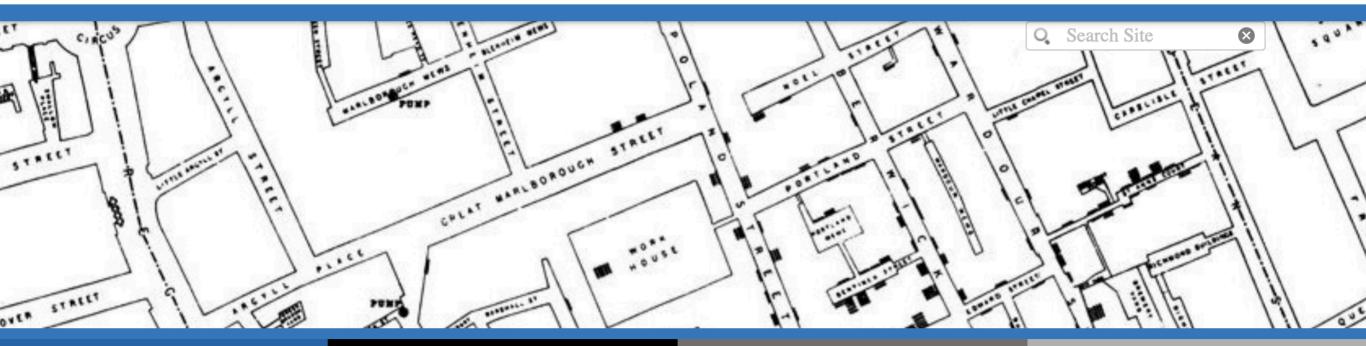# The Prediction Project

The Past and Present of the Future

Alyssa Goodman
Harvard University
Radcliffe Institute for Advanced Study

Search Site

Prediction Essentials

Take a look at the essential elements of the course, including the framework for predictive systems.

→

Omens & Oracles

Gain insight into prediction as a human venture by studying the most ancient forms of prediction in Omens and Oracles.

→

Rise of Theory

Learn how humanity moved from mystical divination practices to genuine, scientific theories to explain natural phenomena.

→

Modern Prediction

Discover the cutting edge predictive methods and modeling from preeminent experts across many fields.

→

How it all fits together

PredictionX: THE PAST & PRESENT OF THE FUTURE

ESSENTIALS   Omens, Oracles & Prophecies   THE RISE OF THEORY   MODERN PREDICTION

Health   Wealth

PredictionX

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Casting Lots

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The Path to Newton

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▷ Indian Mathematics

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edX

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MODERN PREDICTION

edX

John Snow & Cholera

Cholera Map

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"Take A Sweater"

takeasweater.com

with thanks to Eric **Floehr** of Forecast Watch and Bill **Barthelmy** of HUIT Academic Technology at FAS

takeasweater.com

Forecasting Uncertainty

Boston, MA MAY 25

90
82 82 82
80 79
67
70
64 65 64
60 59
now 56
50

🌧️ 🌤️ 🌤️ 🌧️ 🌧️
Today Tue Wed Thu Fri
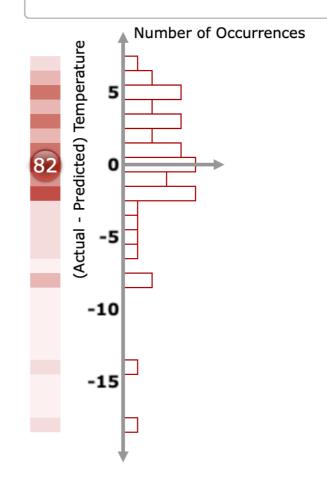
[demo]

Histogram MAY 26

▼ What does this show me?

The graph below shows a sample "distribution" of how far off temperature predictions have been in the past. Perfect predictions give zero as a difference value. The shaded bars just summarize the graph: the darker the shaded bar, the more predictions fell in that difference zone.

Number of Occurrences

(Actual − Predicted) Temperature

82

5

0

−5

−10

−15

The Cost of
Uncertainty

forecastwatch.com

also: uncertainty and risk are not the same
—more on that to come...

The Cost of Uncertainty depends on the cost of being wrong.

Beheading (ancient oracles)

People die (pandemics)

World Ends (climate change)

Don't get tenure (astrophysics)

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#RANDOM

#RANDOMIZED

#HUMAN

#NON-RANDOM

PredictionX

MAKE PREDICTION!

EVALUATE ACCURACY

MAKE CHANGES

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ROMAN AUGURY

"Senior political officials of the Roman state had to take auspices before any major political event like elections." —Emma Dench

7

see "Roman Bird Augury" video on edX

#RANDOM

Observe

PREDICTIVE SYSTEM

MAKE PREDICTION!

#RANDOM

#RANDOMIZED

#HUMAN

#NON-RANDOM

Observe

PREDICTIVE SYSTEM

MAKE PREDICTION!

#NON-RANDOM

Celestial Motion

#RANDOMIZED

00:02:48:11

2:48 / 13:24

Ifa

#HUMAN

Egyptian "Bobble Head"

#RANDOM
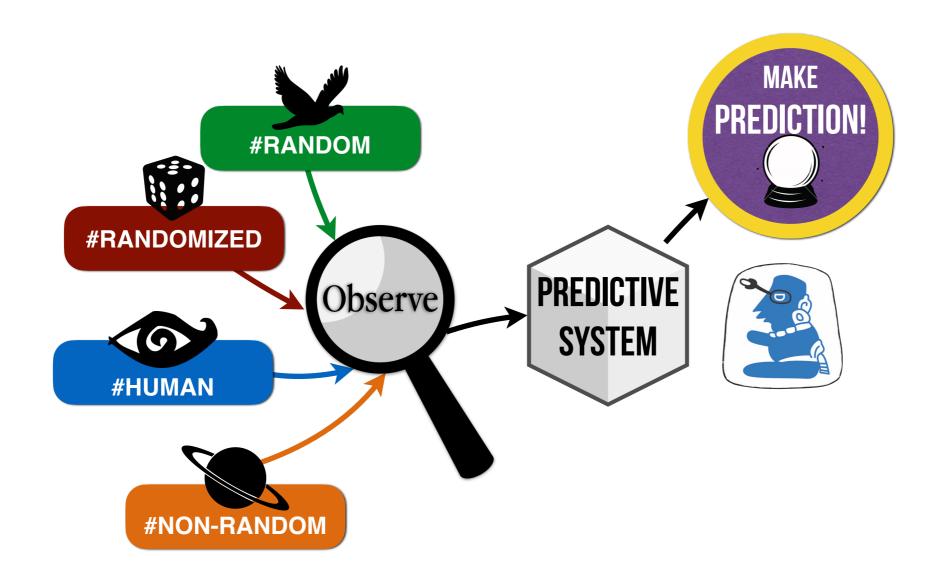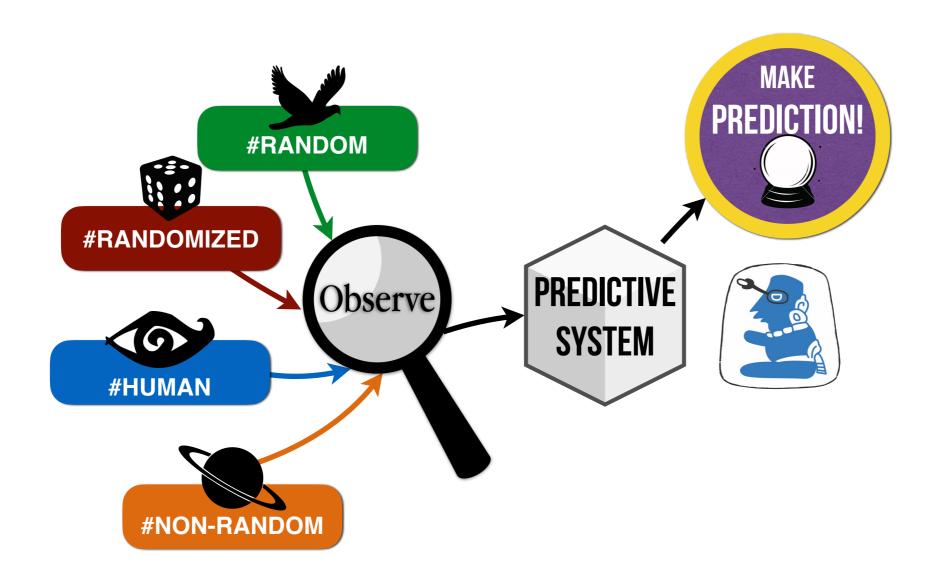
Comets of Doom
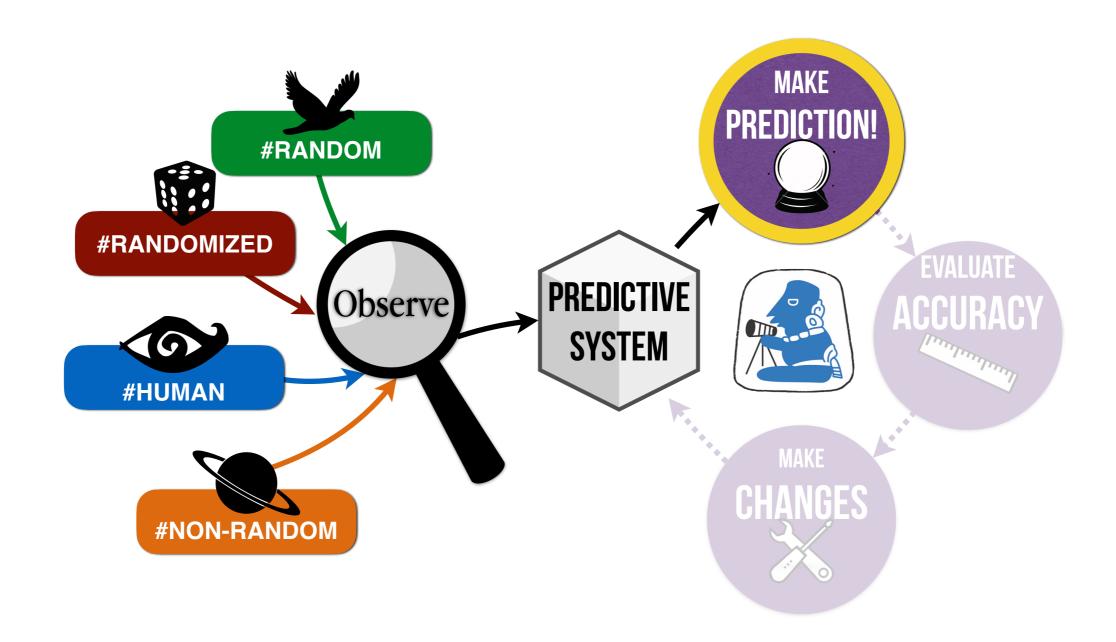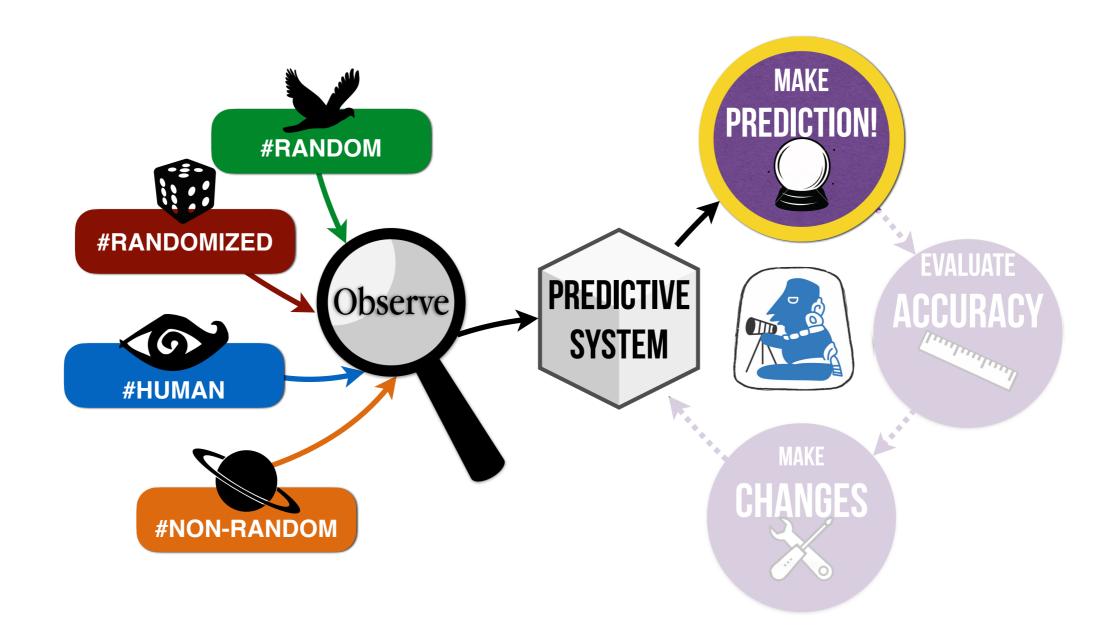
#HUMAN
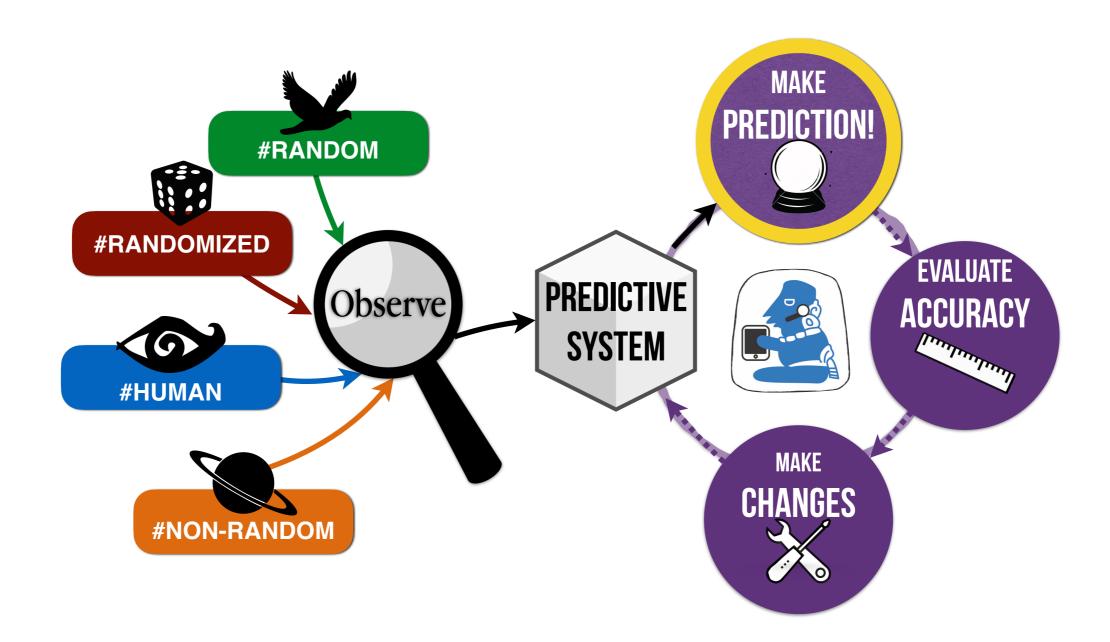
Ancient Egyptian Divination, featuring Prof. Peter der Manuelian (Harvard Semitic Museum)

#RANDOM

#RANDOMIZED

#HUMAN

#NON-RANDOM

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PREDICTIVE SYSTEM

MAKE PREDICTION!

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https://openclipart.org/

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PREDICTIVE SYSTEM

MAKE PREDICTION!

EVALUATE ACCURACY

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"Most companies who do live traffic **compare** their predictions against actual time in traffic to tune their algorithms and data sources.
The likely result of this is that the companies who have access to the best usage data ... are likely to end up with the best predictions in the medium to long term."

Forbes Tech, July 2013

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A project to track the evolution of science

| Phenomenon | Observation* | Data | Rule | Theory | Explanation | Prediction |

The Path to Newton

PredictionX

or, Experiment

[demo: path-to.org]

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"When Knowledge Conquered Fear"
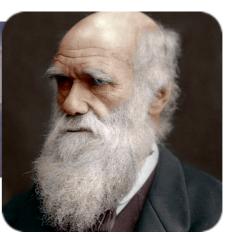
"When Knowledge Conquered Fear" is the third episode of the American documentary television series Cosmos: A Spacetime Odyssey. It premiered on March 23, 2014 on Fox, and premiered on March 24, 2014 on National Geographic Channel. [Wikipedia]. IMDB link
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P A T H T O

A project to track the evolution of science

The Path to Newton

PredictionX

TOOLS AVAILABLE — GNOMON · ASTROLABE · PRINTING PRESS · TELESCOPE

MATH AVAILABLE — ARITHMETIC · ZERO AS PLACE HOLDER · PLANAR GEOMETRY · SPHERICAL GEOMETRY · TRIGONOMETRY · SPHERICAL TRIGONOMETRY · ALGEBRA · SPECIAL FORMS · LOGARITHMS · CALCULUS

BIG IDEAS
- Correct
- Partial credit
- Wrong

CONNECTIONS BETWEEN IDEAS
- Teacher-Pupil or Senior-Junior Researcher
- Travel between cultures

Figures shown include: THALES, ANAXIMANDER, PYTHAGORAS, PARMENIDES, ANAXAGORAS, SOCRATES, PLATO, DEMOCRITUS, EUDOXUS, ARISTOTLE, ARISTARCHUS, EUCLID, HIPPARCHUS, PTOLEMY, ARYABHATA, VARAHAMIHIRA, BRAHMAGUPTA, AL-BATTANI, IBN AL-HAYTHAM, IBN SINA (AVICENNA), IBN RUSHD (AVERROES), AL-TUSI, NICOLE ORESME, JEAN BURIDAN, ALI QUSHJI, REGIOMONTANUS, NICHOLAS COPERNICUS, TYCHO BRAHE, JOHANNES KEPLER, GALILEO GALILEI, RENÉ DESCARTES, ISAAC NEWTON, EDMOND HALLEY

Published works include: Astronomical Diaries, On the Heavens (Aristotle c. 350 BCE), Physics (Aristotle c. 320 BCE), Elements (Euclid c. 300 BCE), The Almagest (Ptolemy c. 150), Aryabhatiya (Aryabhata c. 499), On Aristotle's Physics 3 (Philoponus c. 520), Pancha-siddhantika (Varahamihira c. 575), Brahmasphuta-siddhanta (Brahmagupta), TRANSLATION MOVEMENT, Kitāb az-Zīj (al-Battani c. 900), Kitāb al-Shifā' (Ibn Sīnā c. 1020), Al-Shukūk 'alā Batlamyūs (Ibn al-Haytham c. 1025), Siddhānta Shiromani (Bhāskara II c. 1150–1200), Commentaries on Aristotle (Ibn Rushd), Alfonsine Tables (1252), Al-Tadhkirah fi'ilm al-hay'ah (al-Tusi 1261), Epitome of the Almagest (Regiomontanus 1496), De Revolutionibus (Copernicus 1543), Sidereus Nuncius (Galileo 1610), Dialogue on the Two Chief Systems of the World (Galileo 1632), Two New Sciences (Galileo), Principles of Philosophy (Descartes), Principia (Newton), Synopsis Astronomia Cometicae (Edmond Halley 1705)

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THE OMNI SHOW

Important Figures on the Path to Darwin

Figure	Birth Date	Death Date	Time of Relevance	Rationale for Time of Relevance	Idea/Discovery/Relevance
Anaximander of Miletus	-610	-546	-605	Around when "On Nature" poem was published. No exact dates, I'm just guessing	proposed that the first ever animals lived in water and that the first land-dwelling ancestors of mankind must have been born in water and spent some time on land. Associated humans with fish b/c they also required nursing. Defended Essentialism --> that an entity's attributes are necessary to its identity and function. There have been simpler water-dwelling animals that preceded humans "most similar theory in antiquity to Darwinism." philosopher to propose a cosmology of the world
...goras	-570	-495	-550	Estimate provided by link for spermism/preformationism	"likeness" and spermism: an obsolete biological theory that stated that sperm contained the preformed germ embryo --> Preformationism, that fathers contribute... develop from minature versions of themselves
...itus	-535	-475	-500	PLACEHOLDER GUESSTIMATE	Believed in eternal change (subatomic particles). "...birth and death in animals are just the mingling and... Species don't change now, but species originated a... adding more elements. Did not think of fixation of...
...cles	-490	-430	-460	PLACEHOLDER GUESSTIMATE	
...itus	-460	-370	-400	PLACEHOLDER GUESSTIMATE	Atomism
Plato	-428	-347	-375	Publication of The Republic	"Theory of Form" all forms of life are imperfect copies of an eternal form. Early eugenics... Essentialism**: Essentialism is the view that every entity has a set of attributes that are necessary to its identity and function. Wrote about this in "The Republic." Perfection must already exist in another dimension. What we dimension, is a mere reflection of perfect realities in that other dimension... God is in the other dimension. --> If something is changeable towards another dimension... with--incompatible with the idea of progressive change with a selective force.
Aristotle	-384	-322	-375	ESTIMATE. Generations of Animals was published in the "latter part of the fourth century B.C." (source)	Perfect forms do exist as extrapolations of our imagination. We create perfection in our own minds and we from nature. recognized a close connection between an organism's form and function (what we call "desig attribute to any divine cause. Inspired the dominant belief in the middle ages of the "Great Chain to Being" "Generations of Animals"
Zhuang Zhou	-369	-286	-290	On the Generation of Ani... embryo.asu.edu	...sed that biological species were not fixed and could change over time, in resp... m regarded human nature and the heavens

The TIMELINE CONSORTIUM

Timeline entries: Thomas Burnet 1635–1714; Nicolas Steno 1685 — dissected a Great White Shark to show that the teeth were exactly the same as the fossils ("devil's tongues"). demonstrated that fossils were indeed related to modern species 1609; Goffried Leibniz + Johann Goffried Herder 1646–1715; Nicolaas Hartsoeker 1656–1724; Benoît de Maillet 1656–1737; Pierre Louis Maupertuis 1698–1759

All Events · 1641 · 1661 · 1681 · 1701

Phenomenon · Observation · Data · Rule · Theory · Explanation · Prediction

March 11, 2020 was definitely the most surreal day of my life teaching at Harvard, so far.

Prediction: Day 7

opening remarks on COVID-19 & plans for the rest of GenEd1119

quick review of outdoor **Navigation Exercise**

questions about **"Prediction in Space & Time"** re:Navigation, *and Epidemiology*

John Snow & Cholera (edX highlights & more)

Student research/discussion re:COVID-19   using survey at **tinyurl.com/gened1112covid19**

Modeling the spread of epidemics, *and* **uncertainty**

Bookkeeping   **SIR Models**   **SEIR Models**   **Agent-based models**   **AI models**

Prediction and decision in the face of **uncertainty**: COVID-19 and Harvard (discussions)

Logistics post-Spring-Break
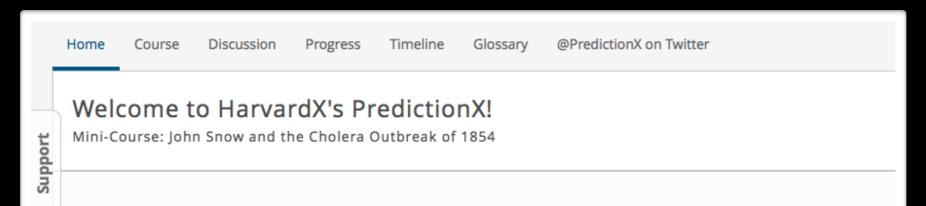
Special Guest: geneticist **Dr. Immaculata DeVivo,** Professor in the Department of Epidemiology at the Harvard T.H. Chan School of Public Health and at Harvard Medical School

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ZOOM
UNIVERSITY
EST. 2020

edX   LabXchange
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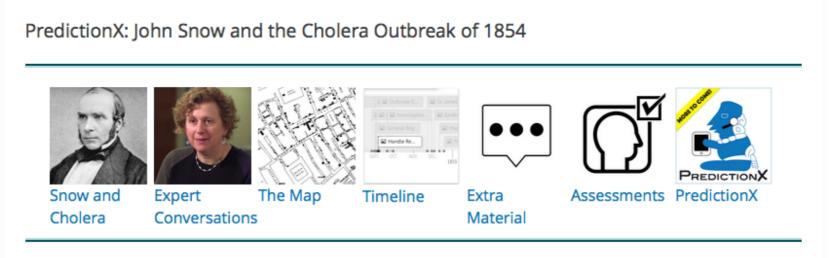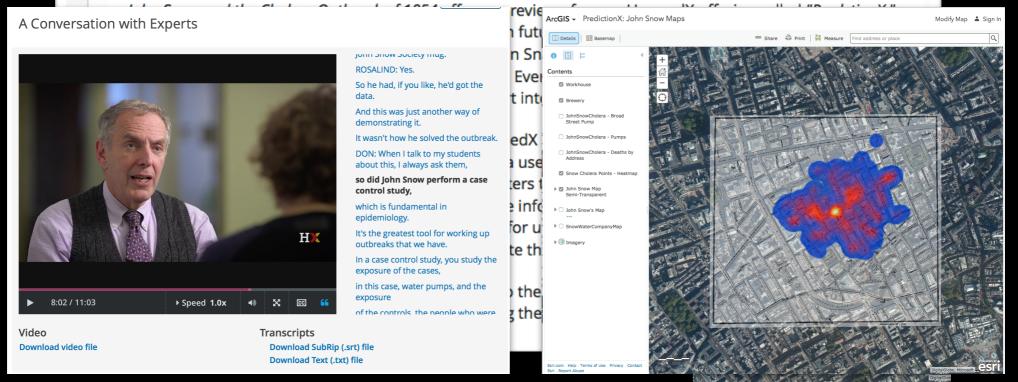
John Snow & Cholera (edX highlights & more)
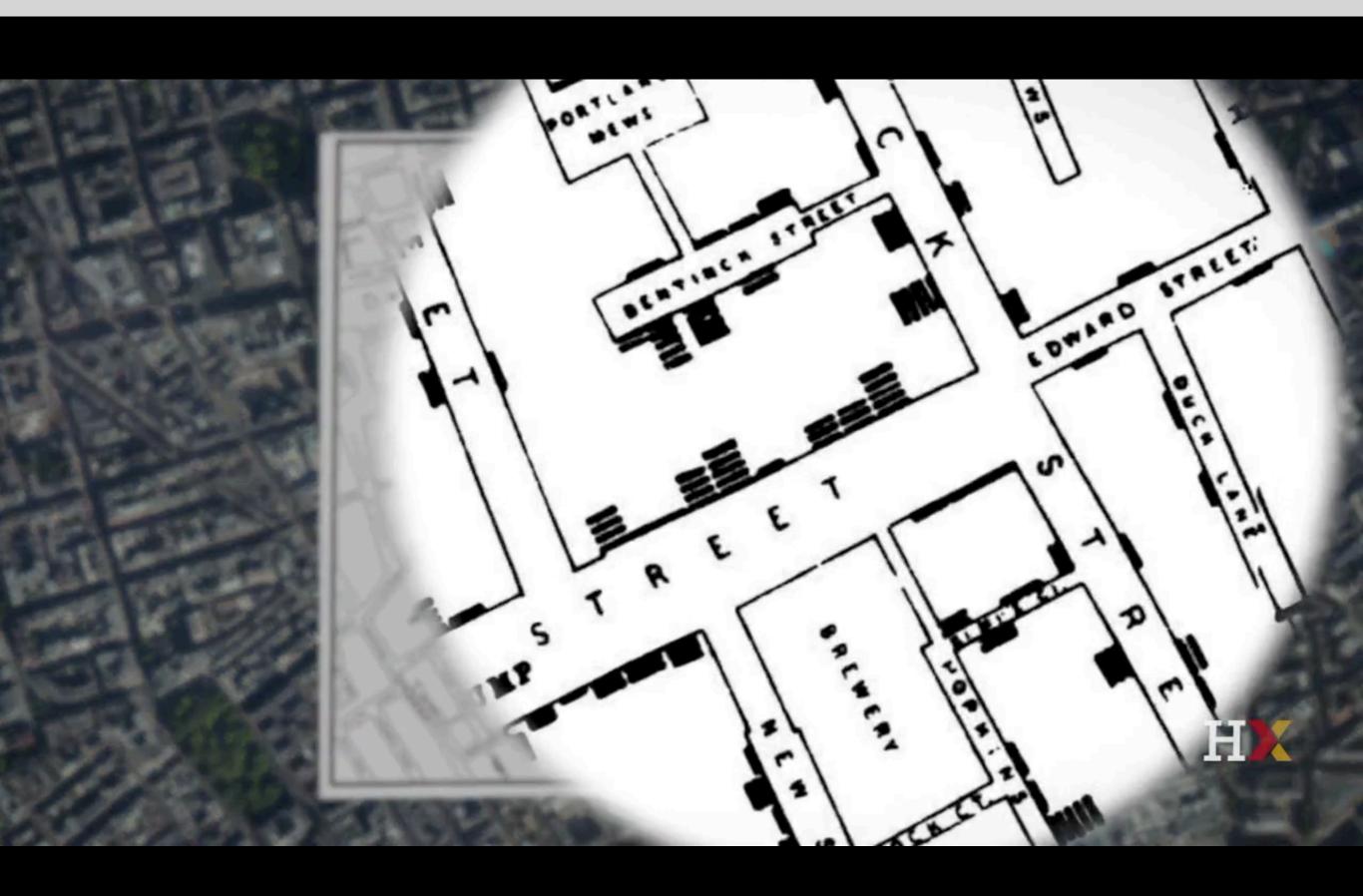
featuring Don Goldmann, AG & Rosalind Stanwell-Smith

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PredictionX

Slide-the-puck

1. Decide how rough your table is

   0.5 0.6 0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5

2. Click anywhere on the grid to throw the puck

3. Click here to finish the game for you

Height = 0.8, Width = 0.8	Height = 1.7, Width = 0.6	Height = 3.9, Width = 0.5	Height = 8.1, Width = 0.5
Height = 1.2, Width = 0.2	Height = 1.4, Width = 0.5	Height = 4.0, Width = 0.5	Height = 8.1, Width = 0.5
Height = 0.4, Width = 0.2	Height = 1.7, Width = 0.7	Height = 4.6, Width = 1.0	Height = 8.2, Width = 0.5
Height = 0.4, Width = 0.2	Height = 2.1, Width = 1.2	Height = 2.8, Width = 0.3	Height = 4.7, Width = 0.2

Number of games: 10, 5, 2, 1
Number of pucks: 1, 2, 5, 10

Flowchart: Find my coordinates without iPhone

Help, I'm lost! → Take out iPhone → iPhone has power, signal & GPS?

- Yes → Measured longitude ✓ / Measured latitude ✓ → Phew—now I'm found!
- No → Find my coordinates w/o iPhone

Find latitude (N or S of equator) using the Sun or stars.

Find longitude (E or W of Greenwich) using the Earth's 24-hour rotation as a clock.

Clear skies?
- Yes → Daytime?
  - Yes → **Use the Sun.** Latitude is the difference between the Sun's declination and its maximum elevation.
  - No → **Use the stars.** Your latitude is equal to the elevation of the celestial pole above the horizon. At present, **Polaris** marks the *North* Celestial Pole. There is no bright star at the *South* Celestial Pole now, so more astronomical expertise will be required if you can't see Polaris.
- No → WAIT

Use the Sun to find local (solar) time at your location.

Use the time at a remote, reference, location.

The *difference* between local (solar) **time** and the time at zero longitude (Greenwich) is your longitude.

Have a super-accurate timepiece?
- Yes → Do you know the exact location where it was set?
  - Yes → Add/subtract to find offset in time from zero-longitude (today, Greenwich).
  - No → Clear skies?
- No → Clear skies?
  - Yes → See Jupiter & its moons?
    - Yes → **Use Jupiter's** moons' positions as a clock.
    - No → WAIT
  - No → See the moon?
    - Yes → **Lunars.** Use the known path of the Moon to determine time.

DEREK'S DAY
The board game
Algorithmic Forecasting in Everyday Life

Morning

START → WAKE UP → PERFORM MORNING ROUTINE

- WAKE UP — You slept 9 hours
- items in your cart
- Your next box is on the way
- Reorder today!
- Mental health
- CHECK EMAIL — Inbox (8), Spam (23)
- Sales forecasting
- Spam filtering
- GO TO CLASS — ESSAYS DUE TODAY
- Plagiarism checker — 0 matches
- AI and Algorithms
- Watch Next
- The Adpocalypse
- Landing optimization
- BOS – AUS
- Bayesian theory in juries
- Longevity assessment
- EAT LUNCH — Calories 950/2000
- FLY HOME
- FINISH
- REWARDS Buy 9, get 1 free
- You have a new message
- JURY DUTY — Austin Court SUMMONS
- PERFORM CIVIC DUTY
- GET COFFEE
- ATTEND SEMINAR

Morning / Afternoon / Evening

Climate Change discussed in interviews with Rebecca Henderson (business), Gina McCarthy (policy) Dan Kammen (energy), James Leonard (performance art), Dan Gilbert (psychology)

#RANDOM

#NON-RANDOM

#HUMAN

#RANDOMIZED

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Essays

PREDICTIONX
‣ Essentials: Ways to Frame Discussions about Prediction
‣ Omens & Oracles
‣ Rise of Theory
‣ Modern Predictive Systems
▾ Sneak Preview: Video Interviews with Experts
   Agustin Rayo (philosophy)
   Avi Loeb (astronomy)
   Ben Shneiderman (artificial intelligence)
   Brendan Meade (earthquakes) and Susan Murphy (computer science)
   Daniel Gilbert (psychology

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Daniel Gilbert (psychology and prediction)

Daniel Gilbert is a Professor of Psychology at Harvard University. In this conversation with Professor Goodman, he discusses the ways in which people understand -- or fail to understand -- prediction in their daily lives.

20190502 Pred v1 Dan Gilbert amy v1jv

Commentary

Title
Uncertain Risks

Possible Tagline
We know how to express risk and uncertainty with numbers, but it's not always easy to take rational actions based on those numbers.

Text
"One shot." Any fan of the classic film, *The Deer Hunter,* will recognize that two-word phrase, and its double-meaning. *One shot* to kill a deer is humane, and *one shot* in the game of Russian Roulette is all that's needed to kill its player–or not. The odds of shooting a deer with a single shot while hunting depend on the skill of the hunter, the weather, the quality of the rifle, and more–and so are quite hard to estimate with great certainty. The odds of being shot in the head in a single round of Russian Roulette are, on the other hand, very easy to estimate--they are *exactly* 1 in 6. *One* bullet loaded into a *six*-chamber gun barrel that's then spun to a random stopping point and then fired by the player at their own head can be expected to blow a hole in the player's head *exactly* one in six times. This kind of certainty when assessing risk is extremely uncommon. Life is usually much more like hunting–with many factors influencing risk, so that estimating odds is hard, and uncertain.

Life is filled with decisions about risk in the face of uncertainty, so misunderstanding the words "risk" and "uncertainty" can be dangerous. These terms are commonly used In everyday life, where we talk about activities being "safe" or "risky," and we talk about being "sure" or "uncertain," but we don't usually attach specific numerical odds to such statements. Instead, psychologists like Dan Gilbert tell us, we humans typically group likelihood into three categories: it will happen; it won't happen; and it might happen. Percentages and numerical odds are relatively new constructs for the human race, so using the word "might" to capture everything between "will" and "won't" is understandable. But, in some cases, numbers can--and should--mitigate fear.

Our non-naturally-mathematical minds are not just bad at estimating and understanding nuanced risk: they also despise uncertainty. Evolution has left us survivors with a "fight or flight" response to fear and risk, so it can be difficult--even for those of us with plenty of mathematical training--to not let emotion overrule calculation.
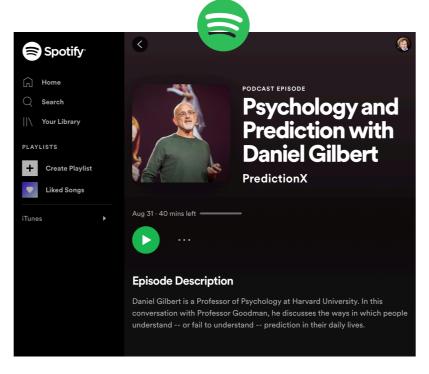
What *does* it look like, though, to see risk and uncertainty through a mathematical lens, unclouded by emotion? Let's consider the answer to that question using a morbid but fully unambiguous example: the risk of death.

Dan Gilbert
Professor of Psychology
Harvard University
HX

Transcript
0:01 Hi, I'm Dan Gilbert in the psychology department of Harvard University.
0:04 And one of the things that I have studied for pretty much the last three decades is
0:08 how people make predictions about what will make them happy,
0:11 how happy it'll make them, and how long that happiness will last.
0:15 And as you might expect, they don't always do a good job of it,
0:18 which gives me a job to do.
0:20 >> Welcome, Dan
12:35

YouTube

PredictionX
Prediction & Psychology
with Daniel Gilbert
SPECIAL GUEST
2:44

Would You Rather 1 Million or 1 Billion Dollars? - Daniel...

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PODCAST EPISODE
Psychology and Prediction with Daniel Gilbert
PredictionX

Aug 31 · 40 mins left

Episode Description
Daniel Gilbert is a Professor of Psychology at Harvard University. In this conversation with Professor Goodman, he discusses the ways in which people understand -- or fail to understand -- prediction in their daily lives.

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predictionxofficial Daniel Gilbert is a Professor of Psychology at Harvard University. In this interview with Professor Alyssa Goodman, he discusses the ways in which people understand -- or fail to understand -- prediction in their daily lives.

Watch the full interview at PredictionX.org

#dangilbert #harvard #harvarduniversity #psychology #money #financialliteracy #investment
1d

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THE STARRY MESSENGER

Alyssa Goodman
Harvard University
Radcliffe Institute for Advanced Study

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PATH TO

A project to track the evolution of science

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This presentation contained a secret preview of the "new" PredictionX.org site, to be launched October 2020.