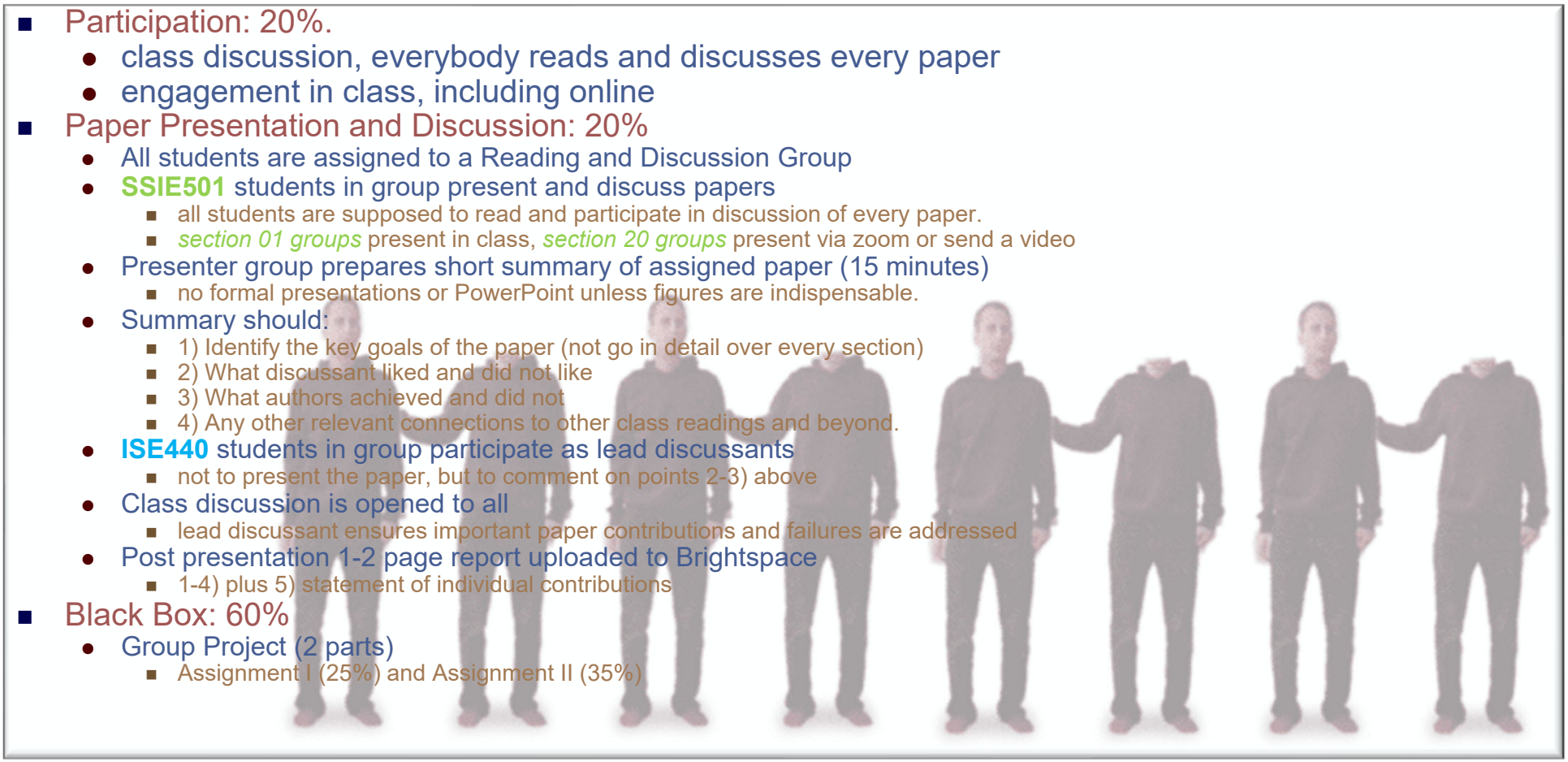
lecture 15: multilevel organization of complex systems and modeling limitations

Multilevel Organization of Complex Systems

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%)



BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

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 14th
    - 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 16th / 28th ?
    - 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 28th ?
    - 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 30th ?
    - 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

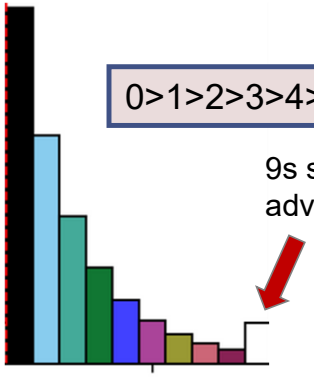
- Remember "published" facts
  - Odd/Even behavior in Q1
  - Statistical behavior in Q2
  - Different regions, transition sequence, complexity in Q4
- Collect or request data (cite)
- Are there quadrant dependencies?
- Focus on smaller grid (mask) subsets?
- Think of neighborhoods and boundary conditions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

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

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 ?

Q3 **Q4**

Are inner regions the same?

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

Inner region model

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

Outer region model

$\rightarrow 0$
$\rightarrow 9$

?

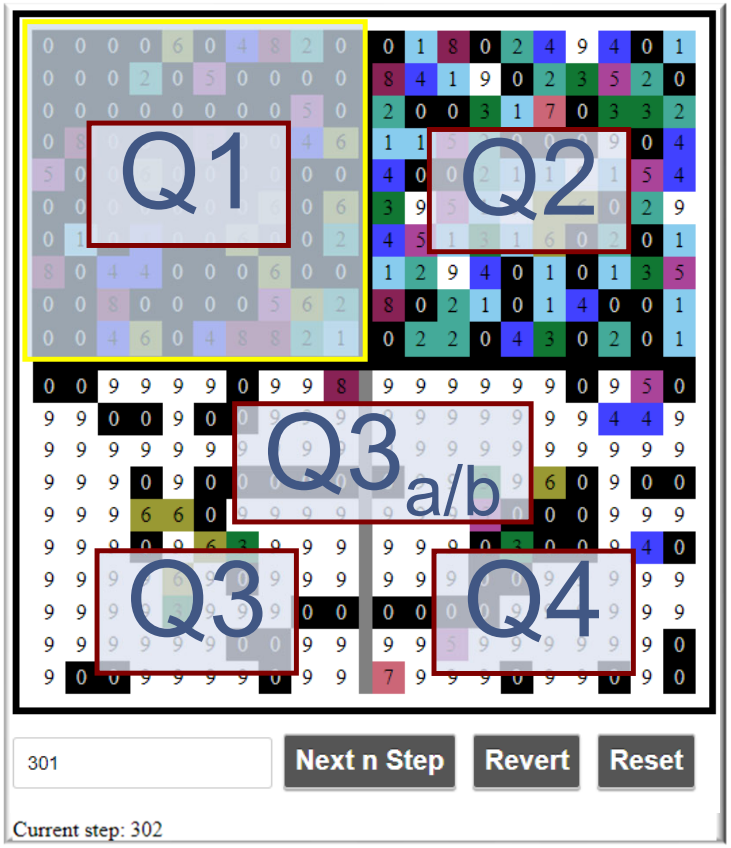
0 → 3,9
1,2 → **0,3,9**
3,4,5 → **0,6,9**
6,7,8 → **0,3,9**
9 → **0,6**

BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

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.



BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

systems modeling

- 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.

BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

systems modeling

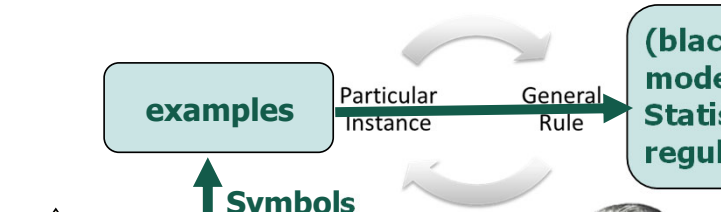
Dirk Helbing

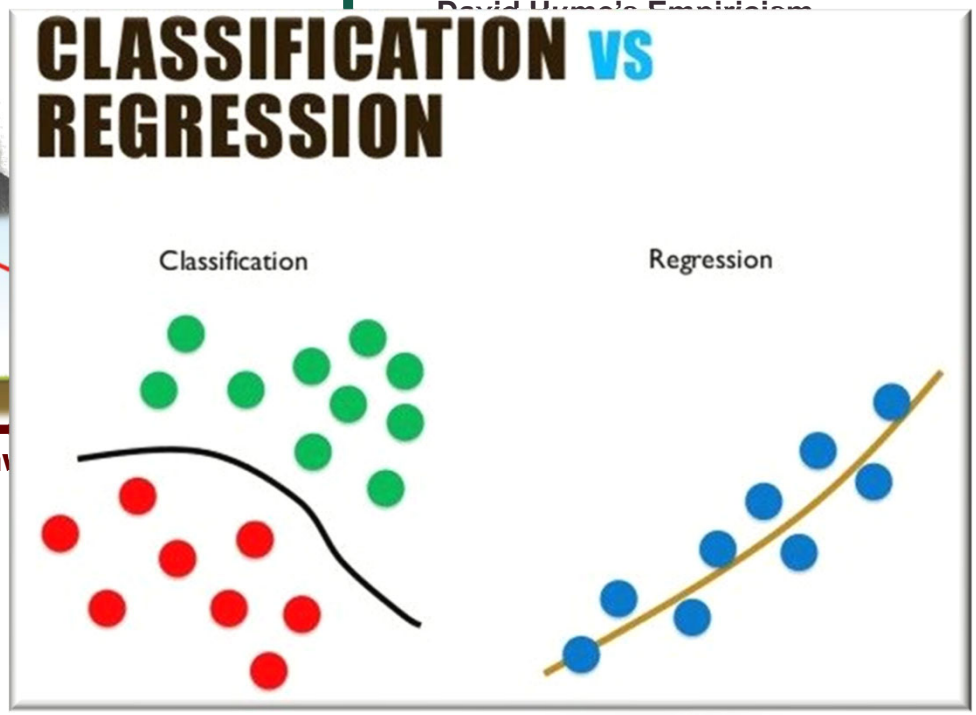
The Magic Formula ...

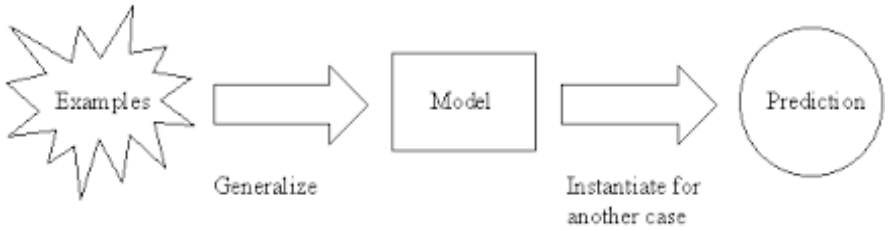
more data
= more knowledge
= more power
= more success

BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

good news I & II: near-decomposability and induction

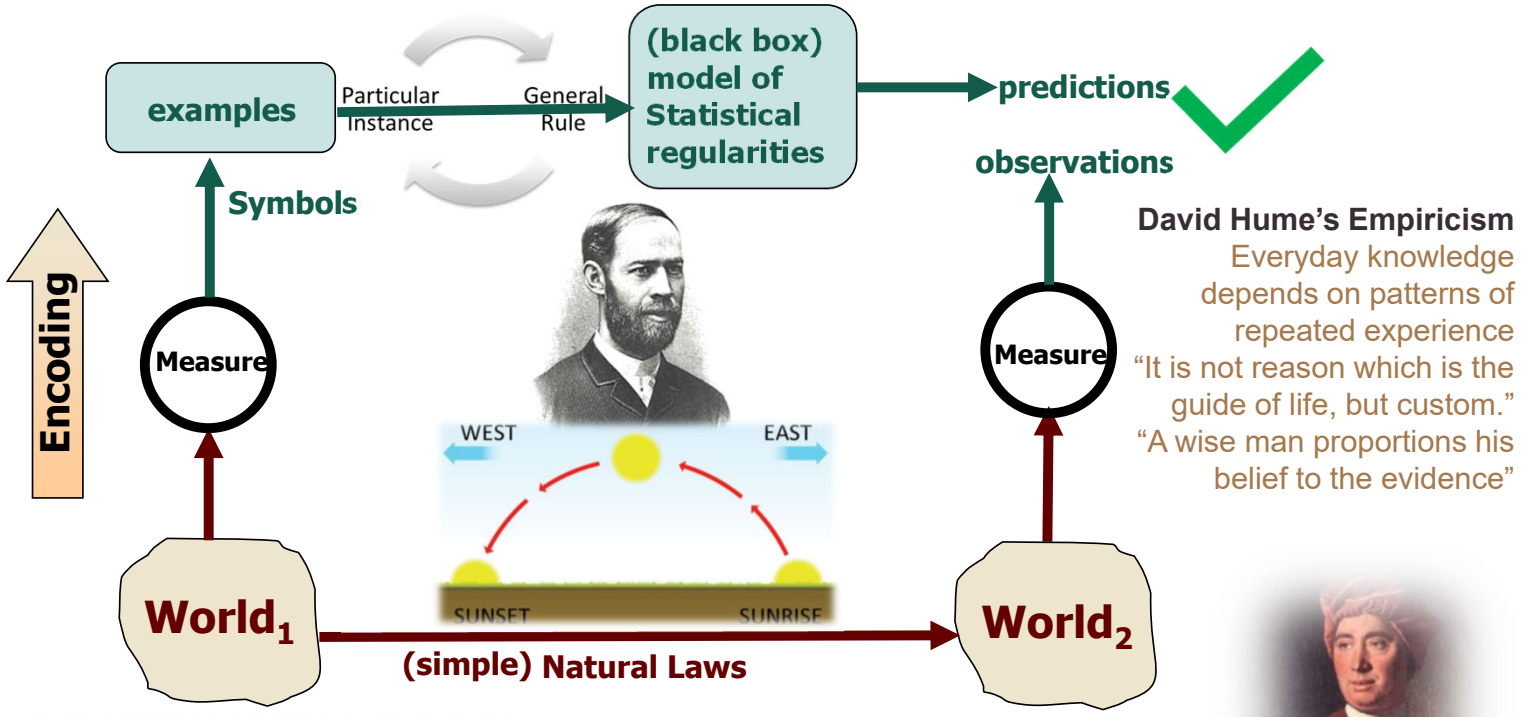






BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

good news I & II: near-decomposability and induction

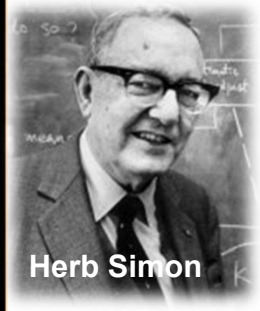


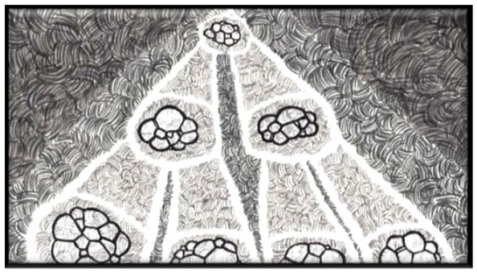
David Hume's Empiricism

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

BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

facing limits

- Physical Limit of Computation
  - Hans Bremmermann in 1962
  - "no data processing system, whether artificial or living, can process more than 2×10^{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}?

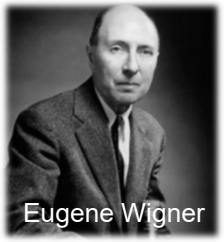
k	2	3	4	5	6	7	8	9	10
n	308	194	154	133	119	110	102	97	93

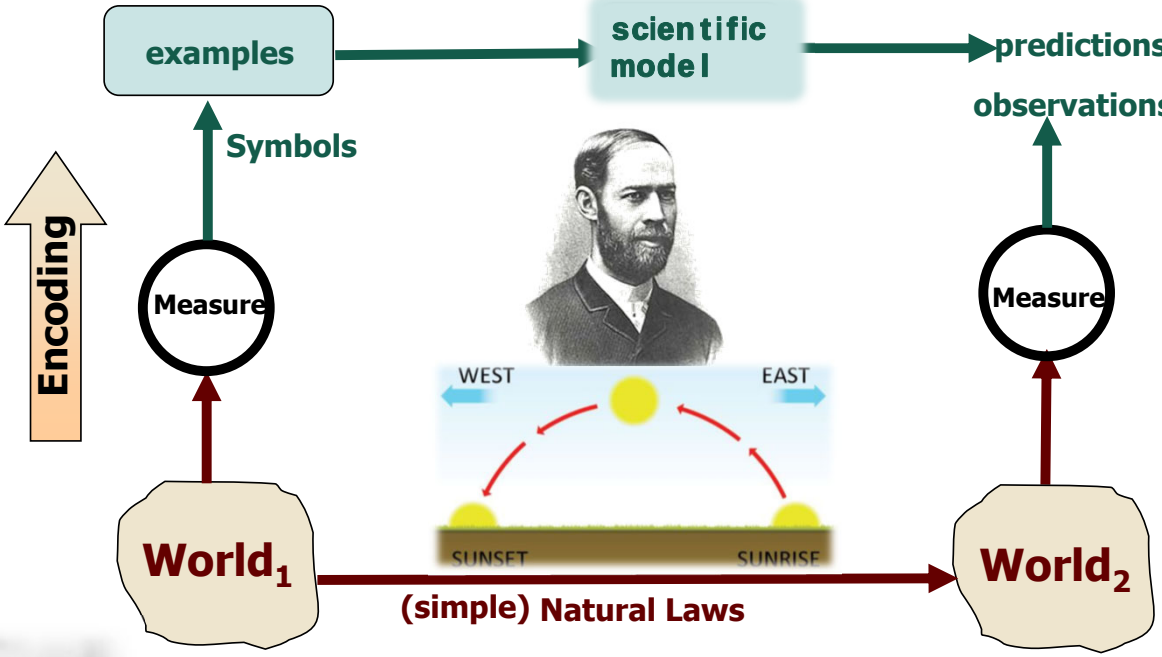
  - Pattern Recognition
    - Grid of $n = q^2$ squares of k colors
    - *Blackbox*: 10^{100} possible states!
    - The human retina contains a million light-sensitive cells
  - Large scale integrated digital circuits
    - K= 2 (bits): a circuit with 308 inputs and one output!
- Complex Problems need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

BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

Bad news I: computational limits

*"**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"*


Eugene Wigner



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"


Hans Bremmermann


George Klir

Model complexity

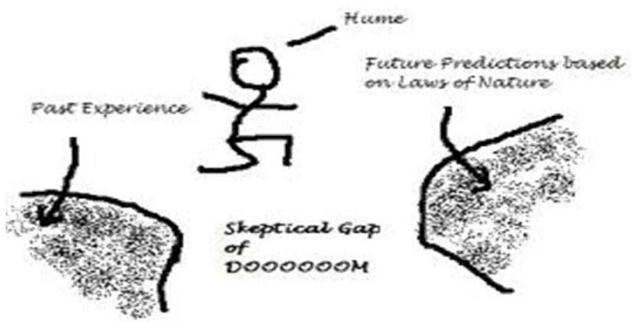
We must simplify computational models

Tradeoff descriptive and uncertainty-based complexity

BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

Induction is dictated (biased) by previous observations

Bad news II: black swans

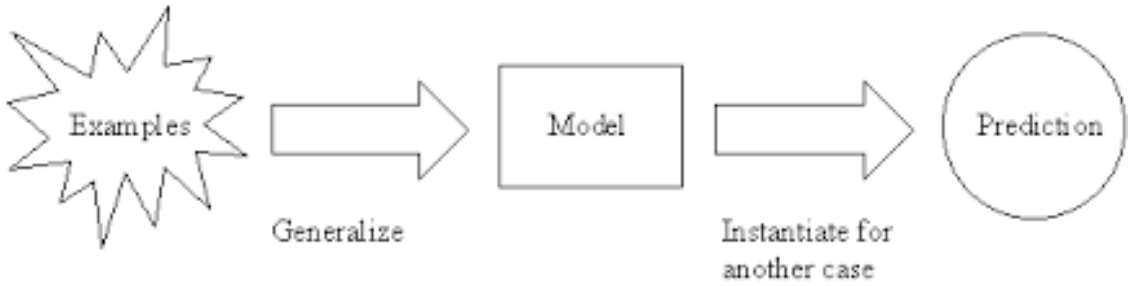


David Hume's Empiricism

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"



BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

Induction is dictated (biased) by previous observations

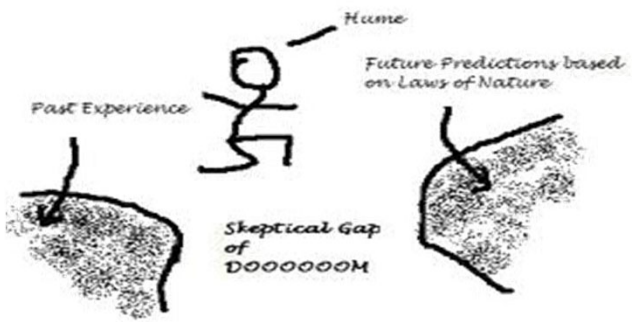
Bad news II: black swans

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

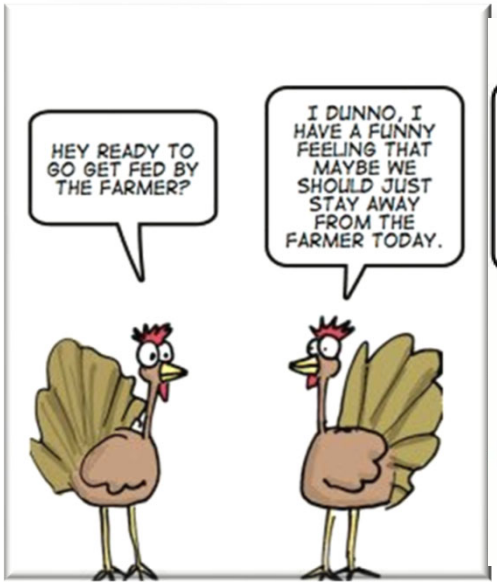
Everyday knowledge depends on patterns of repeated experience

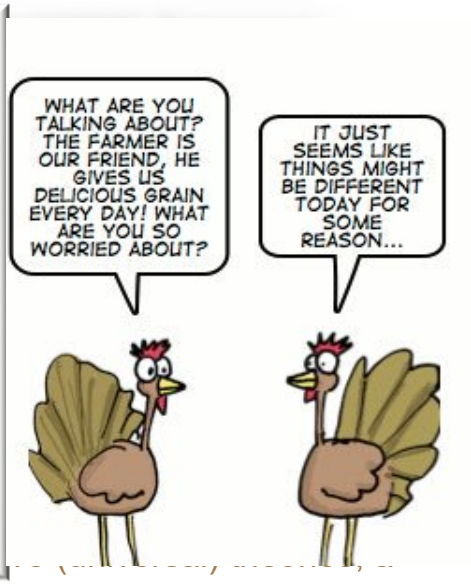
"It is not reason which is the guide of life, but custom."

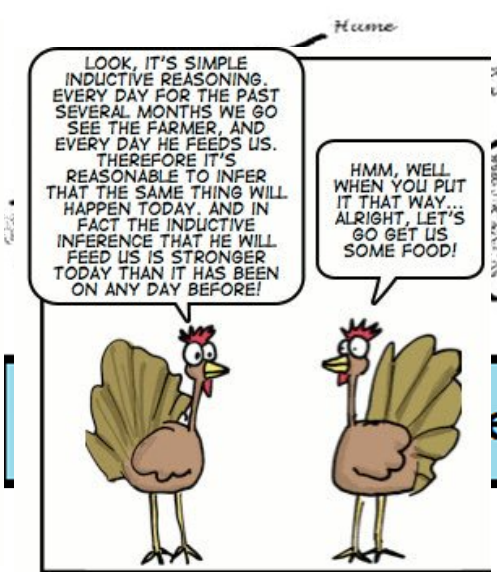
"A wise man proportions his belief to the evidence"

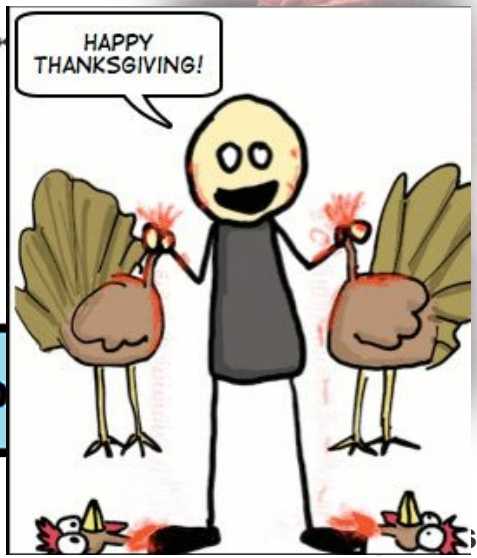
BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

Bad news II: black swans







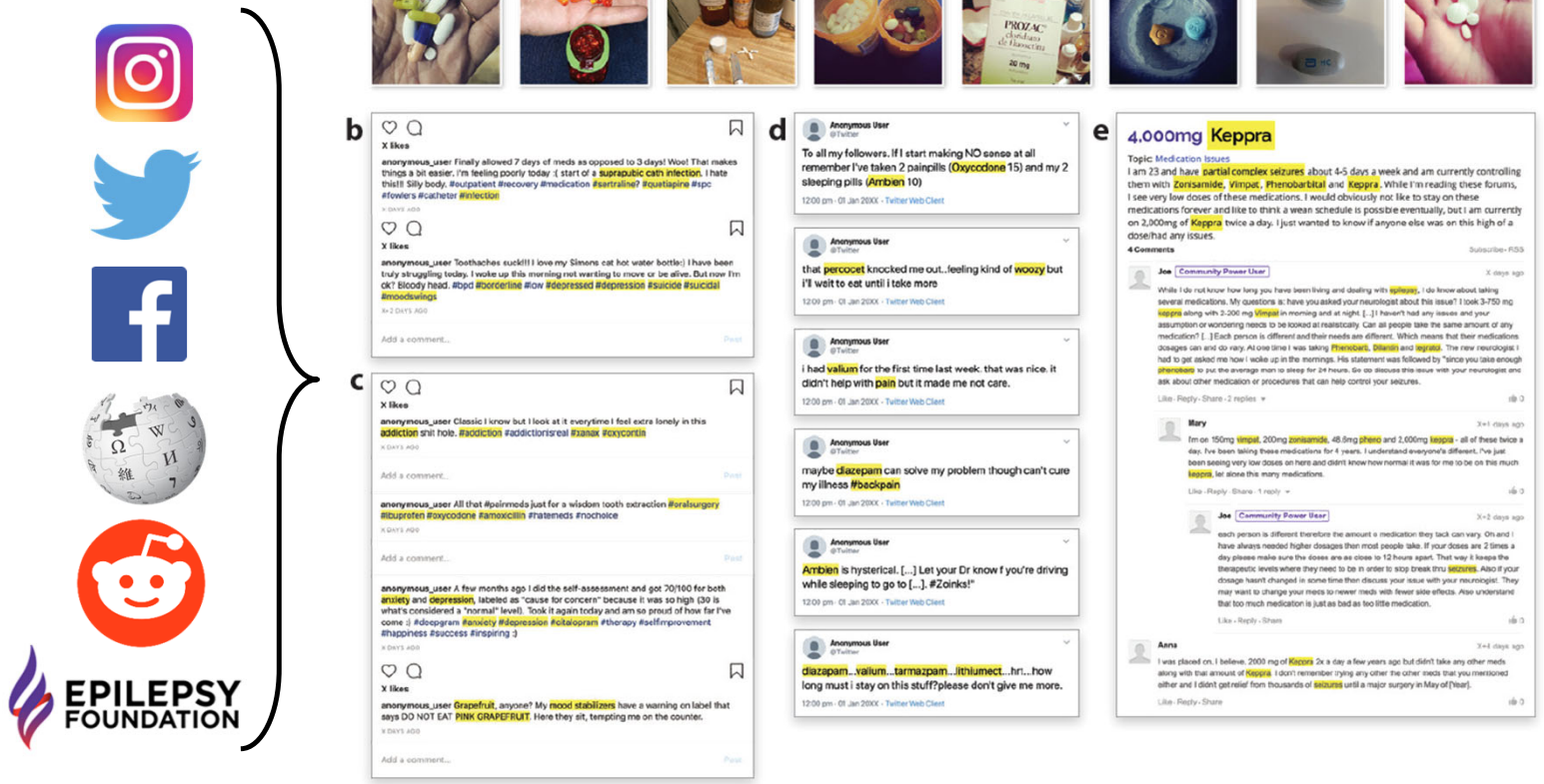


single observation can falsify it: scientific theories (deduced) from induction are **testable**.

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"

BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

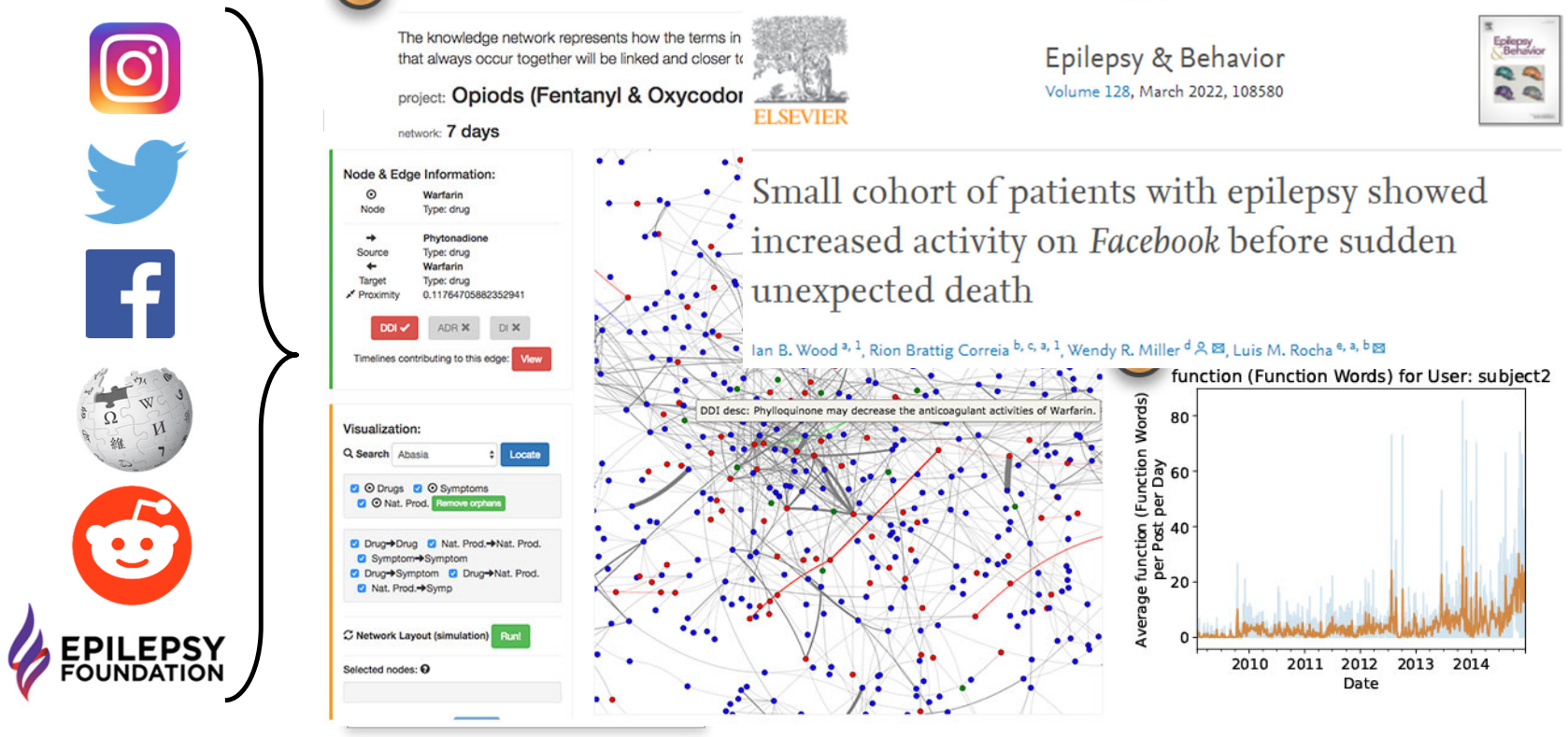
social media data pipelines for biomedicine



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.

BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

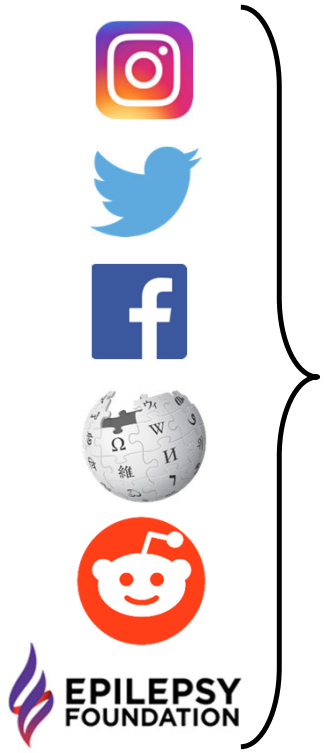
social media data pipelines for biomedicine

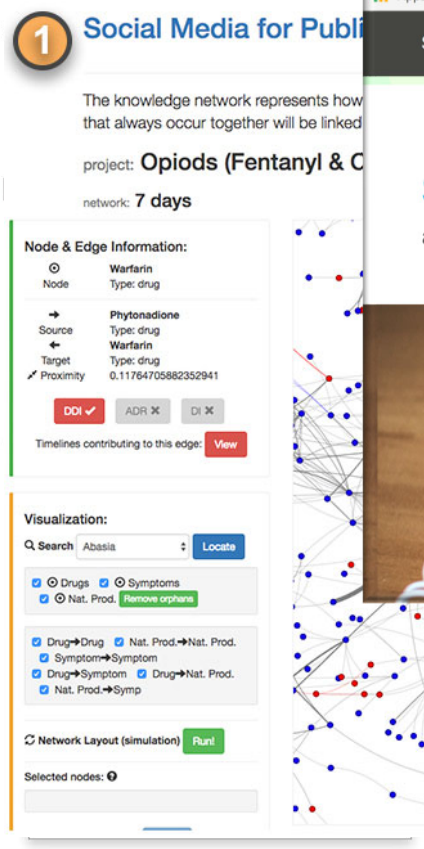


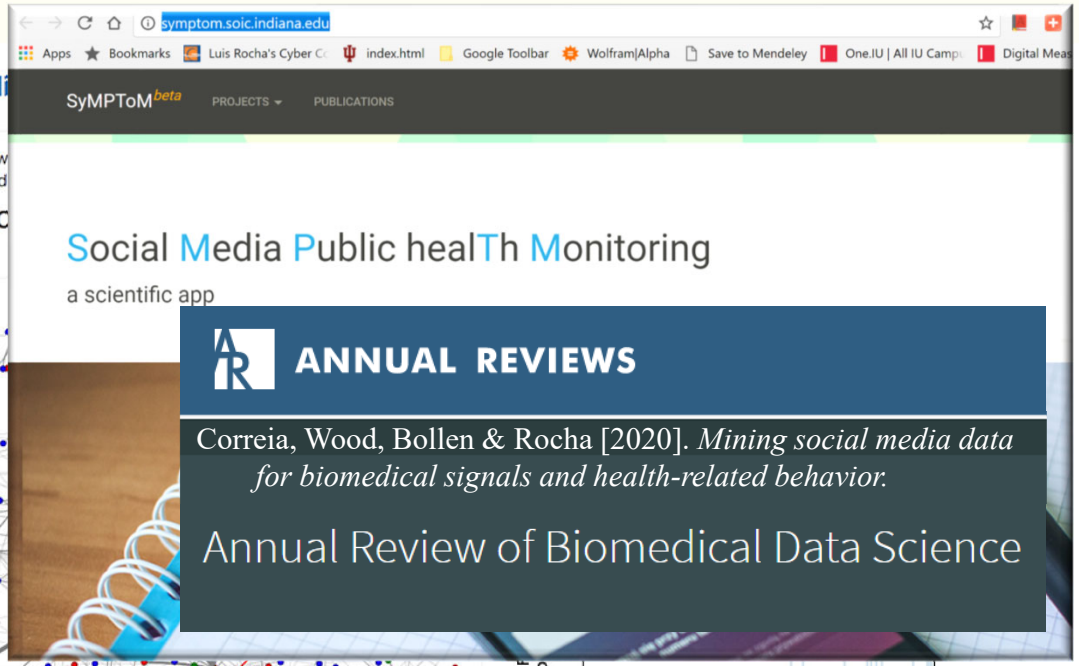
Min et al [2023]. *CHI 2023*. **32.**
Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports. 7: 17973* .
Correia, Li & Rocha [2016]. *PSB*: **21**:492-503.
Ciampaglia, et al [2015]. *PloS ONE*. **10**(6): e0128193.
Wood, Correia, Miller, &Rocha [2022]. *Epilepsy & Behavior*. **128**: 108580.
Correia, Wood, Bollen, & Rocha [2020]. *Annual Review of Biomedical Data Science*, 3:1.

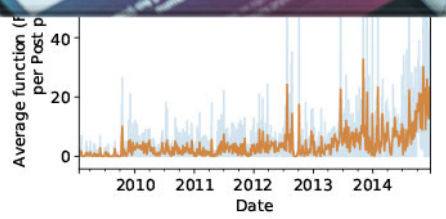
BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

social media data pipelines for biomedicine







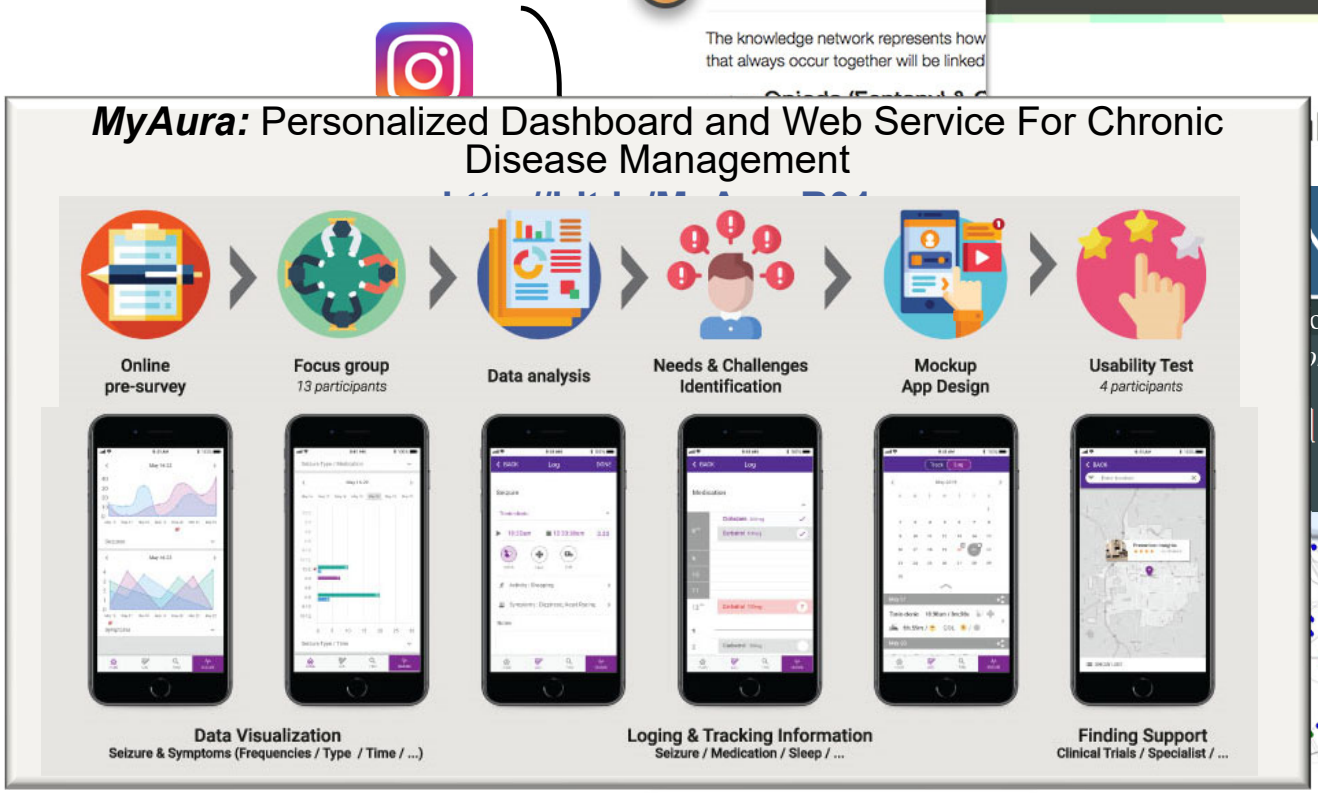


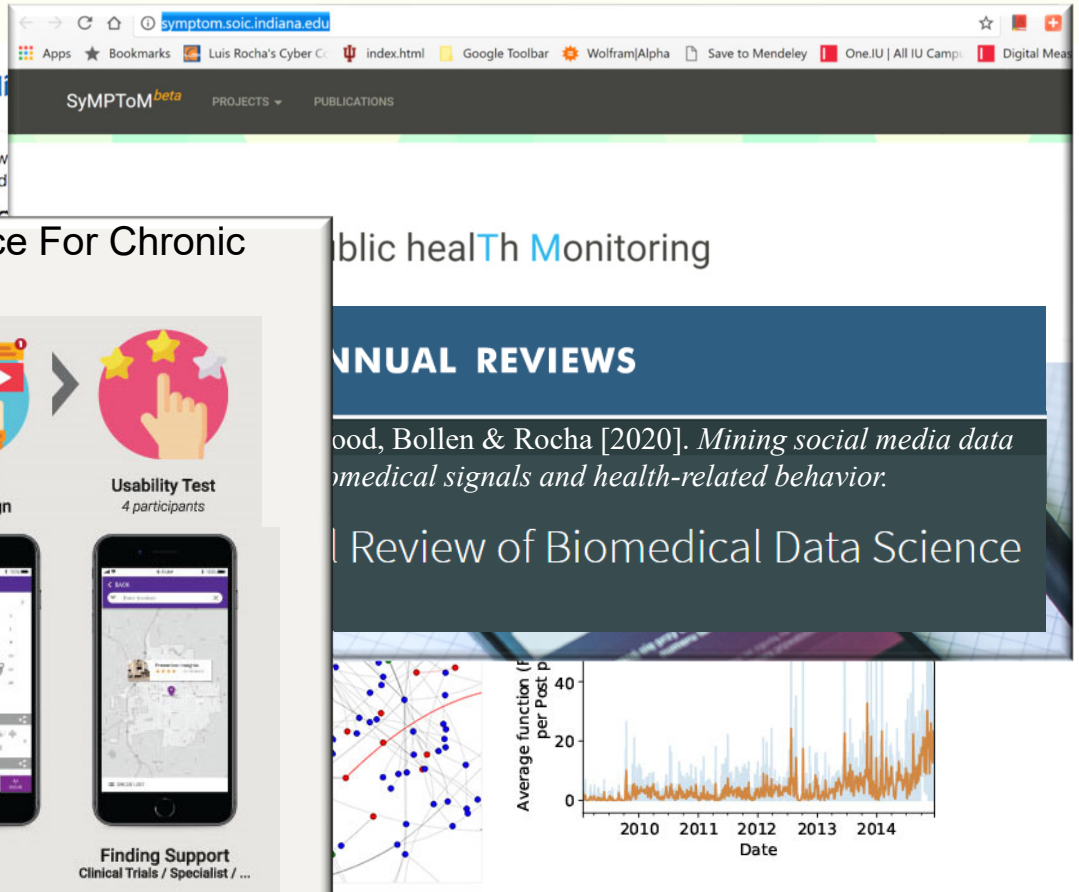
Min et al [2023]. *CHI 2023*. **32.**
Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports. 7: 17973* .
Correia, Li & Rocha [2016]. *PSB*: **21**:492-503.
Ciampaglia, et al [2015]. *PloS ONE*. **10**(6): e0128193.
Wood, Correia, Miller, &Rocha [2022]. *Epilepsy & Behavior*. **128**: 108580.
Correia, Wood, Bollen, & Rocha [2020]. *Annual Review of Biomedical Data Science*, 3:1.

BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

integrating and analyzing multiomics data

social media data pipelines for biomedicine





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.

BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
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

Global Patterns of Seasonal Variation in Human Fertility[a]

DAVID A. LAM[b,d] AND JEFFREY A. MIRON[c]

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

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

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

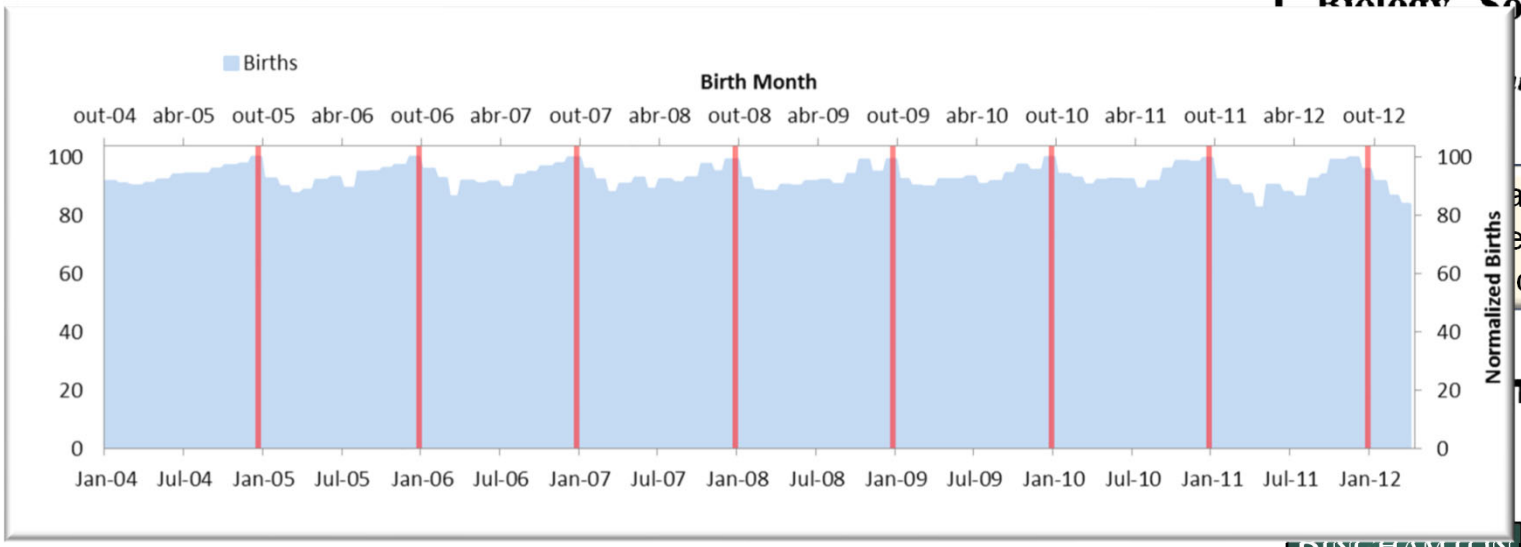
BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

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: Austrialta, Netherlands, Poland, Portugal, Spain, Sweden and USA

Human Sexual Cycles are Driven by



Global Patterns of Seasonal Variation in Human Fertility[a]

DAVID A. LAM[b,d] AND JEFFREY A. MIRON[c]

: A review of the evidence of seasonal tors among young people

, Judith Stephenson, Anna Glasier

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

nd Jürgen Aschoff†

annual birth cycle (in countries e is data). Is it driven by daptation or culture?

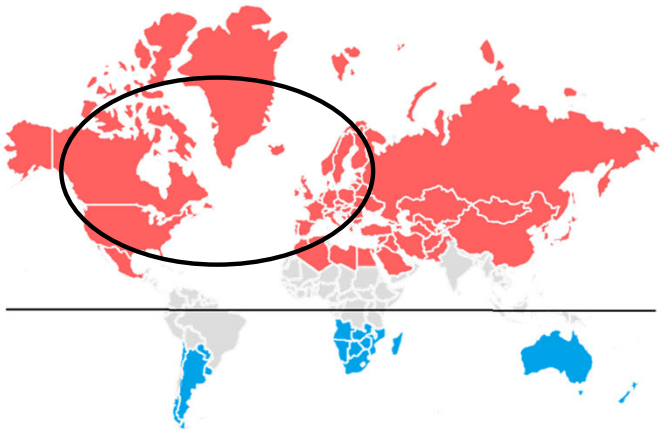
TURE ON HUMAN FERTILITY*

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

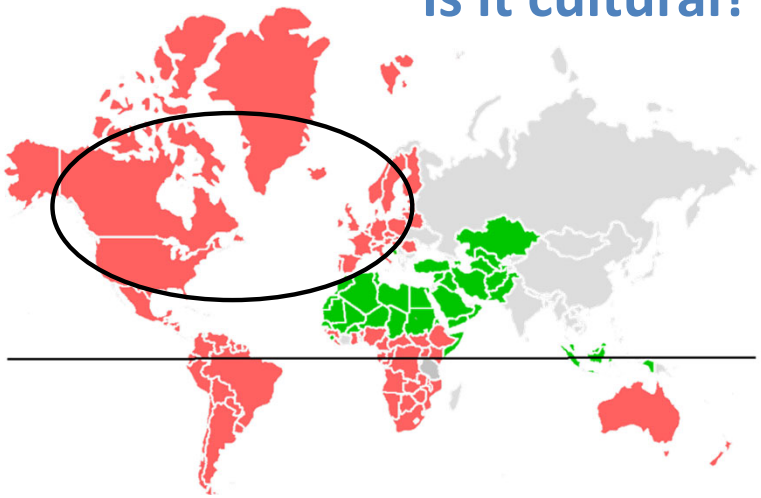
BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

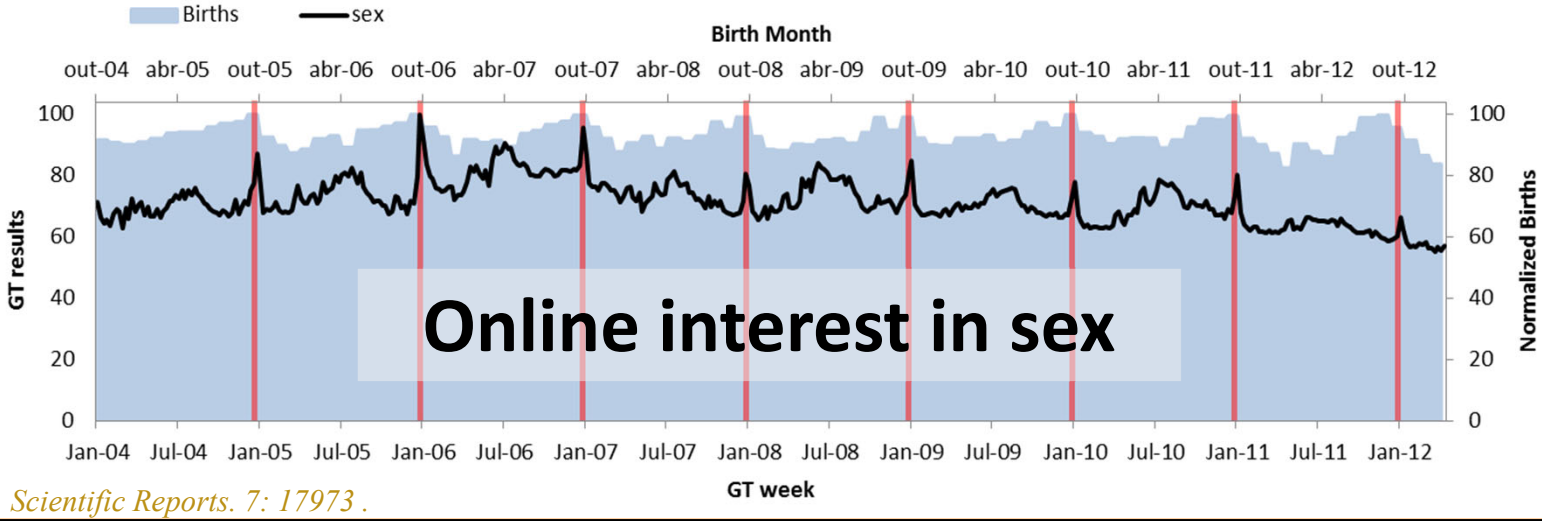
search and social media mood provide global patterns

Is it biological adaptation?



Is it cultural?





Google Trends

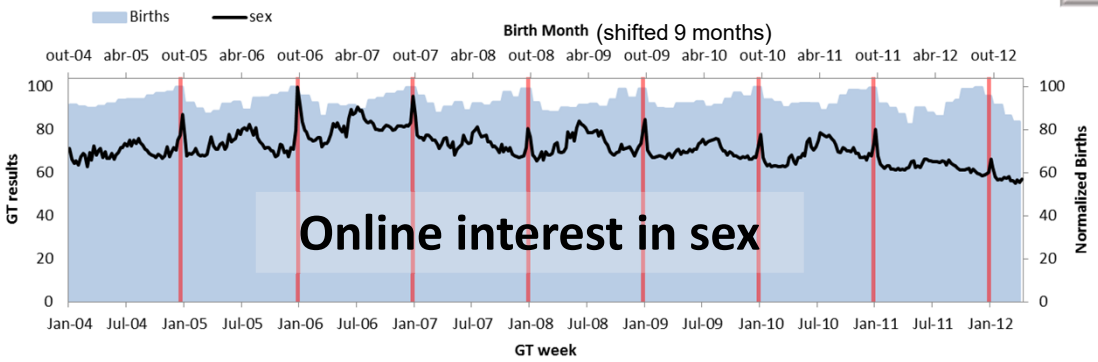
Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports. 7: 17973* .

Hypothesis falsification in data and complexity science

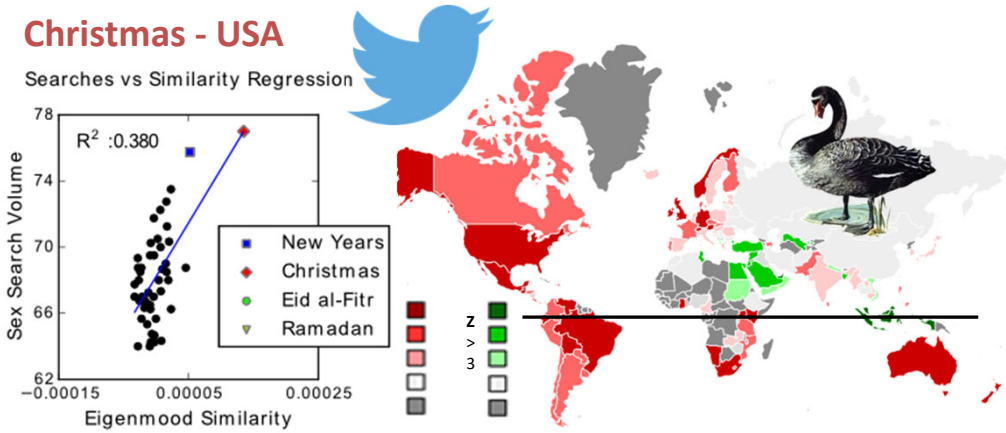
resolving a sociobiology question on a planetary scale

- 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?



granger causality analysis suggests that mood causes interest in sex

BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK

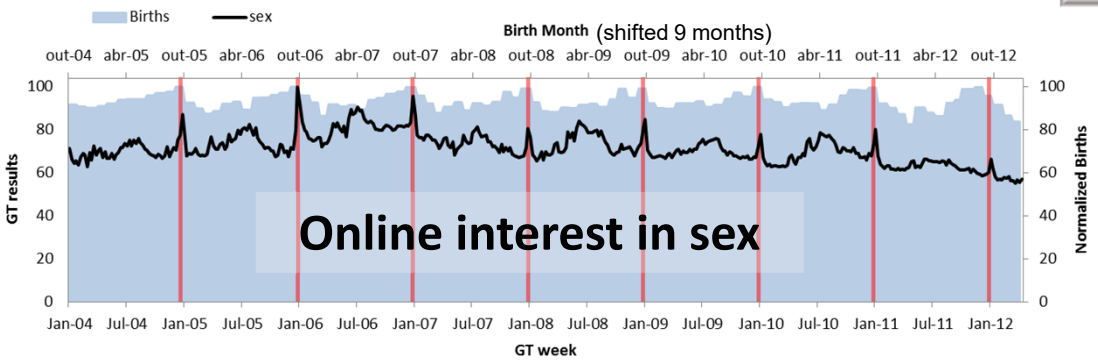
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

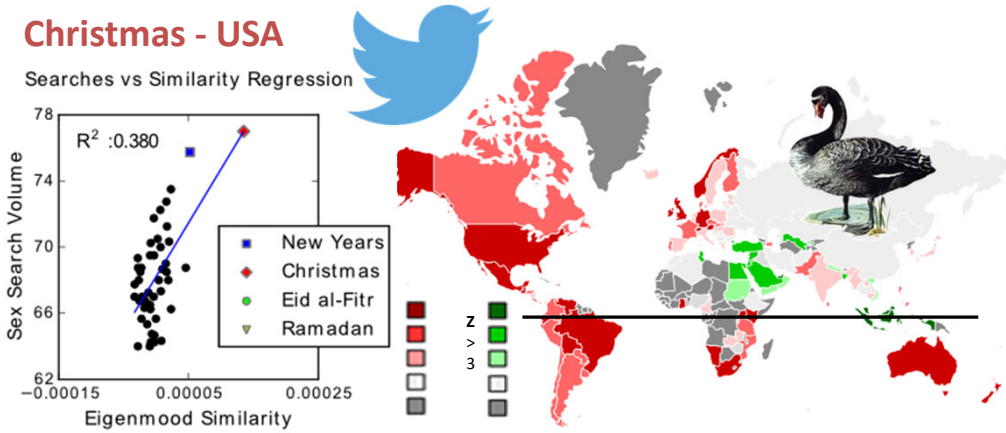
Wood, Varela, Bollen, Rocha & Sá [2017]. *Scientific Reports. 7: 17973 .*

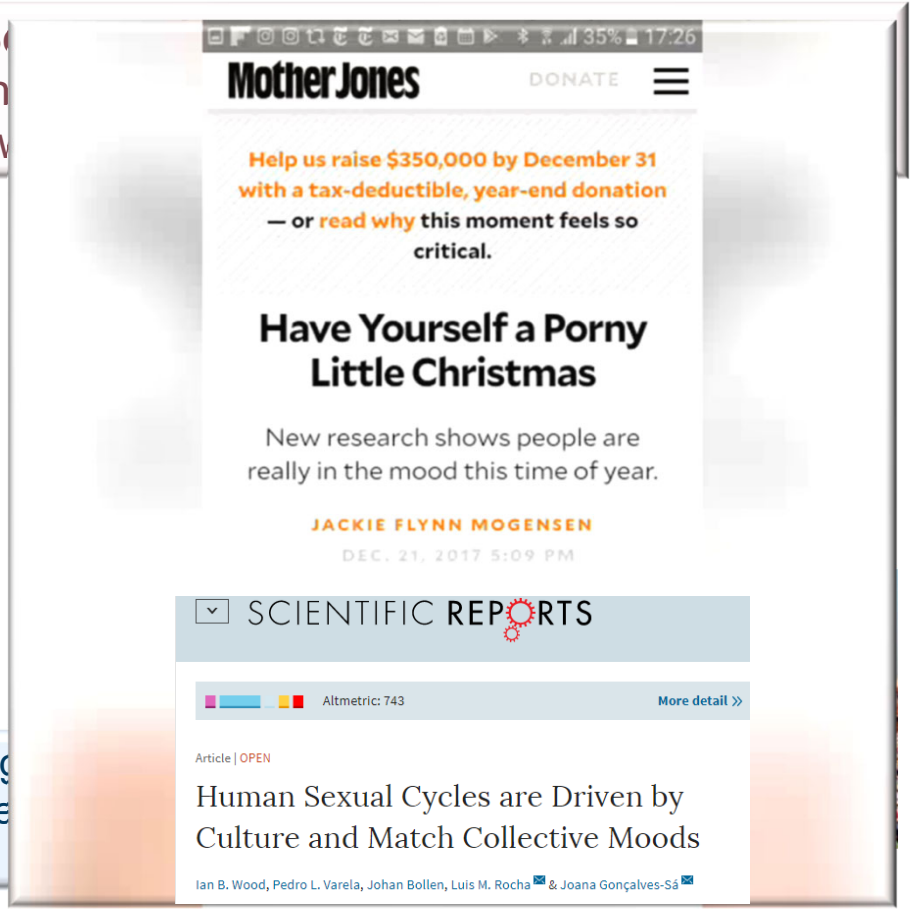
Hypothesis falsification in data and complexity science

resolving a sociobiology question on a planetary scale

- Social Media (Twitter) Mood and Google Searches
  - Understanding collective human behavior
  - Discovering mood transitions in health



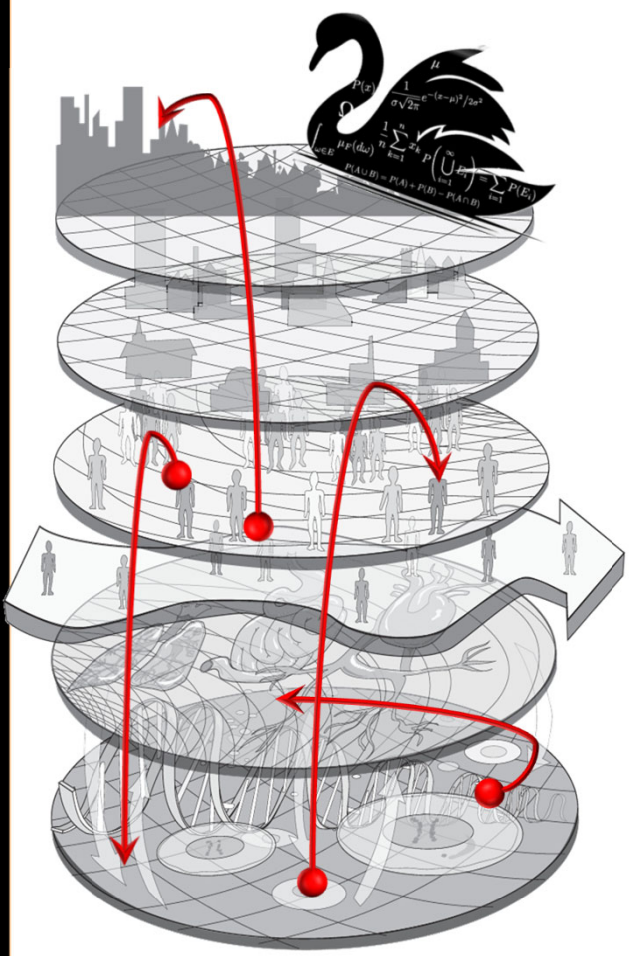


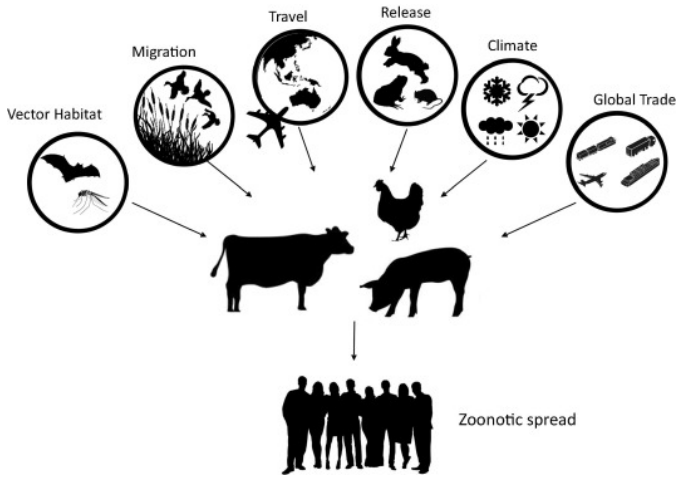


BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

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

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

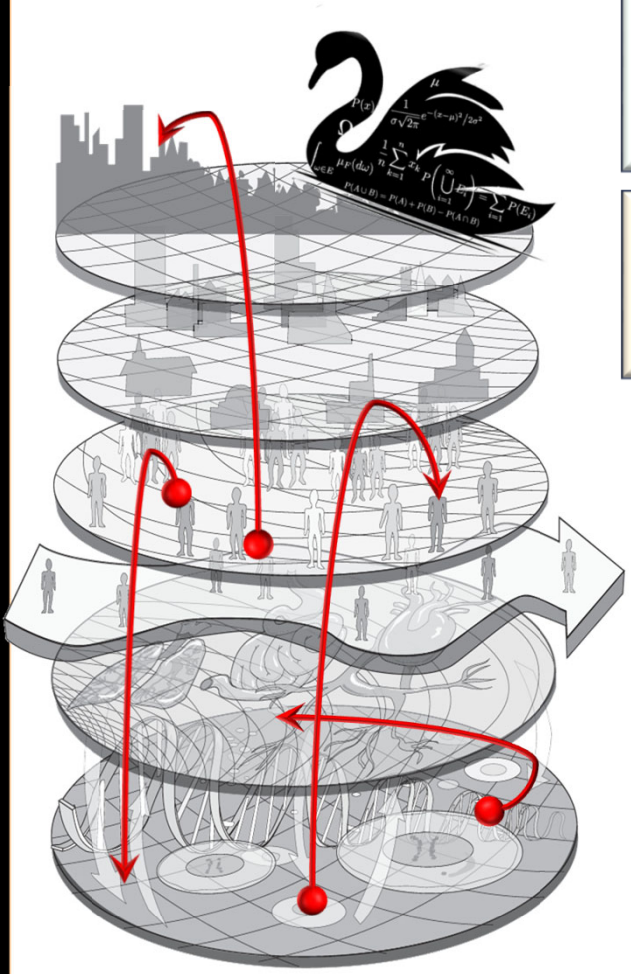




Pescosolido, B.A. 2006. Journal of Health and Social Behavior 47: 189-208.

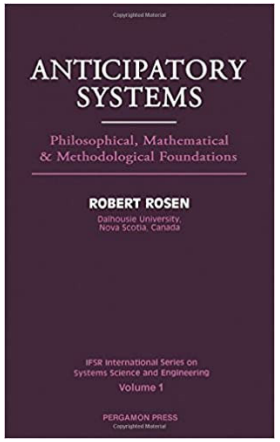
BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

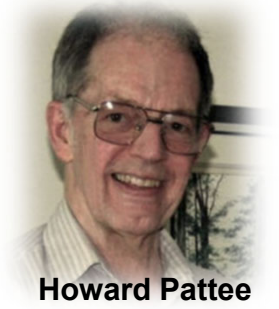
Bad news III: inductive, "boxed" model failure with complex systems



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.

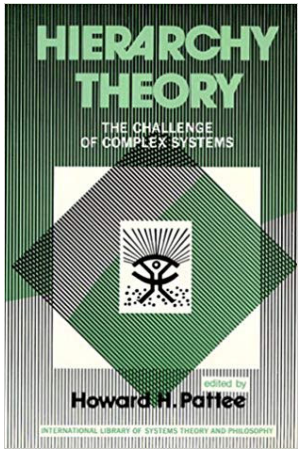




Howard Pattee

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

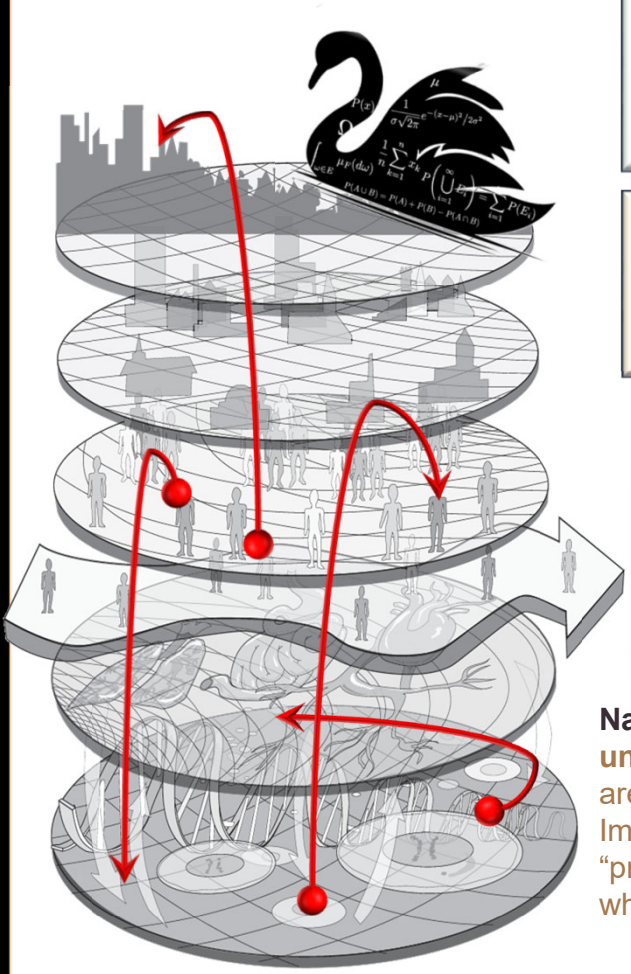
Robert Rosen



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

BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

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.

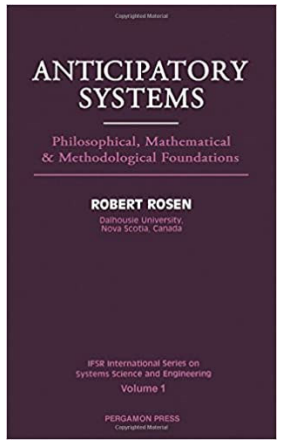
Nassim Nicholas Taleb

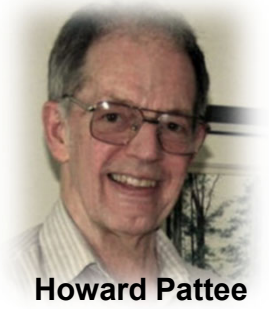
unexpected events of large magnitude and consequence are dominant in history.

Importance of studying robustness/resilience/evolvability

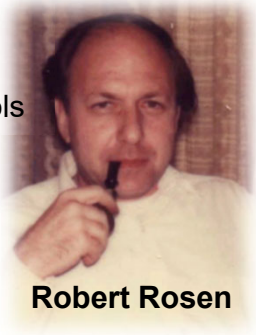
"predictions of events **depend** more and more **on theories** when their probability is small and system is **complex**"

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

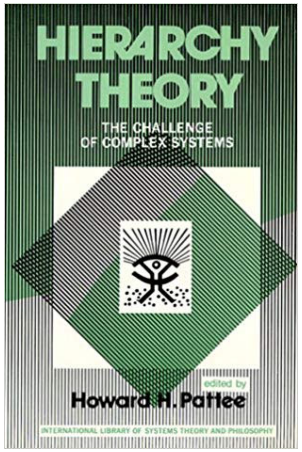




Howard Pattee



Robert Rosen

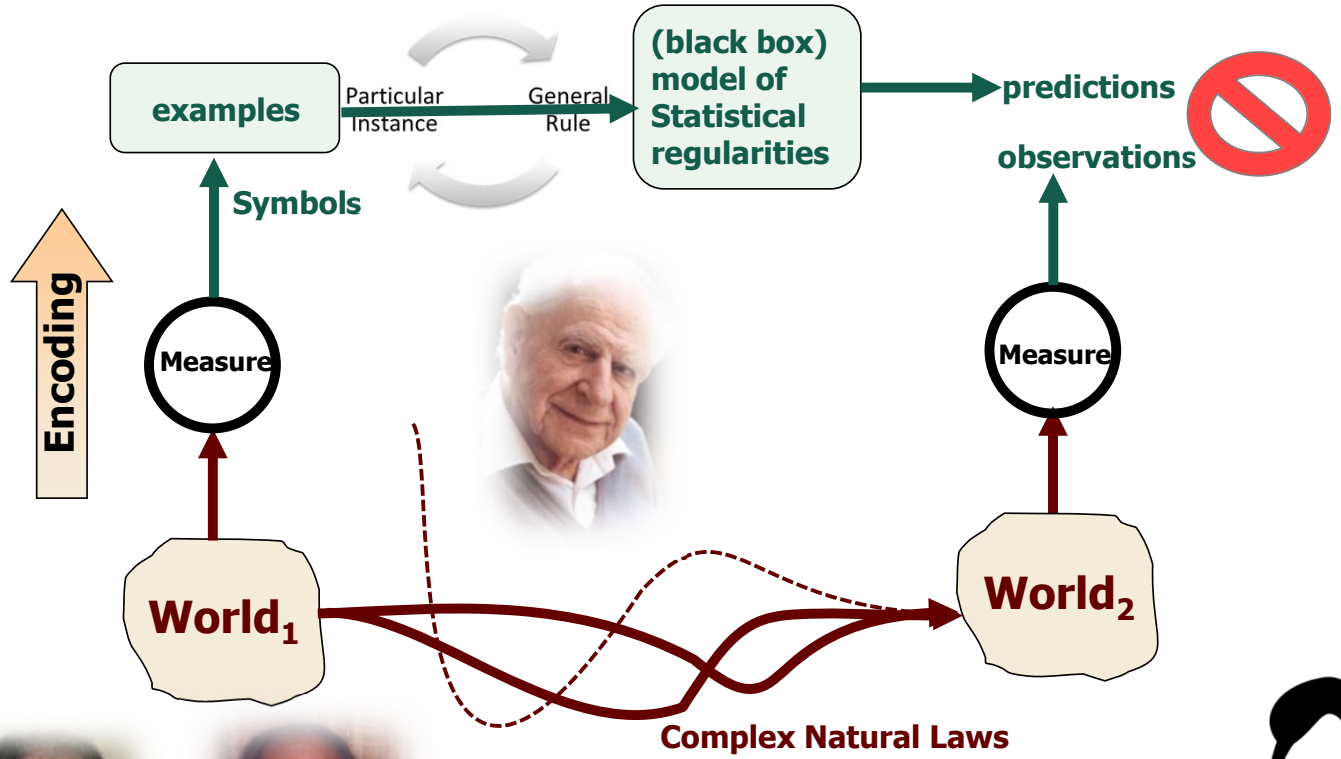


BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK

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

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

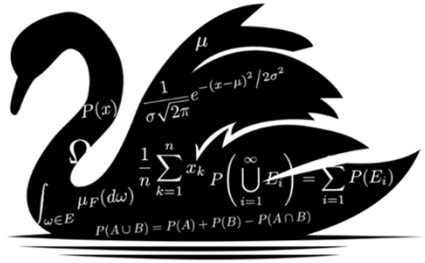
inductive models can be falsified but cannot predict black swans




Nassim Nicholas Taleb

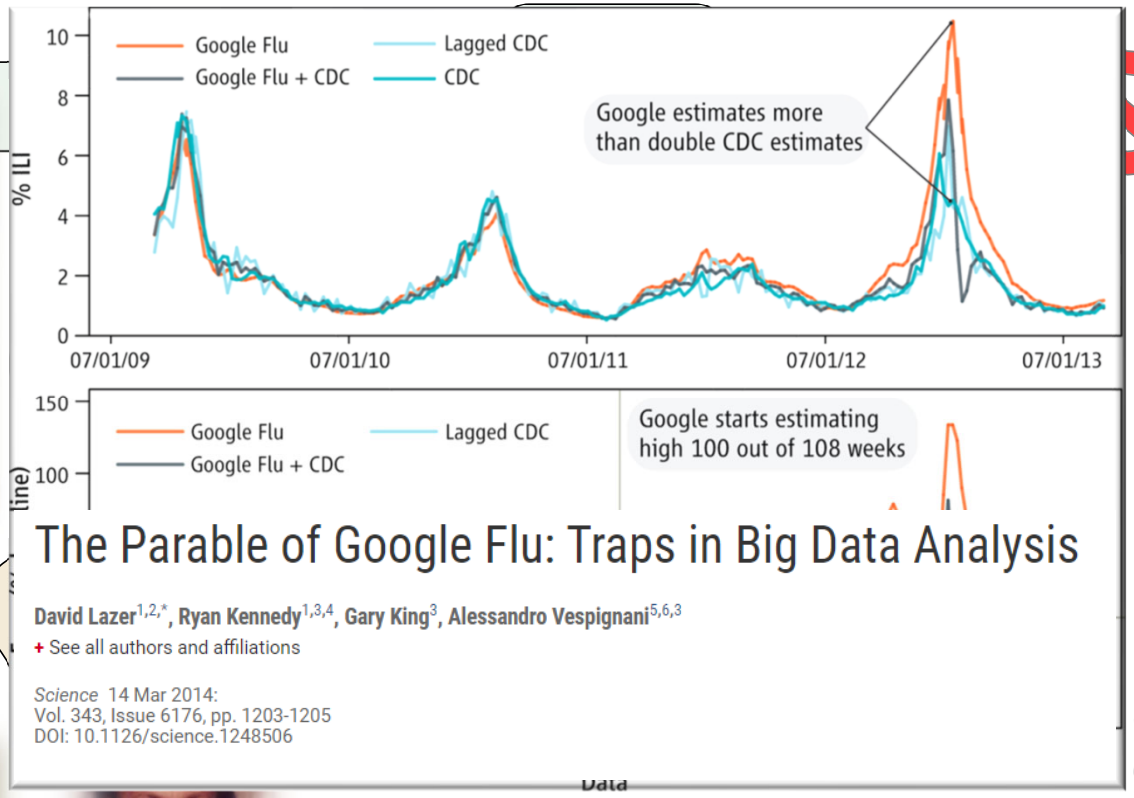

Howard Pattee


Robert Rosen



BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

inductive models can be falsified but cannot predict black swans



The Parable of Google Flu: Traps in Big Data Analysis

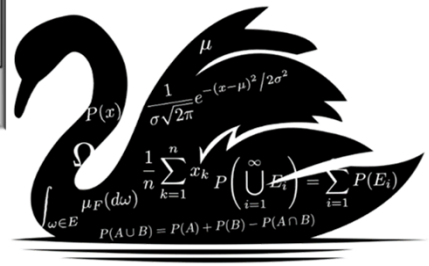
David Lazer[1,2,*], Ryan Kennedy[1,3,4], Gary King[3], Alessandro Vespignani[5,6,3]
+ See all authors and affiliations

Science 14 Mar 2014:
Vol. 343, Issue 6176, pp. 1203-1205
DOI: 10.1126/science.1248506


Nassim Nicholas Taleb


Howard Pattee


Robert Rosen



BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

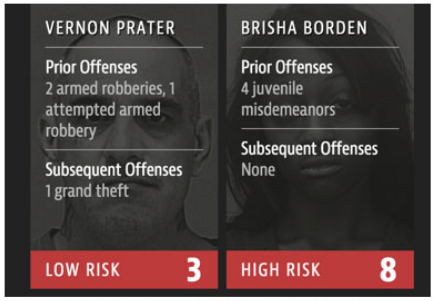
machine learning depends on training data that is contextual

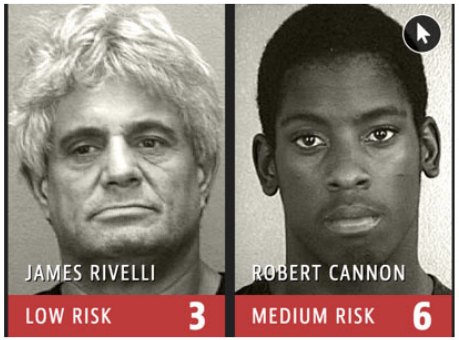
Angwin, Larson, Mattu & Kirchner, “Machine Bias”. *ProPublica*, May 23, 2016
propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing

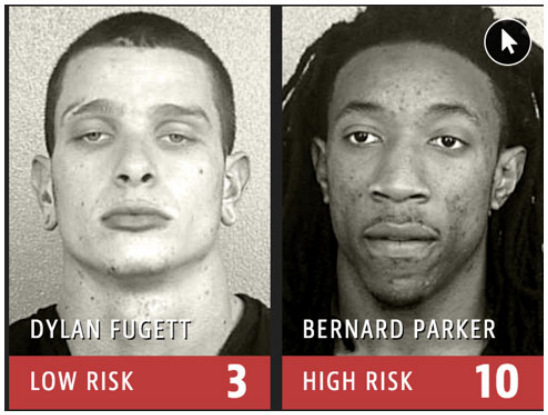
BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

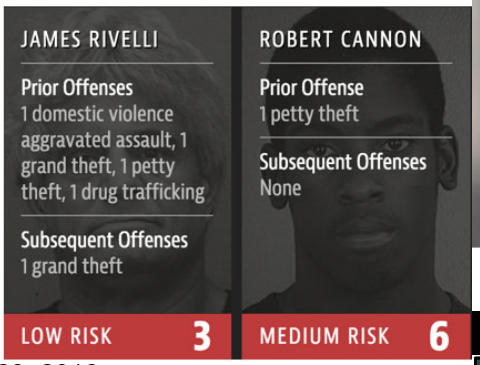
machine learning depends on training data that is contextual

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%









Angwin, Larson, Mattu & Kirchner, “Machine Bias”. *ProPublica*, May 23, 2016
propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing

BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501

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.

BINGHAMTON UNIVERSITY STATE UNIVERSITY OF NEW YORK
rocha@binghamton.edu
casci.binghamton.edu/academics/ssie501