Assignment I (25%) and Assignment II (35%)

## more upcoming readings (check brightspace)

- Paper Presentation: 20%

- Present (501) and lead (501&440) the discussion of an article related to the class materials
- *section 01* presents in class, *section 20* (Enginet) posts videos on Brightspace (exceptions possible)

- Module 4 – Multi-level complexity

- November 14<sup>th</sup>
  - Reading and Discussion Group 4
    - Pattee, Howard H. "[The Physical Basis and Origin of Hierarchical Control](#)." In *Hierarchy Theory: The Challenge of Complex Systems*, edited by Howard H. Pattee, 73–108. New York: Brazillier, 1973.
    - Rosen, Robert. "[On Complex Systems](#)." *European Journal of Operational Research* **30**, no. 2 (June 1987): 129–34.
    - Lazebnik, Y [2002]. "Can a biologist fix a radio?--Or, what I learned while studying apoptosis". *Cancer Cell*, **2**(3):179-182.
      - Optional: Gates, Alexander J., Rion Brattig Correia, Xuan Wang, and Luis M. Rocha. "The Effective Graph Reveals Redundancy, Canalization, and Control Pathways in Biochemical Regulation and Signaling." *Proceedings of the National Academy of Sciences* **118**, no. 12 (March 23, 2021): e2022598118.
- November 16<sup>th</sup> / 28<sup>th</sup> ?
  - Reading and Discussion Group 5 (Enginet)
    - Theise, N.D., and M.C. Kafatos. [2013]. "Complementarity in Biological Systems: A Complexity View." *Complexity* **18** (6): 11-20.
    - Gallotti, Riccardo, Giulia Bertagnolli, and Manlio De Domenico (2021). "Unraveling the Hidden Organisation of Urban Systems and Their Mobility Flows." *EPJ Data Science* **10** (1).
    - Pescosolido, Bernice A., et al. "Linking genes-to-global cultures in public health using network science." *Handbook of applied system science* (2016): 25-48.
      - Optional: Mabry, Patricia L., and Robert M. Kaplan. "Systems Science: A Good Investment for the Public's Health." *Health Education & Behavior* **40**, no. 1\_suppl (October 2013):Future Modules
- See brightspace

## more upcoming readings (check brightspace)

- **Paper Presentation: 20%**
  - Present (501) and lead (501&440) the discussion of an article related to the class materials
  - *section 01* presents in class, *section 20* (Enginet) posts videos on Brightspace (exceptions possible)
- **Module 4 – Multi-level complexity**
  - November 28<sup>th</sup> ?
    - Reading and Discussion Group 1
      - Prieto-Curiel, et al [2023]. “Reducing Cartel Recruitment Is the Only Way to Lower Violence in Mexico.” *Science* **381** (6664): 1312–16.
        - Optional: Caulkins, Jonathan P., Beau Kilmer, and Peter Reuter [2023]. “Modeling Cartel Size to Inform Violence Reduction in Mexico.” *Science* **381**, no. 6664: 1291–93.
    - Reading and Discussion Group 2
      - Gan, Xiao et al. [2023] “Network Medicine Framework Reveals Generic Herb-Symptom Effectiveness of Traditional Chinese Medicine.” *Science Advances* **9**, (43): eadh0215
- **Module 5 – Interdisciplinarity**
  - November 30<sup>th</sup> ?
    - Reading and Discussion Group 3
      - Wu, L., Wang, D., & Evans, J. A. [2019]. “Large teams develop and small teams disrupt science and technology”. *Nature* **566**: 378–382
    - Reading and Discussion Group 4
      - Trochim, William M et al [2006]. “Practical Challenges of Systems Thinking and Modeling in Public Health.” *American Journal of Public Health* **96**(3): 538–46.
        - Optional: Rusoja, Evan, et al [2018]. “Thinking about Complexity in Health: A Systematic Review of the Key Systems Thinking and Complexity Ideas in Health.” *Journal of Evaluation in Clinical Practice* **24** (3): 600–6
    - Reading and Discussion Group 5
      - Editorial. (2015). Mind meld. *Nature*, **525**(7569), 289–90.
      - Van Noorden, R. (2015). Interdisciplinary research by the numbers. *Nature*, **525**(7569), 306–7.
      - Ledford, H. (2015). How to solve the world’s biggest problems. *Nature*, **525**(7569), 308–11.
        - Optional: Kaushal, A., & Altman, R. B. (2019). “Wiring minds”. *Nature*, **576**(7787), S62-S63.
        - Optional: Iwasaki, A. (2019) “Why we need to increase diversity in the immunology research community”. *Nat Immunol* **20**, 1085–1088.
    - See brightspace



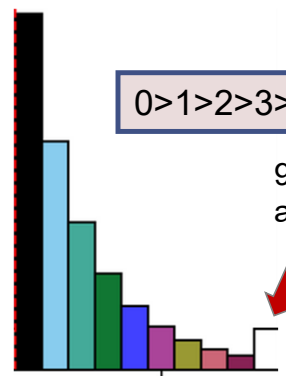
Questions and suggestions

- Remember “published” facts
  - Odd/Even behavior in Q1
  - Statistical behavior in Q2
  - Different regions, transition sequence, complexity in Q4
- Collect or request data (cite)
- Are there quadrant dependencies?
- Focus on smaller grid (mask) subsets?
- Think of neighborhoods and boundary conditions
- **Move from descriptive to mechanistic models**
- Induction and deduction
  - Data and reasoning
  - Given a model, are things you have never seen possible?

Q1

1.  $0 \rightarrow 0$
2.  $\{5\} \rightarrow \{0, 5\}$
3.  $\{2, 4, 6, 8\} \rightarrow \{0, 2, 4, 6, 8\}$
4.  $\{1, 3, 7, 9\} \rightarrow \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$

Q2



$0 > 1 > 2 > 3 > 4 > 5 > 6 > 7 > 8 > ? > 9$

9s seem to have a slight advantage in prevalence?

$$state(cell(i, j))_{t+1} = ? \otimes ? \dots$$

Q3

Q4

- $\rightarrow 0$
- $\rightarrow 3$
- $\rightarrow 6$
- $\rightarrow 9$

Inner region model  
 $0 \rightarrow 3 \rightarrow 9 \rightarrow 6 \rightarrow 0$

Outer region model  
 $\rightarrow 0$   
 $\rightarrow 9$



Are inner regions the same?

- $0 \rightarrow 3, 9$
- $1, 2 \rightarrow 0, 3, 9$
- $3, 4, 5 \rightarrow 0, 6, 9$
- $6, 7, 8 \rightarrow 0, 3, 9$
- $9 \rightarrow 0, 6$

The Black Box: Due: December 1st, 2023



**Herbert Simon:** Law discovery means only finding **pattern** in the data; whether the pattern will continue to hold for new data that are observed subsequently will be decided in the course of **testing the law**, not discovering it. The **discovery process** runs from particular facts to general laws that are somehow induced from them; the **process of testing** discoveries runs from the laws to predictions of particular facts from them [...] To explain why the patterns we extract from observations frequently lead to correct predictions (when they do) requires us to face again the problem of **induction**, and perhaps to make some hypothesis about the uniformity of nature. But that hypothesis is neither required for, nor relevant to, the theory of discovery processes. [...] By separating the question of pattern detection from the question of prediction, we can construct a **true normative theory of discovery**-a logic of discovery.

- Focus on uncovering quadrants
  - using data collection, descriptive patterns & statistics, statistical tests, and induction.
- Propose a formal model or algorithm of what each quadrant is doing.
  - Analyze, using deduction, the behavior of this algorithm.

What is it!!!??

301

Current step: 302

- Data and statistics provide **the essential basis to understand** (i) the ontogeny of systems and (ii) their evolution.
- **Machine Learning** is the **key technology** for the creation of **predictive models** and the eventual automation of decision making across different economic valuations.
- Providing analytical insights [from the currently available] huge amount of data, in real time, requires not only strong computational processing power and specific tools, but **awareness of the technical, ethical and legal complexities all along the processual pipeline.**
  - The philosophical implications of modeling from the perspective of complex systems science.



International Conference on  
Robot Ethics and Standards  
ICRES 2021

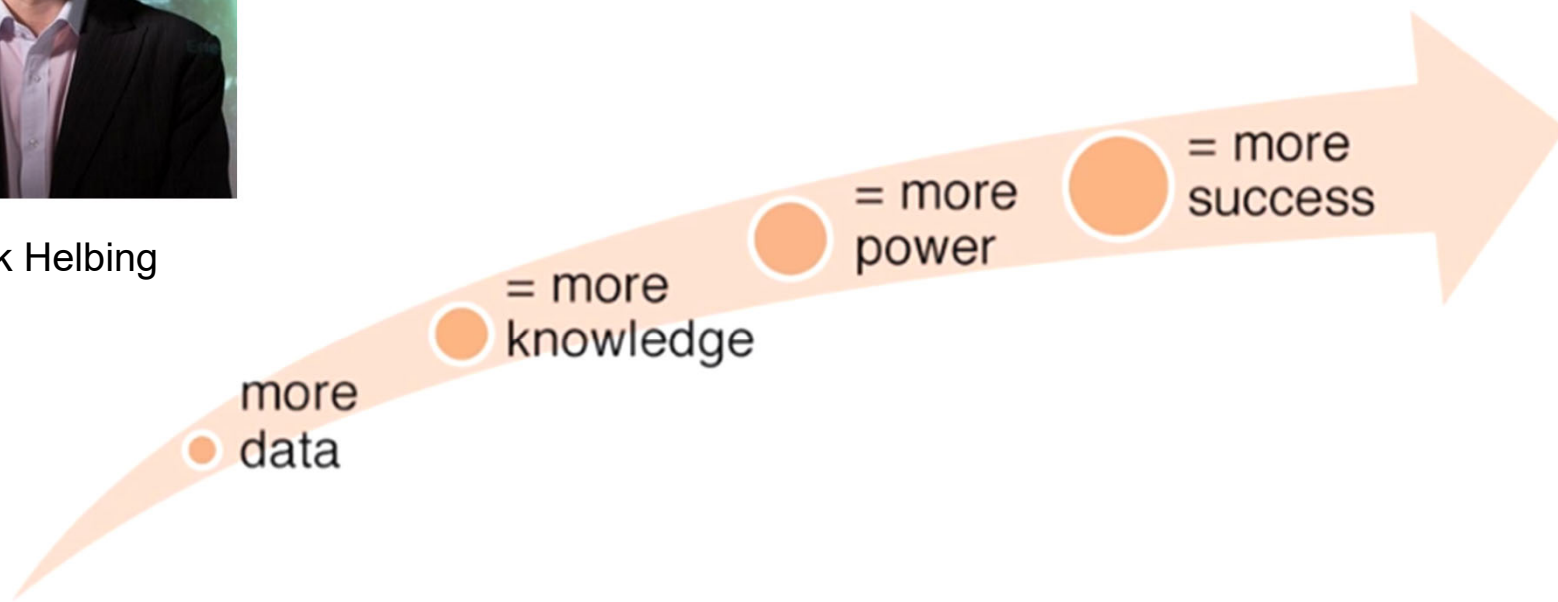
New York, USA, 26-27 July 2021

ICRES 2021



Dirk Helbing

## The Magic Formula ...

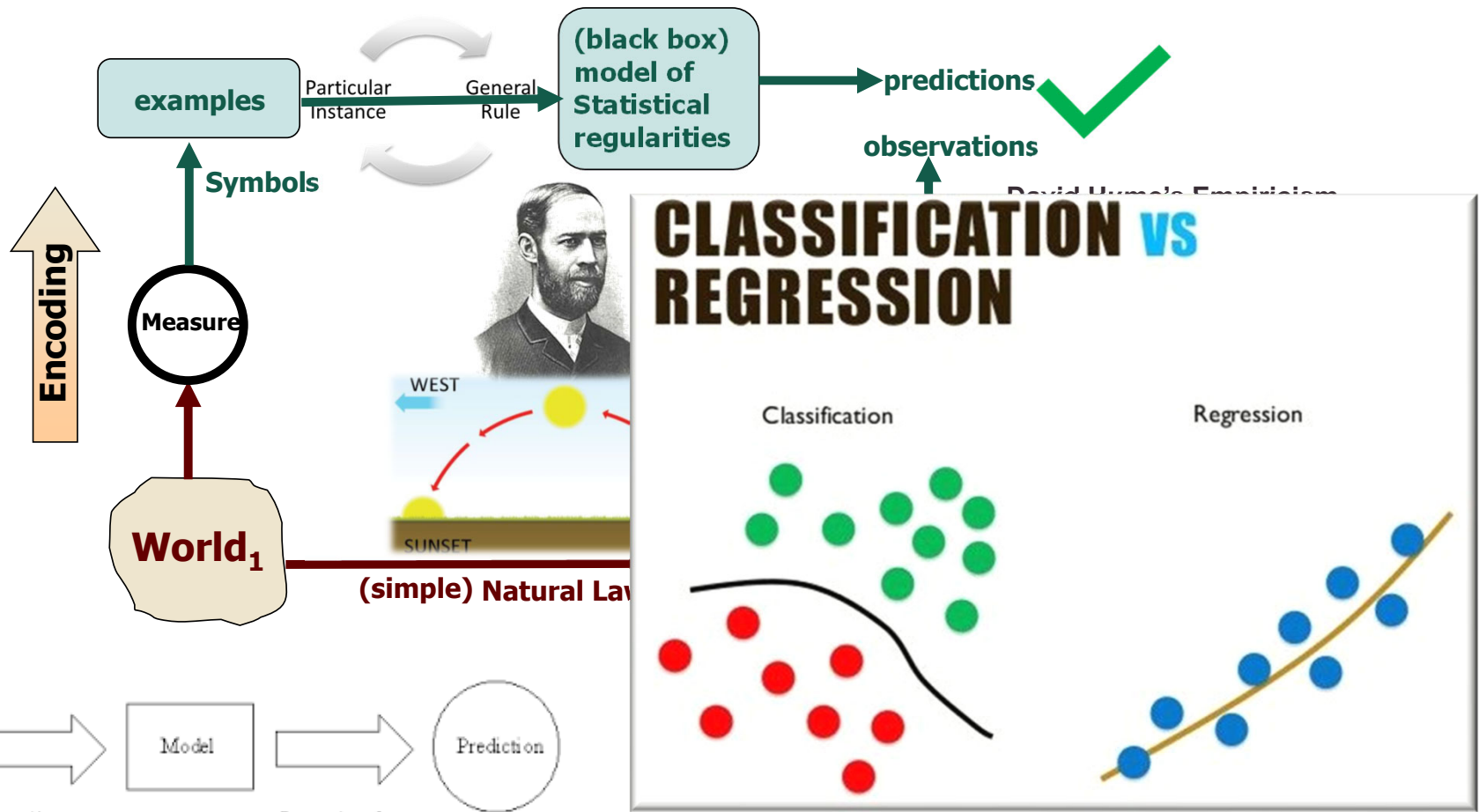


ICRES 2021



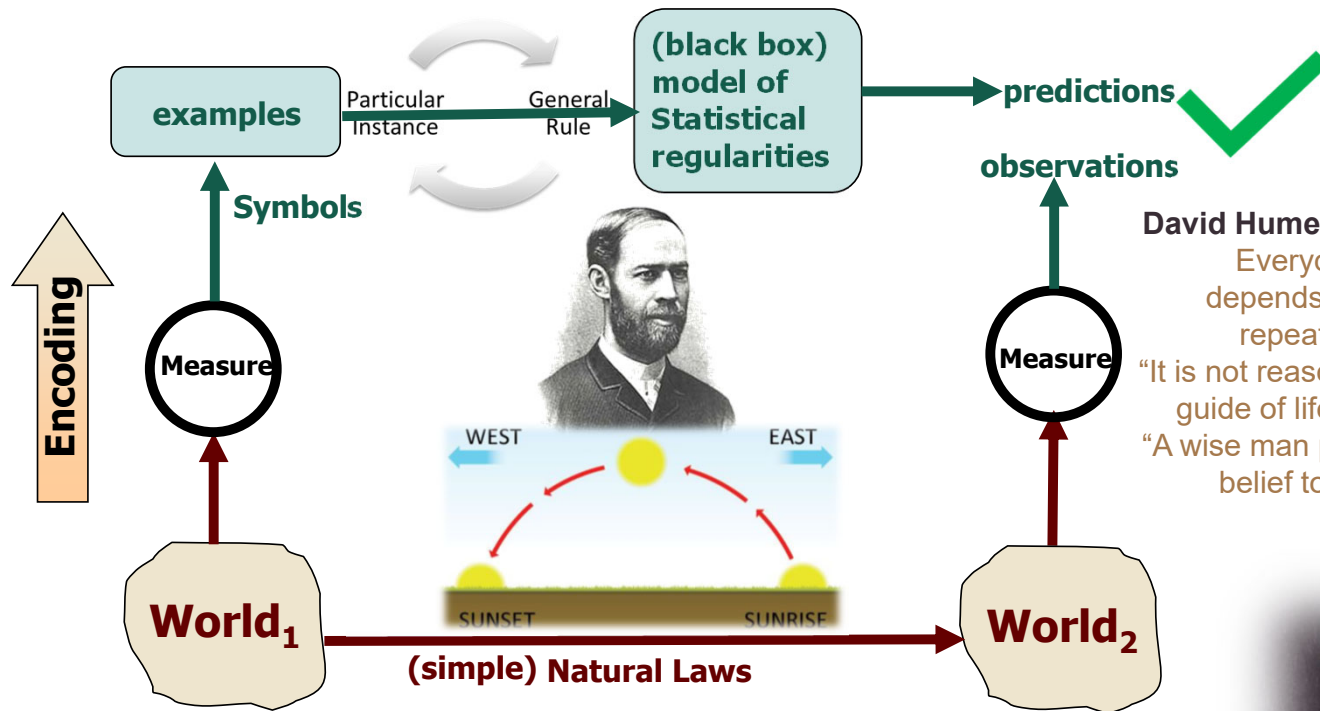
# Hume's and Hertz's World (of AI): Inductive learning

good news I & II: near-decomposability and induction



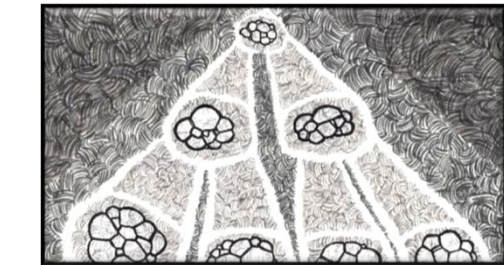
# Hume's and Hertz's World (of AI): Inductive learning

good news I & II: near-decomposability and induction



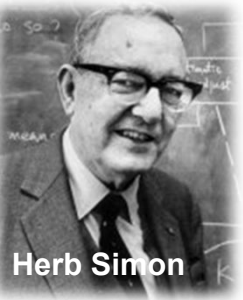
## David Hume's Empiricism

Everyday knowledge depends on patterns of repeated experience  
"It is not reason which is the guide of life, but custom."  
"A wise man proportions his belief to the evidence"



Studying (multilayered, contextual) complexity possible if world is near-decomposable and predictable from past examples

Encoding ↑



Herb Simon

facing limits

## ■ Physical Limit of Computation

- Hans Bremmermann in 1962
- “no data processing system, whether artificial or living, can process more than  $2 \times 10^{47}$  bits per second per gram of its mass.”
  - Based on the idea that information could be stored in the energy levels of matter
  - Calculated using Heisenberg's uncertainty principle, the Hartley measure, Planck's constant, and Einstein's famous  $E = mc^2$  formula
- A computer with the mass of the entire Earth and a time period equal to the estimated age of the Earth
  - **would not be able to process more than about  $10^{93}$  bits**
- *transcomputational problems*



- A system of  $n$  variables, each of which can take  $k$  different states

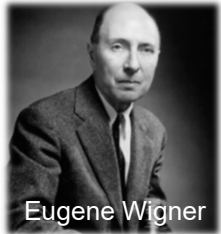
- $k^n$  possible system states
- When is it larger than  $10^{93}$ ?

|     |     |     |     |     |     |     |     |    |    |
|-----|-----|-----|-----|-----|-----|-----|-----|----|----|
| $k$ | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9  | 10 |
| $n$ | 308 | 194 | 154 | 133 | 119 | 110 | 102 | 97 | 93 |

- Pattern Recognition
  - Grid of  $n = q^2$  squares of  $k$  colors
  - *Blackbox*:  $10^{100}$  possible states!
  - The human retina contains a million light-sensitive cells
- Large scale integrated digital circuits
  - $K=2$  (bits): a circuit with 308 inputs and one output!
- Complex Problems need simplification!

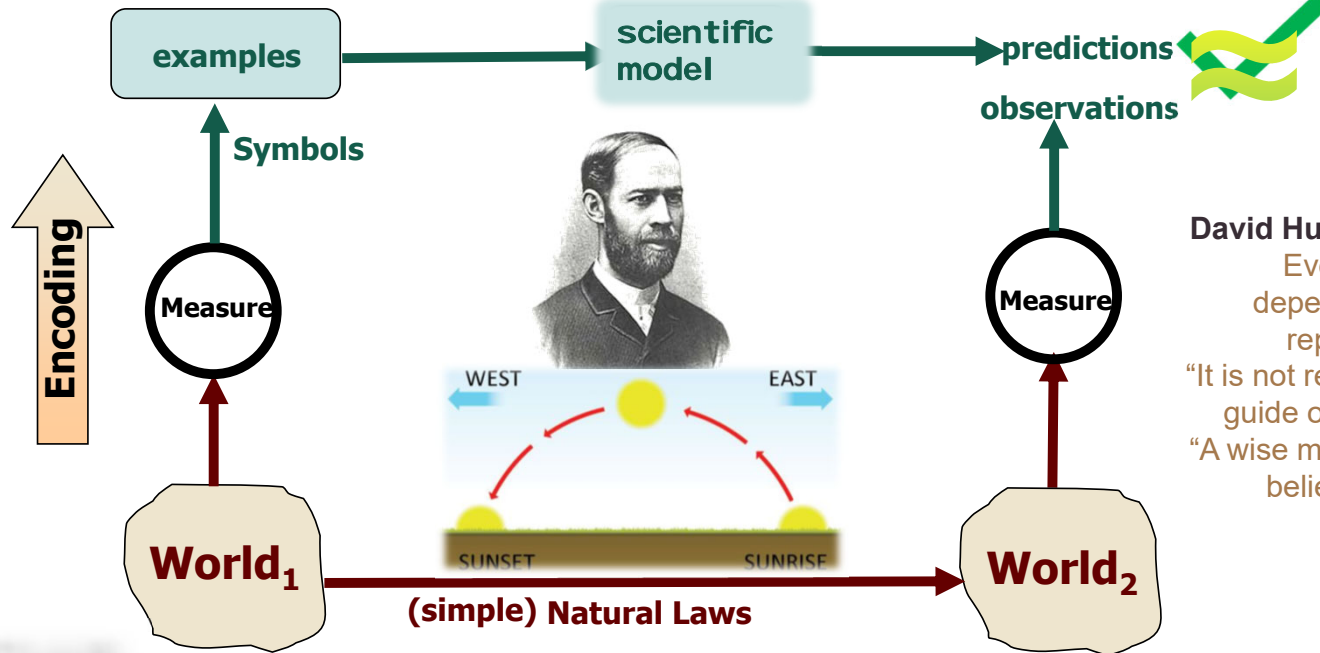
# Hume's and Hertz's World (of AI): Inductive learning

## Bad news I: computational limits



Eugene Wigner

*"Every empirical law has the disquieting quality that one does not know its limitations."* E. Wigner [1957] in "The Unreasonable Effectiveness of Mathematics in the Natural Sciences"



### David Hume's Empiricism

Everyday knowledge depends on patterns of repeated experience  
"It is not reason which is the guide of life, but custom."  
"A wise man proportions his belief to the evidence"

### Model complexity

We must simplify computational models  
Tradeoff descriptive and uncertainty-based complexity



Hans Bremmerrmann



George Klir

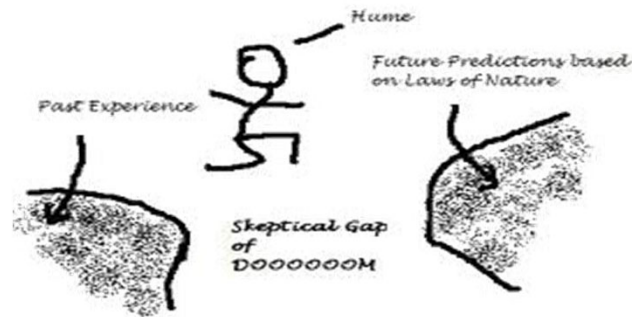


rocha@binghamton.edu  
casci.binghamton.edu/academics/ssie501



Induction is dictated (biased) by previous observations

Bad news II: black swans



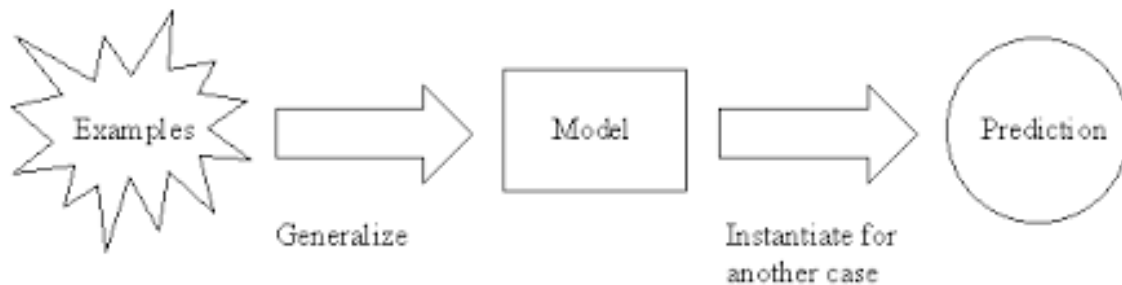
## The Inductive Leap

### David Hume's Empiricism

Everyday knowledge depends on patterns of repeated experience

"It is not reason which is the guide of life, but custom."

"A wise man proportions his belief to the evidence"



Induction is dictated (biased) by previous observations

## Bad news II: black swans



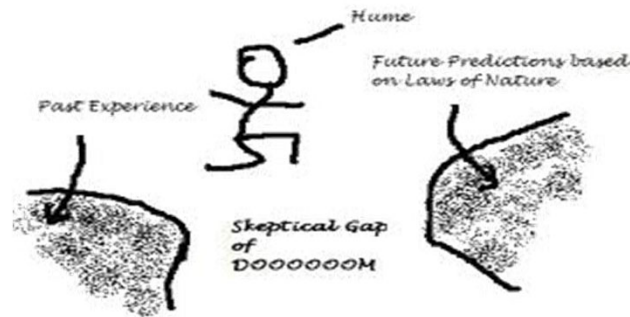
### Karl Popper's Falsification Principle

logical asymmetry between verification and falsification: many observations do not derive (universal) theories, a single observation can falsify it: scientific theories (deduced) from induction are **testable**.



### Bertrand Russell

On Hume's common sense practical skepticism

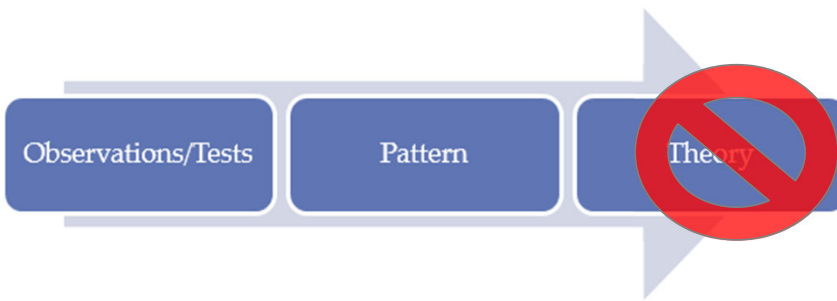


## The Inductive Leap



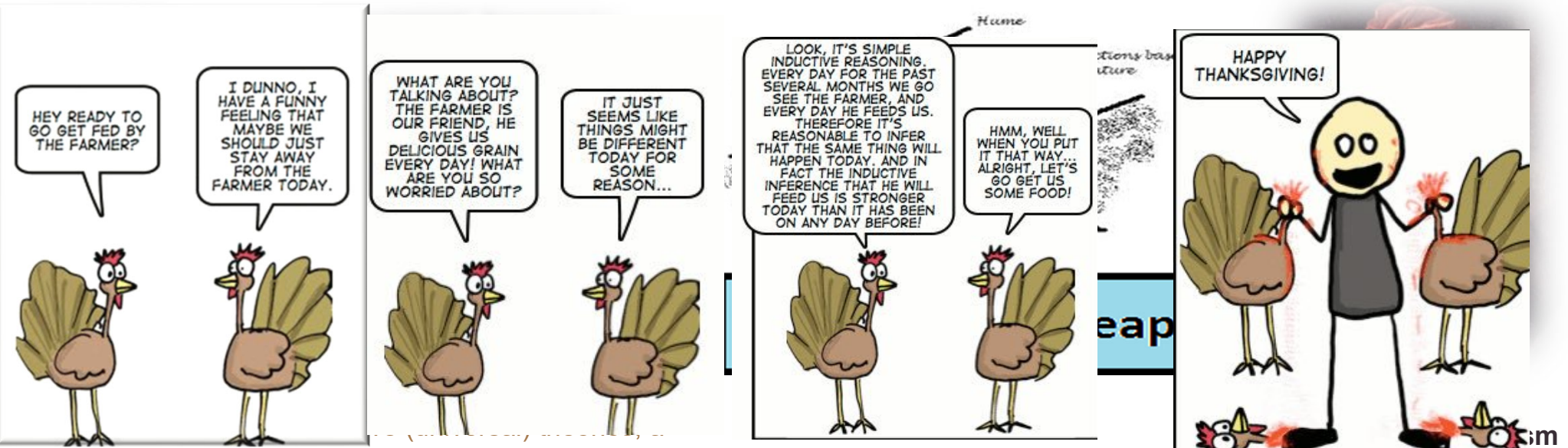
### David Hume's Empiricism

Everyday knowledge depends on patterns of repeated experience  
"It is not reason which is the guide of life, but custom."  
"A wise man proportions his belief to the evidence"



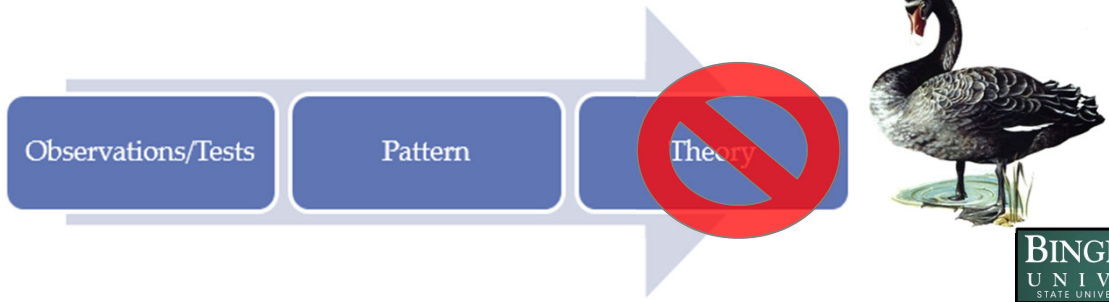
# Induction is dictated (biased) by previous observations

## Bad news II: black swans



single observation can falsify it: scientific theories (deduced) from induction are **testable**.

Everyday knowledge depends on patterns of repeated experience  
 "It is not reason which is the guide of life, but custom."  
 "A wise man proportions his belief to the evidence"





# integrating and analyzing multiomics data

## social media data pipelines for biomedicine



**a**

**b**

X likes

anonymous\_user Finally allowed 7 days of meds as opposed to 3 days! Woof That makes things a bit easier. I'm feeling poorly today. I start of a **suprapubic cath** injection. I hate that!! Sits body. Reupatient recovery medication **Extraxim?** **Equilopine** #pc #fowlers #catheter #injection

X likes

anonymous\_user Toothaches suck!!! I love my Simons eat hot water bottle! I have been truly struggling today. I woke up this morning not wanting to move or be alive. But now I'm OK! Bloody head. #bpd #borderline #low #depressed #depression #suicide #suicidal #moodswings

Add a comment...

**c**

X likes

anonymous\_user Classic I know but I look at it everytime I feel extra lonely in the addiction sh!t hole. #addiction #addictoristreat #naaa #oxycotin

Add a comment...

anonymous\_user All that #belmeds just for a wisdom tooth extraction #oralurgery #ibuprofen #oxycodone #amoxicillin #tratemeds #nochoice

Add a comment...

anonymous\_user A few months ago I did the self-assessment and got 70/100 for both **anxiety** and **depression**, labeled as "cause for concern" because it was so high (DP is what's considered a "normal" level). Took it again today and am so proud of how far I've come. I #doggram #anxiety #depression #otalopram #therapy #selfimprovement #happiness #success #inspiring :)

X likes

anonymous\_user **Grapefruit**, anyone? My **mood stabilizers** have a warning on label that says DO NOT EAT **PINK GRAPEFRUIT**. Here they sit, tempting me on the counter.

Add a comment...

**d**

Anonymous User @Twitter

To all my followers. If I start making NO sense at all remember I've taken 2 paincills (**Oxycodone 15**) and my 2 sleeping pills (**Ambien 10**)

12:00 pm · 01 Jan 20XX · Twitter Web Client

Anonymous User @Twitter

that **percocet** knocked me out...feeling kind of **woosy** but I'll wait to eat until I teke more

12:00 pm · 01 Jan 20XX · Twitter Web Client

Anonymous User @Twitter

I had **valium** for the first time last week. that was nice. it didn't help with **pain** but it made me not care.

12:00 pm · 01 Jan 20XX · Twitter Web Client

Anonymous User @Twitter

maybe **diazepam** can solve my problem though can't cure my illness #**backpain**

12:00 pm · 01 Jan 20XX · Twitter Web Client

Anonymous User @Twitter

**Ambien** is hysterical. [...] Let your Dr know if you're driving while sleeping to go to [...]. #Zinks!

12:00 pm · 01 Jan 20XX · Twitter Web Client

Anonymous User @Twitter

**diazepam**...**valium**...**tamazepam**...**lithiumect**...hr...how long must I stay on this stuff?please don't give me more.

12:00 pm · 01 Jan 20XX · Twitter Web Client

**e**

**4,000mg Keppra**

Topic Medication Issues

I am 23 and have **partial complex seizures** about 4-5 days a week and am currently controlling them with **Zonisamide**, **Keppra**, **Phenobarbital** and **Keppra**. While I'm reading these forums, I see very low doses of these medications. I would obviously not like to stay on these medications forever and like to think a wean schedule is possible eventually, but I am currently on 2,000mg of **Keppra** twice a day. I just wanted to know if anyone else was on this high of a dose/had any issues.

4 Comments

Subscribe · PDS

Joe [Community Power User]

While I do not know how long you have been living and dealing with **epilepsy**, I do know about taking several medications. My question is, have you asked your neurologist about this issue? I took 3-750 mg **Keppra** along with 3-200 mg **Valium** in morning and at night [..] I haven't had any issues and your assumption or wondering needs to be looked at realistically. Can all people take the same amount of any medication? [..] Each person is different and their needs are different. Which means that their medications change and do vary. At one time I was taking **Phenobarbital**, **Keppra** and **Valium**. The new neurologist I had to get asked me how I "lock up" in the morning. His statement was followed by "since you take enough **Keppra** to put the average man to sleep for 24 hours. Go on discuss this issue with your neurologist and ask about other medication or procedures that can help control your seizures.

Like · Reply · Share · 2 replies ·

Mary

I'm on 150mg **Keppra**, 200mg **Zonisamide**, 48.5mg **Phen** and 2,000mg **Keppra** - all of these twice a day. I've been taking these medications for 4 years. I understand everyone's different. I've just been seeing very low doses on here and didn't know how normal it was for me to be on this much **Keppra**. let alone this many medications.

Like · Reply · Share · 1 reply ·

Joe [Community Power User]

each person is different therefore the amount a medication they take can vary. Oh and I have always needed higher dosages than most people take. If your doses are 2 times a day please make sure the doses are as close to 12 hours apart. That way it keeps the therapeutic levels where they need to be in order to stop these **epilepsy**. Also if your dosage hasn't changed in some time then discuss your issue with your neurologist. They may want to change your meds to newer meds with fewer side effects. Also understand that too much medication is just as bad as too little medication.

Like · Reply · Share

Ann

I was placed on, I believe, 2000 mg of **Keppra** 2x a day a few years ago but didn't take any other meds along with that amount of **Keppra**. I don't remember trying any other the other meds that you mentioned either and I didn't get relief from thousands of **Keppra** until a major surgery in May of [year].

Like · Reply · Share

Min et al [2023]. *CHI 2023*. 32.

Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports*. 7: 17973.

Correia, Li & Rocha [2016]. *PSB*: 21:492-503.

Ciampaglia, et al [2015]. *PLoS ONE*. 10(6): e0128193.

Wood, Correia, Miller, & Rocha [2022]. *Epilepsy & Behavior*. 128: 108580.

Correia, Wood, Bollen, & Rocha [2020]. *Annual Review of Biomedical Data Science*, 3:1.



rocha@binghamton.edu  
casci.binghamton.edu/academics/ssie501

social media data pipelines for biomedicine



**1 Social Media for Public Health Monitoring** a scientific app.

The knowledge network represents how the terms in that always occur together will be linked and closer to

project: **Opioids (Fentanyl & Oxycodone)**

network: 7 days

**Epilepsy & Behavior**  
Volume 128, March 2022, 108580

**Small cohort of patients with epilepsy showed increased activity on Facebook before sudden unexpected death**

Ian B. Wood<sup>a,1</sup>, Rion Brattig Correia<sup>b, c, a, 1</sup>, Wendy R. Miller<sup>d, a, 1</sup>, Luis M. Rocha<sup>e, a, b, 1</sup>

function (Function Words) for User: subject2

Min et al [2023]. *CHI 2023*. 32.  
 Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports*. 7: 17973.  
 Correia, Li & Rocha [2016]. *PSB*: 21:492-503.  
 Ciampaglia, et al [2015]. *PLoS ONE*. 10(6): e0128193.

Wood, Correia, Miller, & Rocha [2022]. *Epilepsy & Behavior*. 128: 108580.  
 Correia, Wood, Bollen, & Rocha [2020]. *Annual Review of Biomedical Data Science*, 3:1.



# integrating and analyzing multiomics data

## social media data pipelines for biomedicine



### 1 Social Media for Public Health

The knowledge network represents how things that always occur together will be linked together.

project: Opioids (Fentanyl & Oxycodone)

network: 7 days

**Node & Edge Information:**

|           |                     |            |
|-----------|---------------------|------------|
| Node      | Warfarin            | Type: drug |
| Source    | Phytonadione        | Type: drug |
| Target    | Warfarin            | Type: drug |
| Proximity | 0.11764705882352941 |            |

DDI ✓ ADR ✗ DI ✗

Timeines contributing to this edge: [View](#)

**Visualization:**

Q Search Abasia [Locate](#)

Drugs  Symptoms  
 Nat. Prod. [Remove orphans](#)

Drug→Drug  Nat. Prod.→Nat. Prod.  
 Symptom→Symptom  
 Drug→Symptom  Drug→Nat. Prod.  
 Nat. Prod.→Symp

Network Layout (simulation) [Run!](#)

Selected nodes: 0

SyMPToM *beta* PROJECTS PUBLICATIONS

## Social Media Public health Monitoring

a scientific app

**ANNUAL REVIEWS**

Correia, Wood, Bollen & Rocha [2020]. *Mining social media data for biomedical signals and health-related behavior.*

### Annual Review of Biomedical Data Science

Average function (f) per Post p

Date

| Year | Average function (f) per Post p |
|------|---------------------------------|
| 2010 | ~5                              |
| 2011 | ~10                             |
| 2012 | ~15                             |
| 2013 | ~25                             |
| 2014 | ~35                             |

Min et al [2023]. *CHI 2023*. **32**.

Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports*. **7**: 17973.

Correia, Li & Rocha [2016]. *PSB*: **21**:492-503.

Ciampaglia, et al [2015]. *PLoS ONE*. **10**(6): e0128193.

Wood, Correia, Miller, & Rocha [2022]. *Epilepsy & Behavior*. **128**: 108580.

Correia, Wood, Bollen, & Rocha [2020]. *Annual Review of Biomedical Data Science*, **3**:1.



rocha@binghamton.edu  
casci.binghamton.edu/academics/ssie501

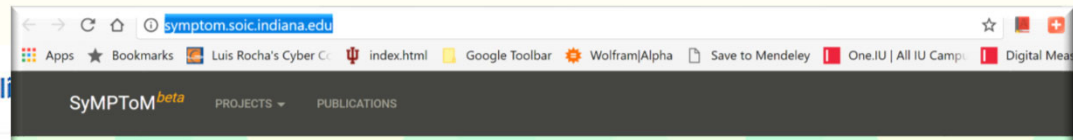
# integrating and analyzing multiomics data

## social media data pipelines for biomedicine



### 1 Social Media for Public Health Monitoring

The knowledge network represents how that always occur together will be linked



## MyAura: Personalized Dashboard and Web Service For Chronic Disease Management



Online pre-survey



Focus group  
13 participants



Data analysis



Needs & Challenges Identification



Mockup App Design



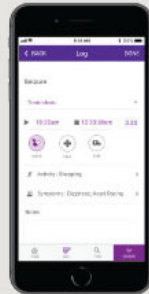
Usability Test  
4 participants



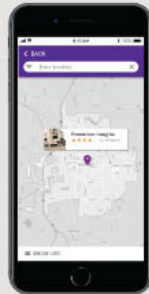
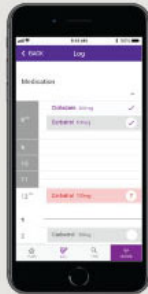
Data Visualization  
Seizure & Symptoms (Frequencies / Type / Time / ...)



Logging & Tracking Information  
Seizure / Medication / Sleep / ...



Finding Support  
Clinical Trials / Specialist / ...

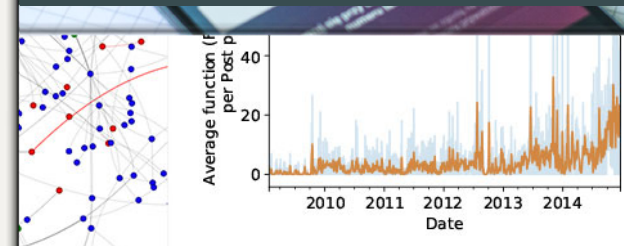


## Public health Monitoring

### ANNUAL REVIEWS

Wood, Bollen & Rocha [2020]. *Mining social media data for biomedical signals and health-related behavior.*

## Annual Review of Biomedical Data Science



Min et al [2023]. *CHI 2023*. 32.

Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports*. 7: 17973.

Correia, Li & Rocha [2016]. *PSB*: 21:492-503.

Ciampaglia, et al [2015]. *PLoS ONE*. 10(6): e0128193.

Wood, Correia, Miller, & Rocha [2022]. *Epilepsy & Behavior*. 128: 108580.

Correia, Wood, Bollen, & Rocha [2020]. *Annual Review of Biomedical Data Science*, 3:1.



rocha@binghamton.edu  
casci.binghamton.edu/academics/ssie501

# hypothesis falsification in data and complexity science

## resolving a sociobiology question on a planetary scale

### ■ Social Media (Twitter) Mood and Web Searches

- Understanding collective human behavior
- Discovering mood transitions in health

SCIENTIFIC REPORTS

Altmetric: 743

[More detail >>](#)

Article | [OPEN](#)

### Human Sexual Cycles are Driven by Culture and Match Collective Moods

Ian B. Wood, Pedro L. Varela, Johan Bollen, Luis M. Rocha & Joana Gonçalves-Sá



Joana Sá  
IST



Johan Bollen  
Indiana University



Ian Wood  
Indiana University

Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports*. 7: 17973.

### Global Patterns of Seasonal Variation in Human Fertility<sup>a</sup>

DAVID A. LAM<sup>b,d</sup> AND JEFFREY A. MIRON<sup>c</sup>

### Emerald Article: Summer nights: A review of the evidence of seasonal variations in sexual health indicators among young people

Wendy Macdowall, Kaye Wellings, Judith Stephenson, Anna Glasier

### Annual Rhythm of Human Reproduction: I. Biology, Sociology, or Both?

*Till Roenneberg\* and Jürgen Aschoff†*

The observed annual birth cycle (in countries where there is data). Is it driven by biological adaptation or culture?

### THE EFFECTS OF TEMPERATURE ON HUMAN FERTILITY\*

DAVID A. LAM AND JEFFREY A. MIRON



rocha@binghamton.edu  
casci.binghamton.edu/academics/ssie501

# hypothesis falsification in data and complexity science

resolving a sociobiology question on a planetary scale

## ■ Social Media (Twitter) Mood and Web Searches

- Understanding collective human behavior
- Discovering mood transitions in health

Western Northern countries, Canada, Denmark, Finland, France, Germany, Italy, Lithuania, Mas: Austria, Netherlands, Poland, Portugal, Spain, Sweden and USA

Human Sexual Cycles are Driven by

## Global Patterns of Seasonal Variation in Human Fertility<sup>a</sup>

DAVID A. LAM<sup>b,d</sup> AND JEFFREY A. MIRON<sup>c</sup>

A review of the evidence of seasonal factors among young people

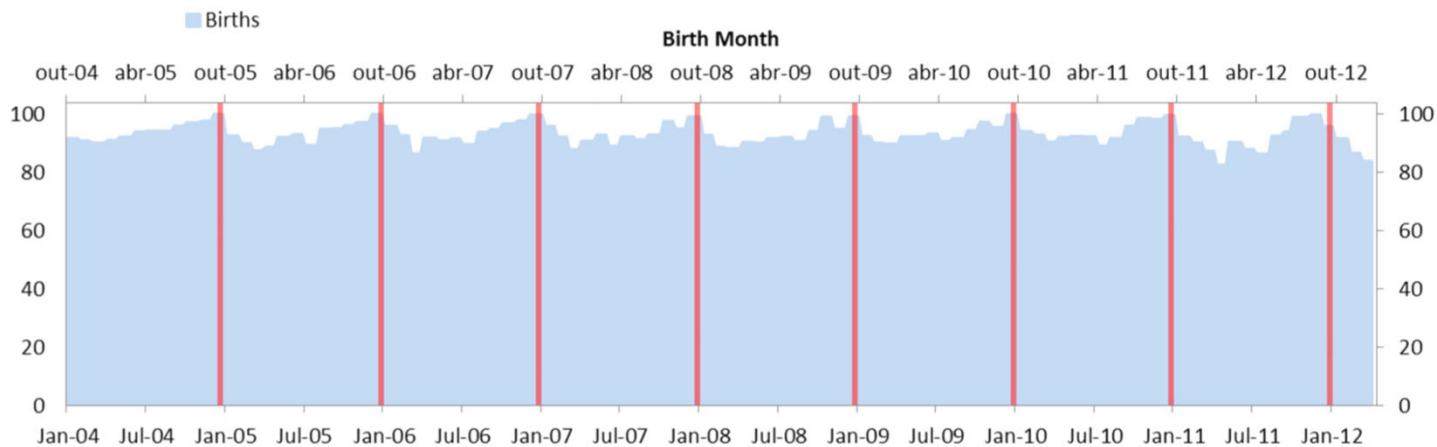
Judith Stephenson, Anna Glasier

## Annual Rhythm of Human Reproduction: Biology, Sociology, or Both?

and Jürgen Aschoff<sup>†</sup>

annual birth cycle (in countries where data is available). Is it driven by biological adaptation or culture?

## CULTURE ON HUMAN FERTILITY\*



Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports*. 7: 17973.



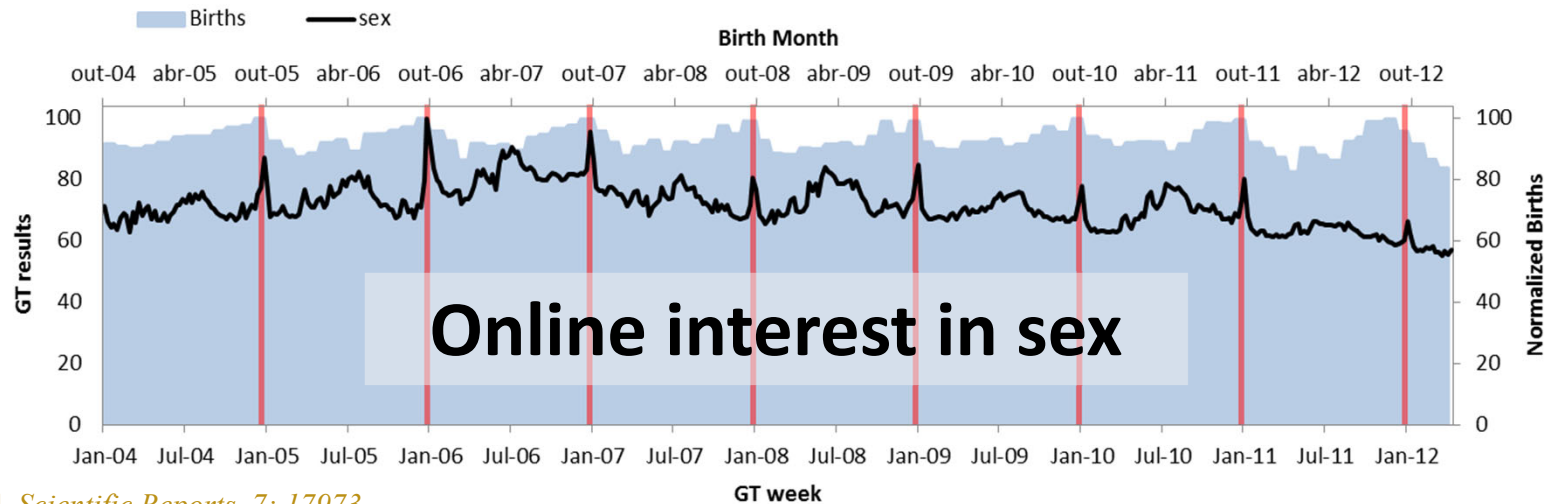
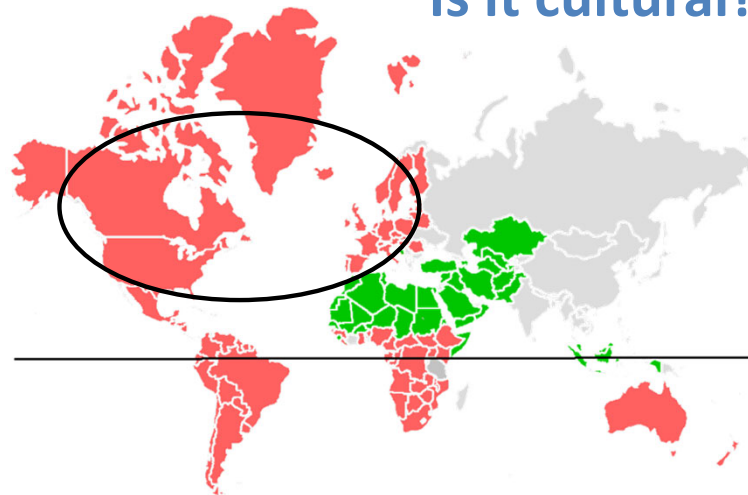
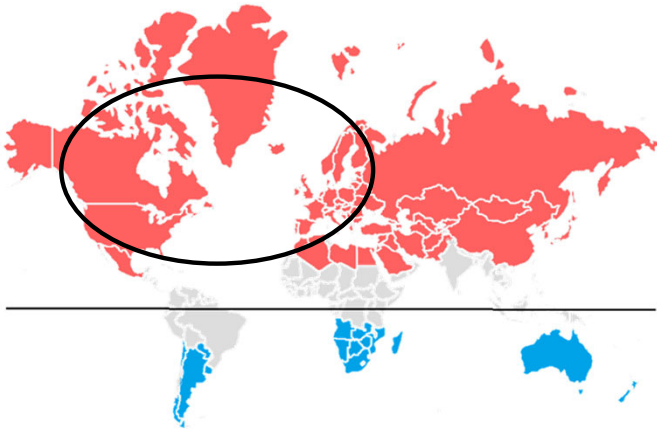
rocha@binghamton.edu  
casci.binghamton.edu/academics/ssie501



search and social media mood provide global patterns

Is it biological adaptation?

Is it cultural?





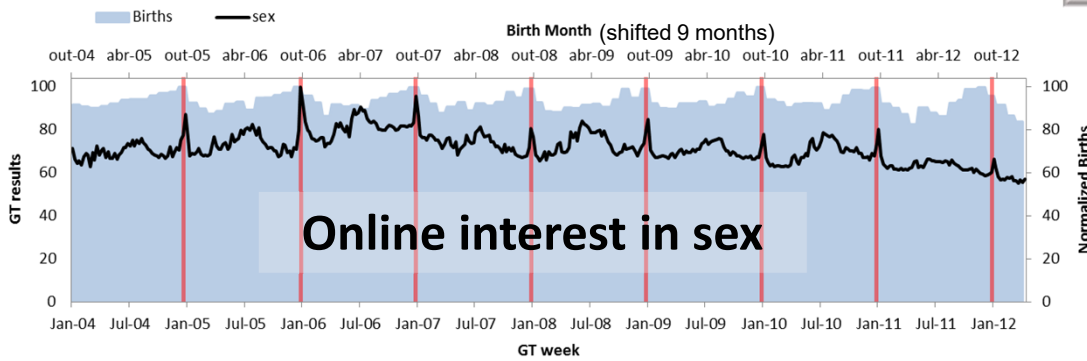
# Hypothesis falsification in data and complexity science

## resolving a sociobiology question on a planetary scale

### Social Media (Twitter) Mood and Google Searches

- Understanding collective human behavior
- Discovering mood transitions in health

**Sex search** patterns (proxy for interest in sex and births) are culturally-driven and correlate with distinct **mood patterns** on social media

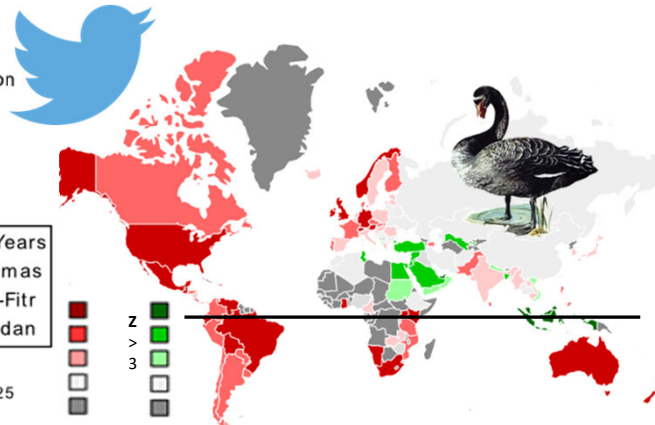
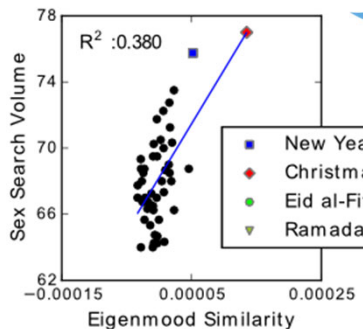


Why? child-centered and gift-giving holidays?



### Christmas - USA

Searches vs Similarity Regression



granger causality analysis suggests that mood causes interest in sex

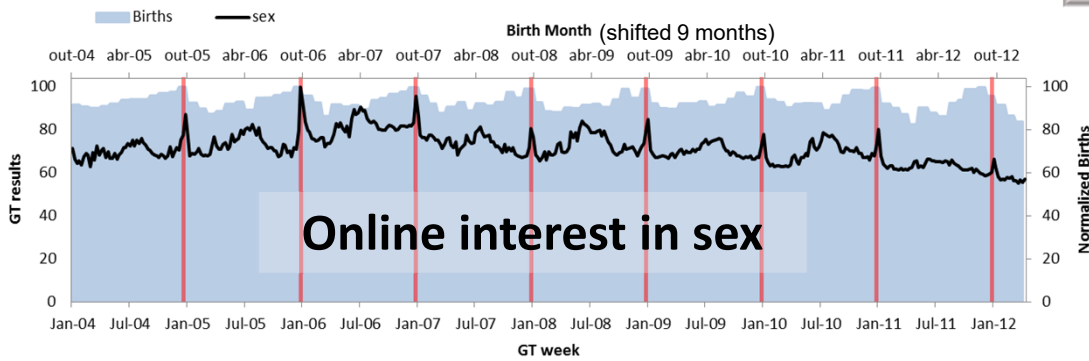


# Hypothesis falsification in data and complexity science

resolving a sociobiology question on a planetary scale

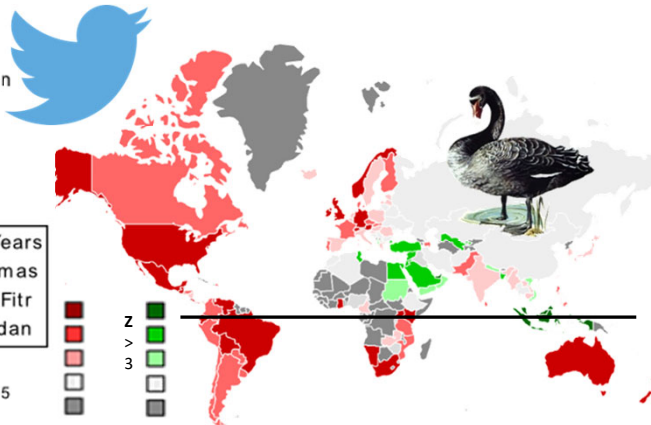
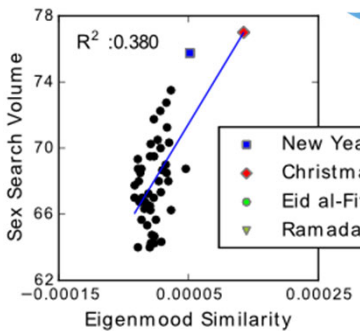
## Social Media (Twitter) Mood and Google Searches

- Understanding collective human behavior
- Discovering mood transitions in health



## Christmas - USA

Searches vs Similarity Regression



grand  
sugge

Mother Jones

DONATE

Help us raise \$350,000 by December 31 with a tax-deductible, year-end donation — or read why this moment feels so critical.

**Have Yourself a Porny Little Christmas**

New research shows people are really in the mood this time of year.

JACKIE FLYNN MOGENSEN

DEC. 21, 2017 5:09 PM

SCIENTIFIC REPORTS

Altmetric: 743

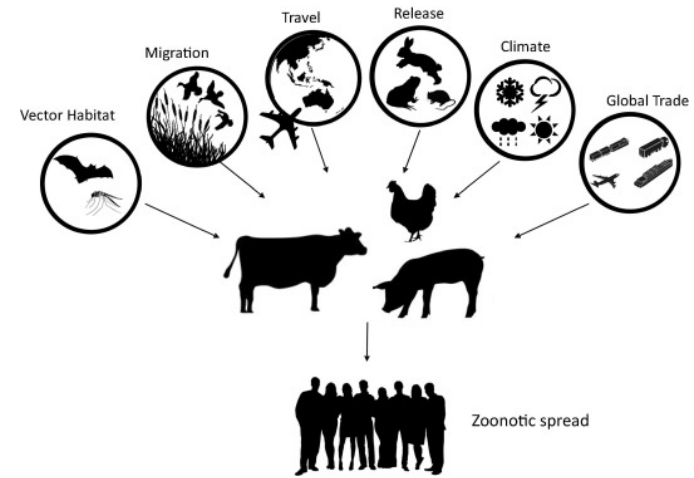
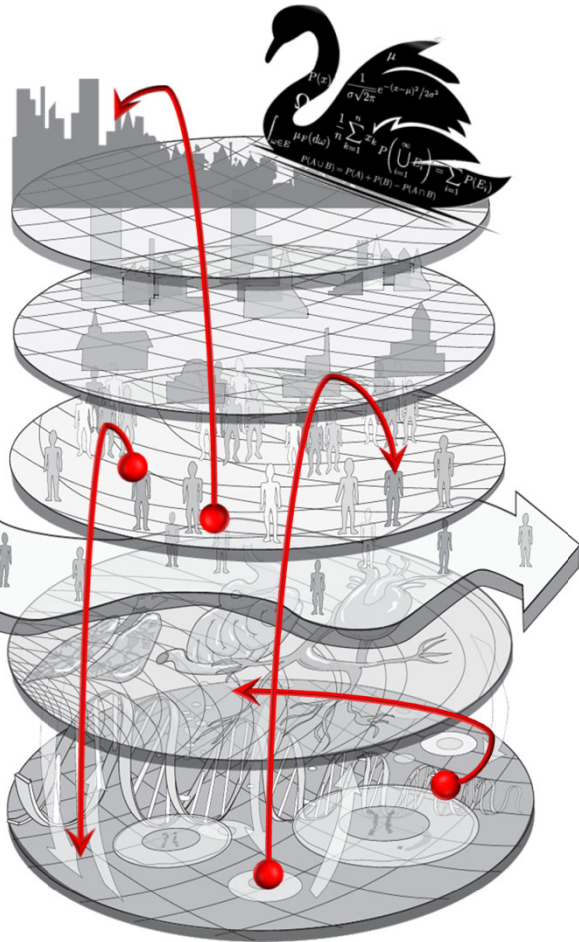
Article | OPEN

Human Sexual Cycles are Driven by Culture and Match Collective Moods

Ian B. Wood, Pedro L. Varela, Johan Bollen, Luis M. Rocha & Joana Gonçalves-Sá

control hierarchies are not near-decomposable

### Bad news III: inductive, “boxed” model failure with complex systems



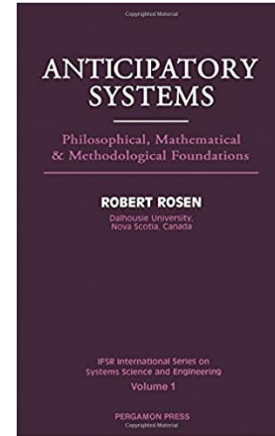
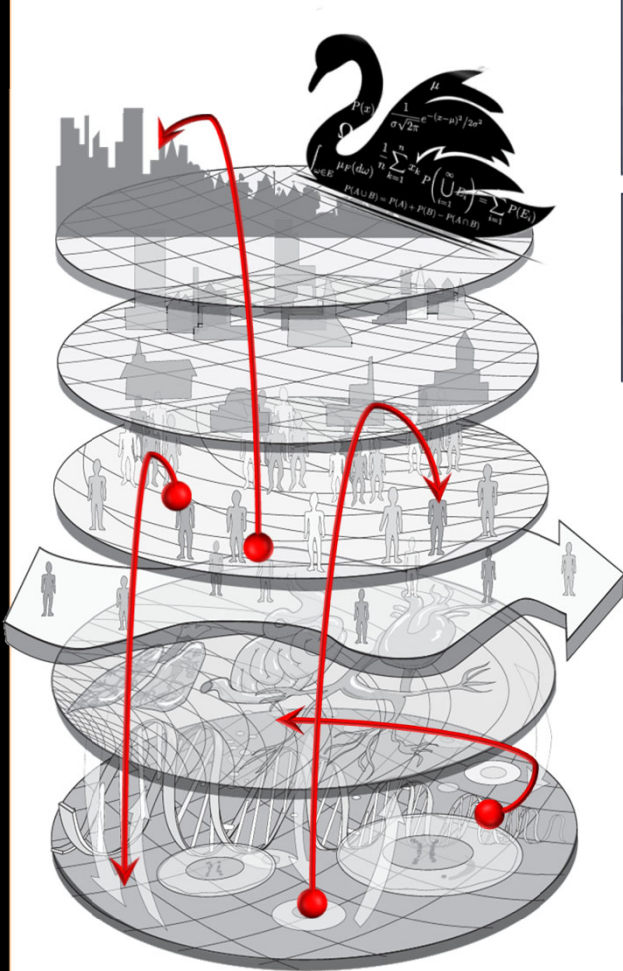


control hierarchies are not near-decomposable

## Bad news III: inductive, “boxed” model failure with complex systems

**Key insight:** complex systems need multi-level, contextual/actionable **models and theory** to predict rare, major transitions (not predictable by empirical evidence from single layer)

**Key insight:** complex systems are: 1) not reducible to self-contained multivariate structure or dynamics (boxed mechanisms), 2) not predictable from past data when it matters.

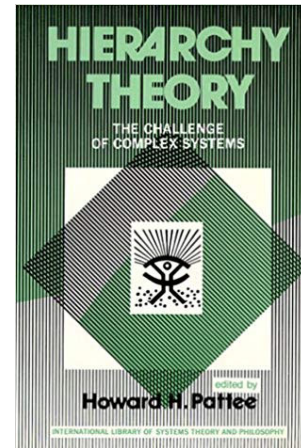


Howard Pattee

A model of any complex system will deviate as emergent properties arise from (rare) external controls



Robert Rosen



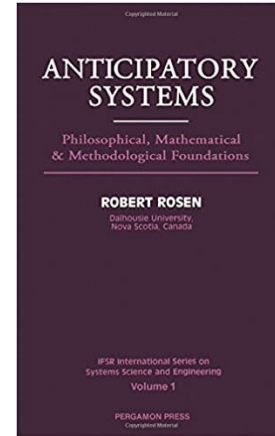


control hierarchies are not near-decomposable

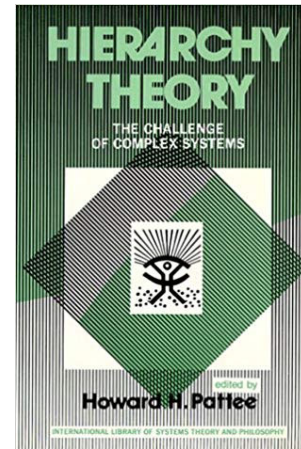
### Bad news III: inductive, "boxed" model failure with complex systems

**Key insight:** complex systems need multi-level, contextual/actionable **models and theory** to predict rare, major transitions (not predictable by empirical evidence from single layer)

**Key insight:** complex systems are: 1) not reducible to self-contained multivariate structure or dynamics (boxed mechanisms), 2) not predictable from past data when it matters.



Howard Pattee

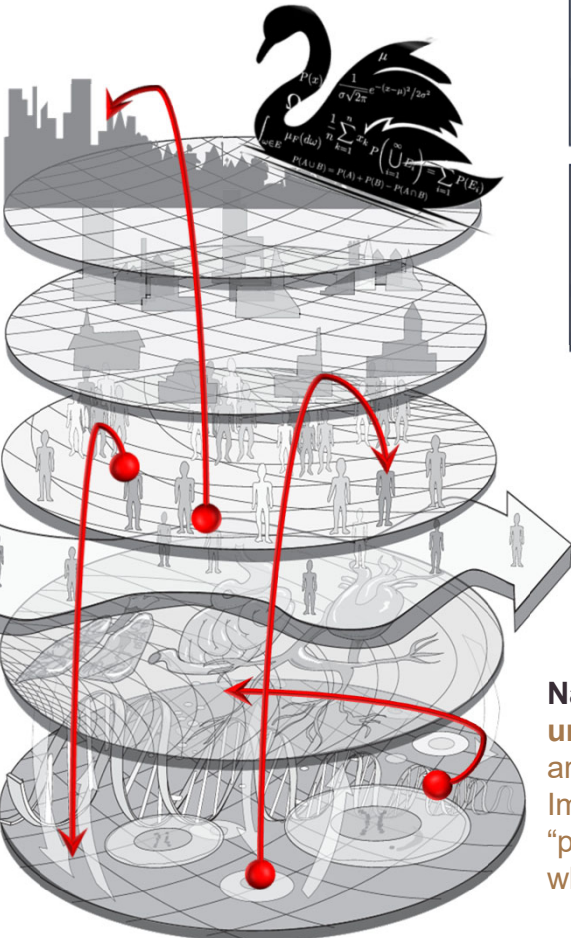


Robert Rosen

A model of any complex system will deviate as emergent properties arise from (rare) external controls

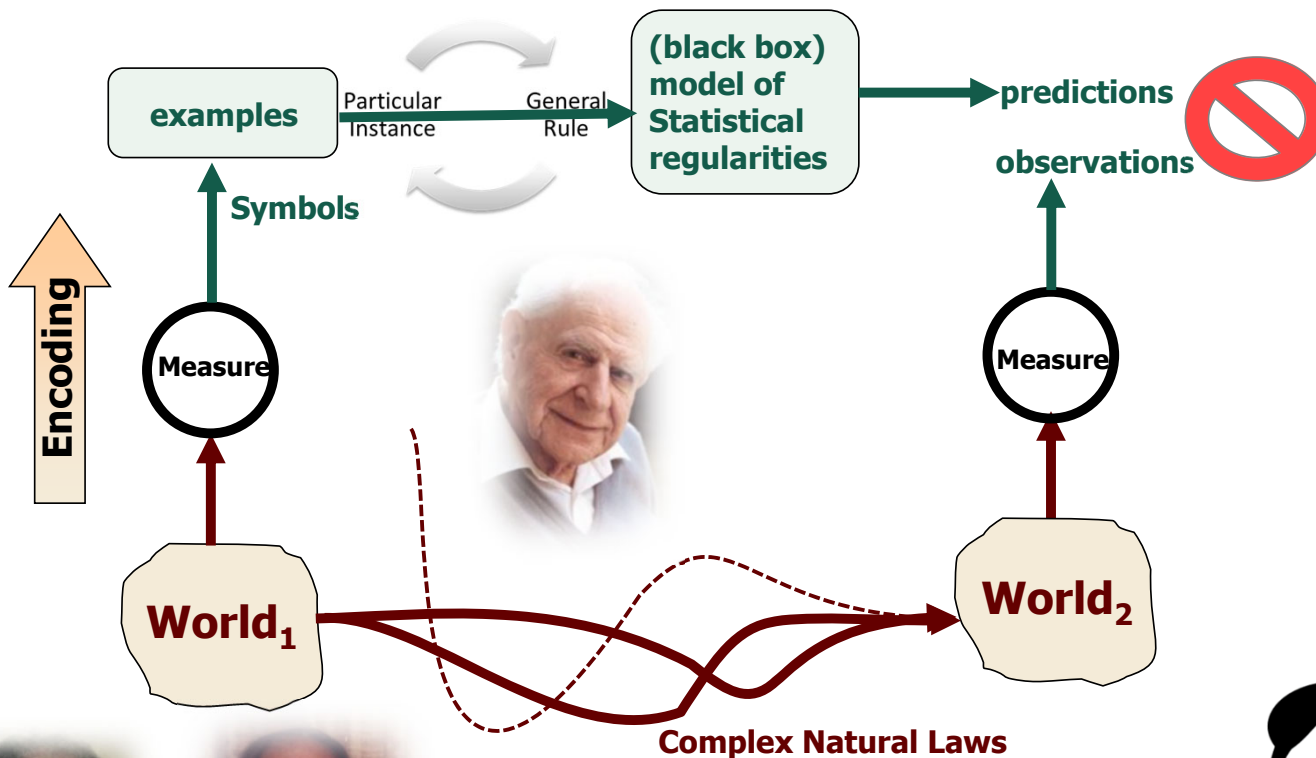


**Nassim Nicholas Taleb**  
**unexpected events** of large magnitude and consequence are dominant in history. Importance of studying robustness/resilience/evolvability "predictions of events **depend** more and more **on theories** when their probability is small and system is **complex**"



Pescosolido, B.A. 2006. Journal of Health and Social Behavior 47: 189-208.

inductive models can be falsified but cannot predict black swans

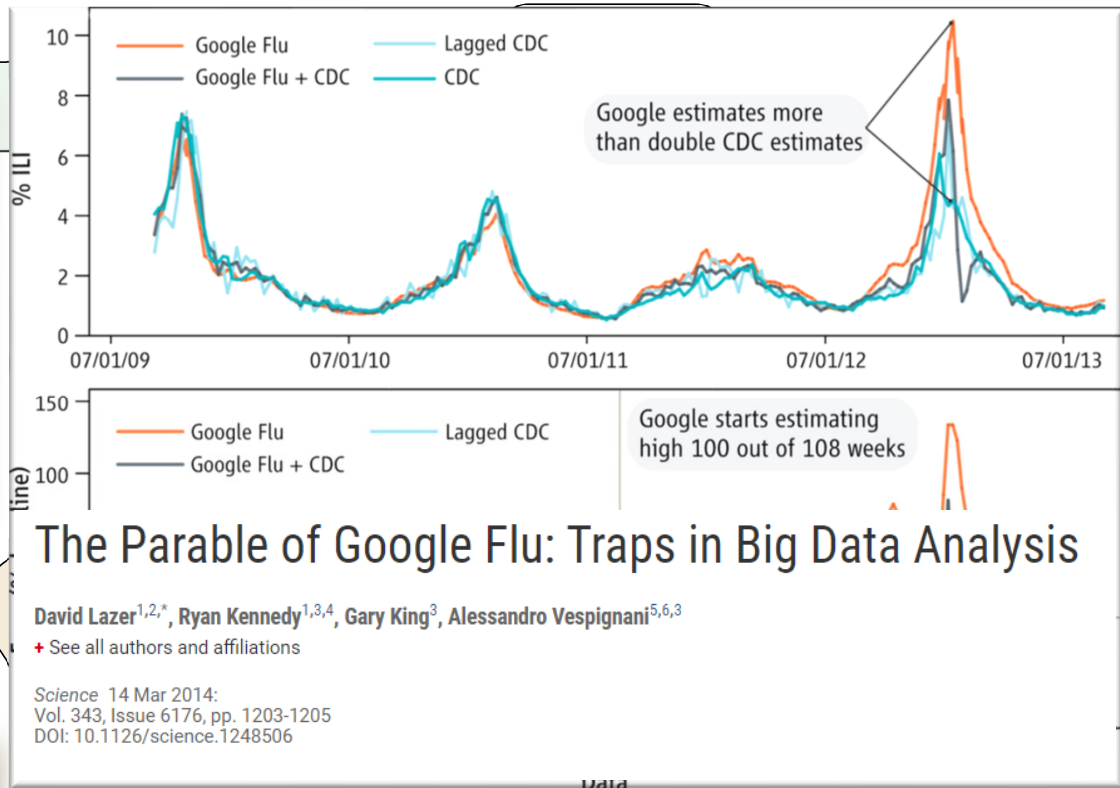


Nassim Nicholas Taleb

Howard Pattee

Robert Rosen

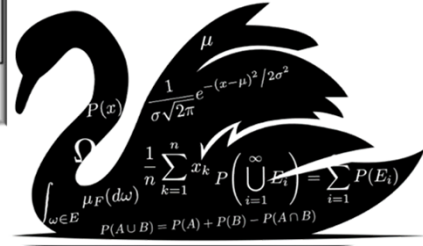
inductive models can be falsified but cannot predict black swans



Nassim Nicholas Taleb

Howard Pattee

Robert Rosen





machine learning depends on training data that is contextual



Angwin, Larson, Mattu & Kirchner, "Machine Bias". *ProPublica*, May 23, 2016  
[propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing](http://propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing)



# inductive bias in diverse scenarios

machine learning depends on training data that is contextual



| Gender Classifier | Darker Male | Darker Female | Lighter Male | Lighter Female | Largest Gap |
|-------------------|-------------|---------------|--------------|----------------|-------------|
| Microsoft         | 94.0%       | 79.2%         | 100%         | 98.3%          | 20.8%       |
| FACE++            | 99.3%       | 65.5%         | 99.2%        | 94.0%          | 33.8%       |
|                   | 8.0%        | 65.3%         | 99.7%        | 92.9%          | 34.4%       |

**VERNON PRATER**

**Prior Offenses**  
2 armed robberies, 1 attempted armed robbery

**Subsequent Offenses**  
1 grand theft


**LOW RISK 3**

**BRISHA BORDEN**

**Prior Offenses**  
4 juvenile misdemeanors


**Subsequent Offenses**  
None

**HIGH RISK 8**



**JAMES RIVELLI**

**LOW RISK 3**




**ROBERT CANNON**

**MEDIUM RISK 6**



**DYLAN FUGETT**

**LOW RISK 3**



**BERNARD PARKER**

**HIGH RISK 10**

**JAMES RIVELLI**

**Prior Offenses**  
1 domestic violence aggravated assault, 1 grand theft, 1 petty theft, 1 drug trafficking

**Subsequent Offenses**  
1 grand theft

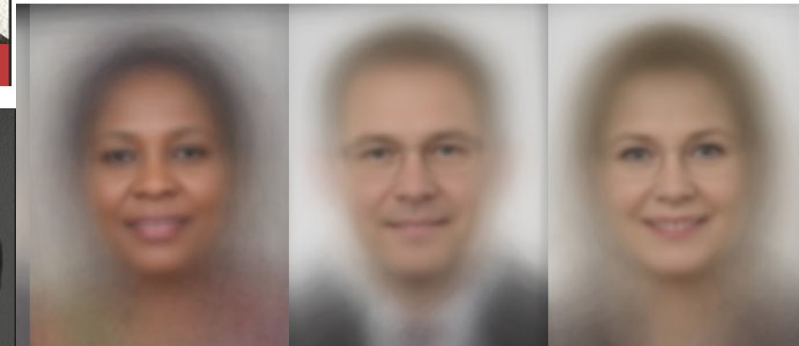
**LOW RISK 3**

**ROBERT CANNON**

**Prior Offense**  
1 petty theft

**Subsequent Offenses**  
None

**MEDIUM RISK 6**



Angwin, Larson, Mattu & Kirchner, "Machine Bias". *ProPublica*, May 23, 2016  
[propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing](http://propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing)

## readings

## ■ Class Book

- Klir, G.J. [2001]. *Facets of systems science*. Springer.

## ■ Papers and other materials

### ● Module 4 – Multi-level Complexity

#### ■ Reading and Discussion Group 4

- Pattee, Howard H. "[The Physical Basis and Origin of Hierarchical Control](#)." In *Hierarchy Theory: The Challenge of Complex Systems*, edited by Howard H. Pattee, 73–108. New York: Brazillier, 1973.
- Rosen, Robert. "[On Complex Systems](#)." *European Journal of Operational Research* **30**, no. 2 (June 1987): 129–34.
- Lazebnik, Y [2002]. "Can a biologist fix a radio?--Or, what I learned while studying apoptosis". *Cancer Cell*, **2**(3):179-182.
  - **Optional:** Gates, Alexander J., Rion Brattig Correia, Xuan Wang, and Luis M. Rocha. "The Effective Graph Reveals Redundancy, Canalization, and Control Pathways in Biochemical Regulation and Signaling." *Proceedings of the National Academy of Sciences* **118**, no. 12 (March 23, 2021): e2022598118.

