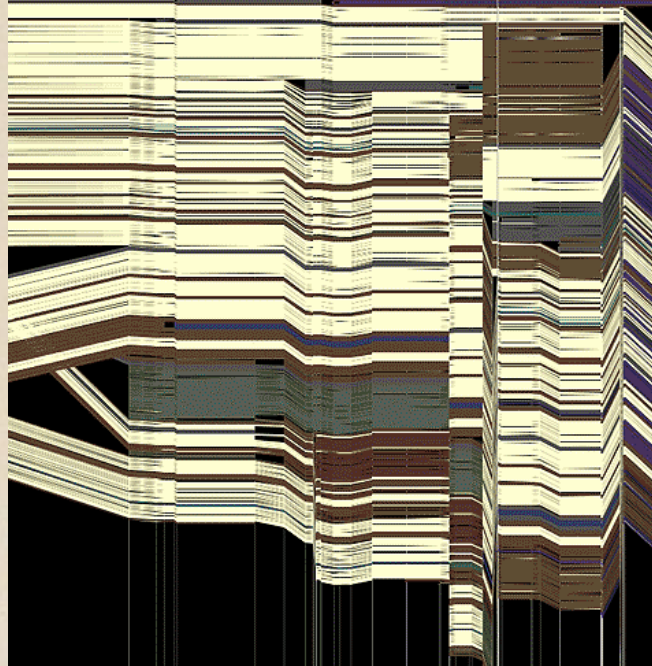
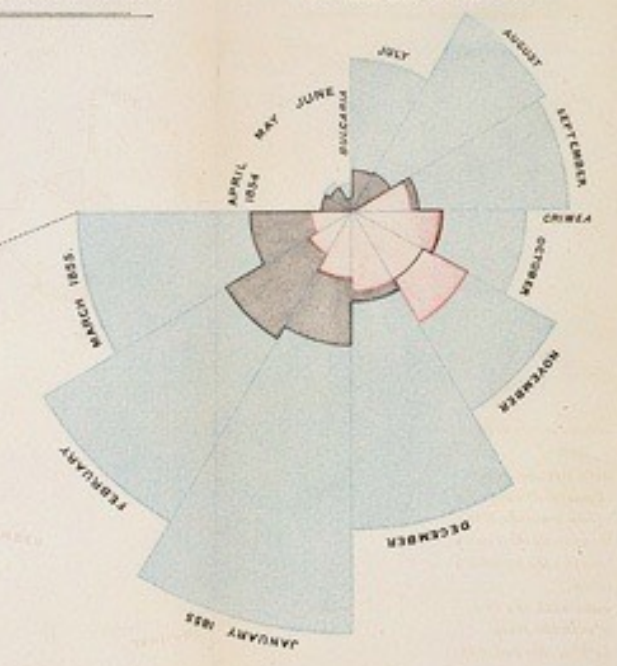


CSE 512 - Data Visualization

The Value of Visualization

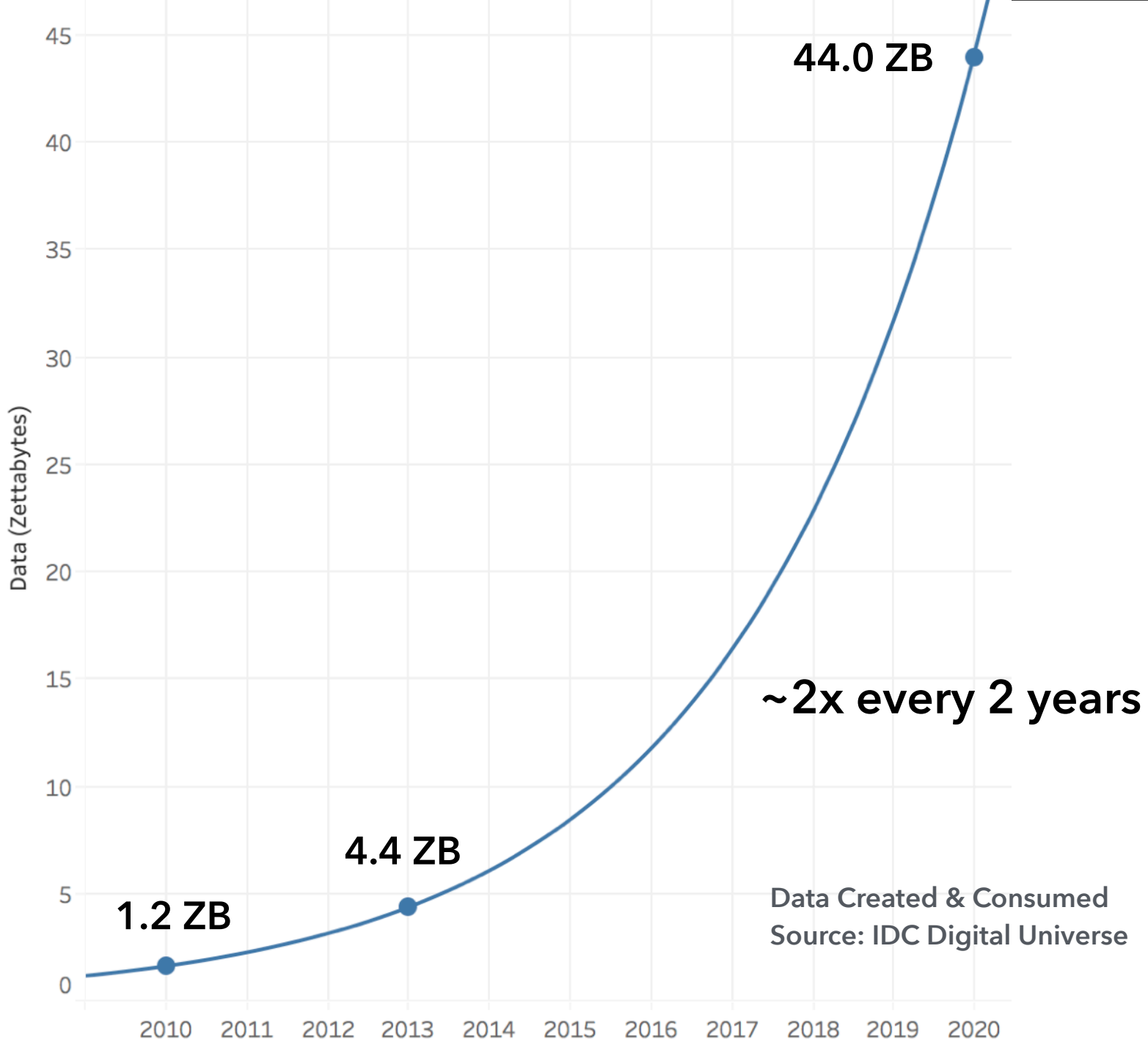


Jeffrey Heer University of Washington

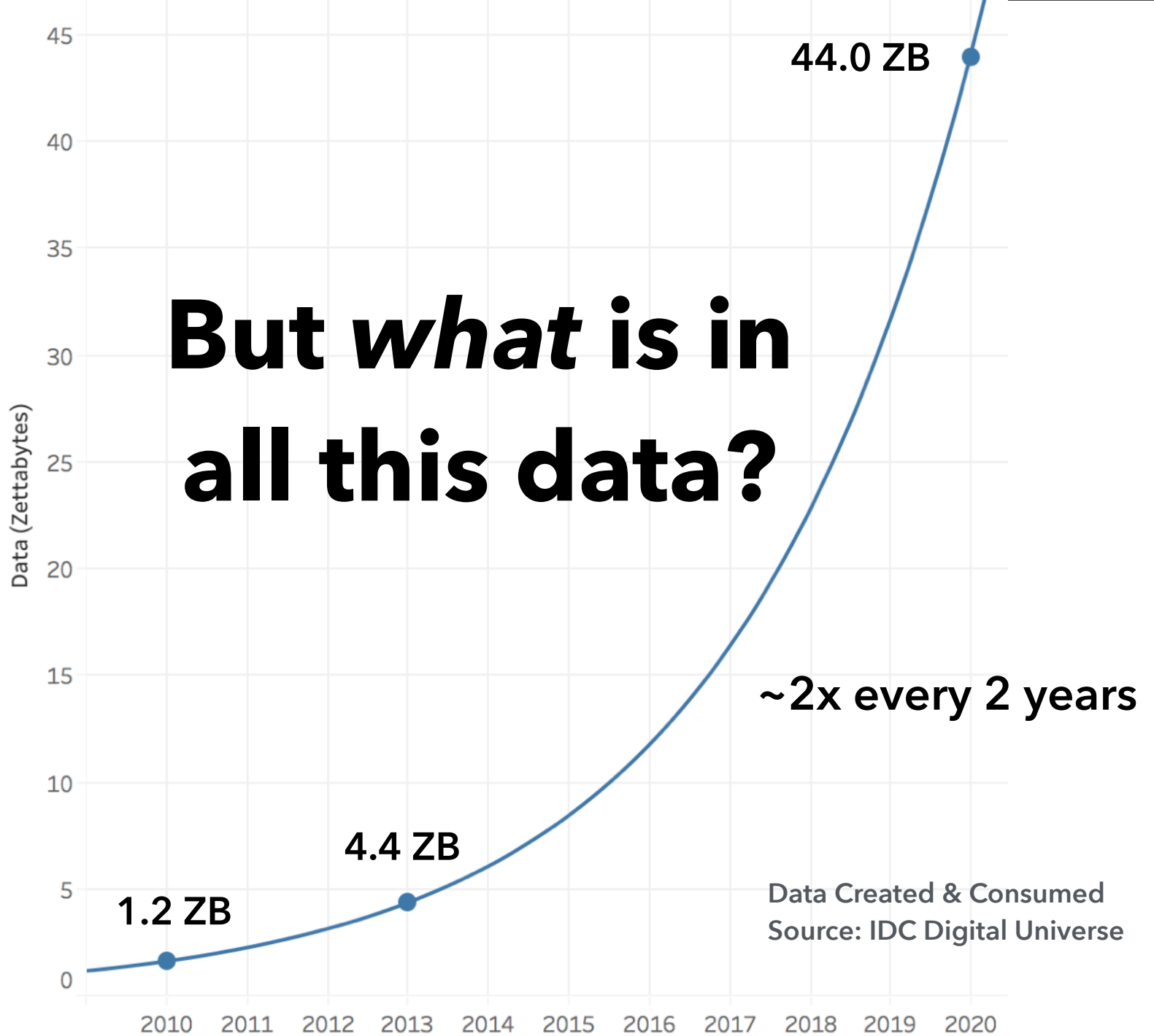
**How much data (bytes)
did we produce in 2010?**

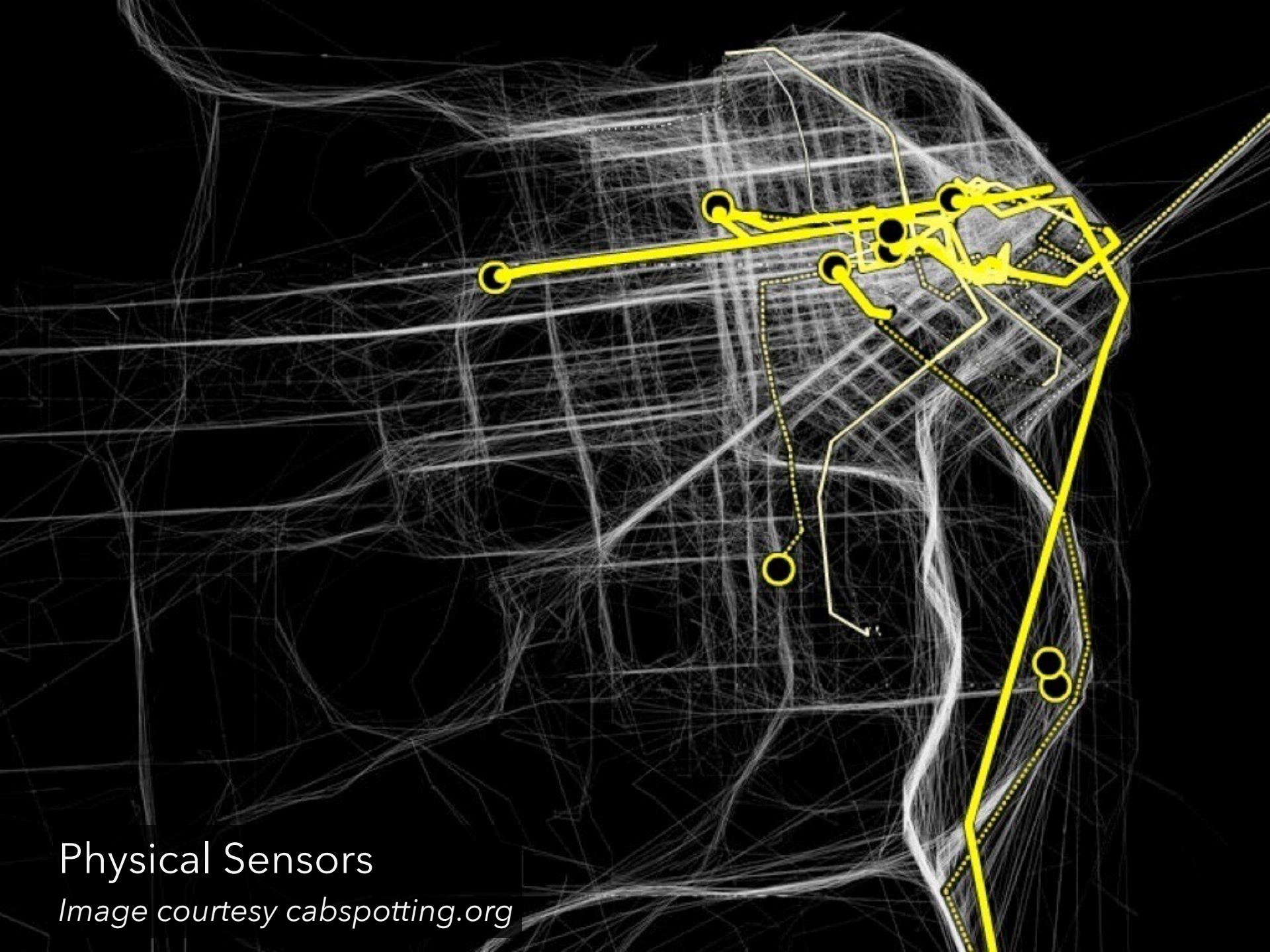
2010: 1,200 exabytes
and exponential growth...

Gantz et al., 2008, 2010



But *what* is in all this data?





Physical Sensors

Image courtesy cabspotting.org



157

HR/ECG
1/min

130/65

Art
mmHg sys/dia

93

SpO2
%

RR/CO2
1/min

97

HR/ECG
1/min

82/60

Art
mmHg sys/dia

99

SpO2
%

RR/CO2
1/min

79

HR/ECG
1/min

152/79

Art
mmHg sys/dia

95

SpO2
%

RR/CO2
1/min

64

HR/ECG
1/min

93/55

mmHg sys/dia

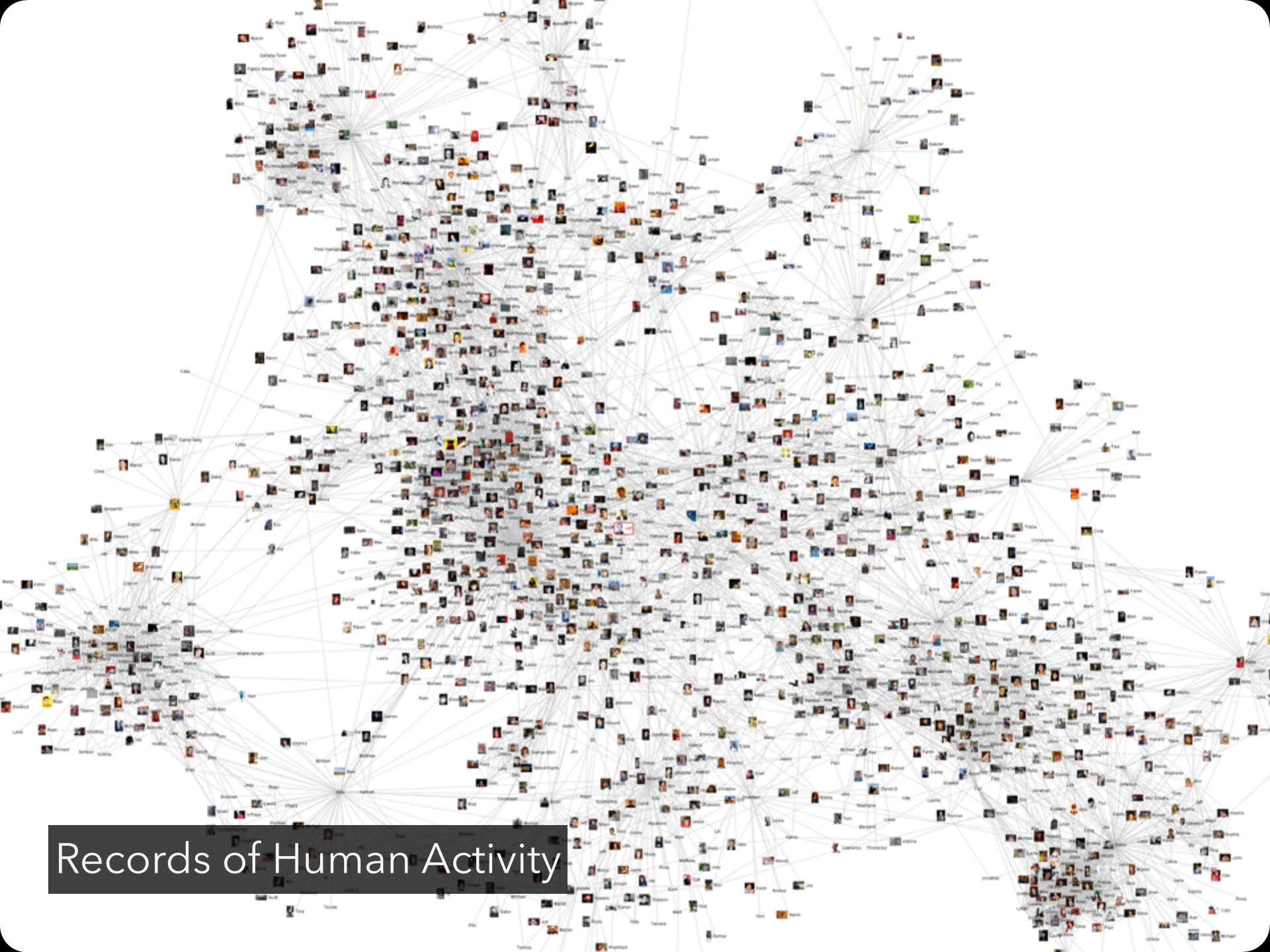
99

SpO2
%

RR/Imp
1/min

99

Health & Medicine



Records of Human Activity

The ability to take data—to be able to **understand** it, to **process** it, to **extract value** from it, to **visualize** it, to **communicate** it—that's going to be a hugely important skill in the next decades, ... because now we really do have **essentially free and ubiquitous data**. So the complimentary scarce factor is the ability to understand that data and extract value from it.

Hal Varian, Google's Chief Economist
The McKinsey Quarterly, Jan 2009

But wait!

The ability to take data—to be able to **understand** it, to **process** it, to **extract value** from it, to **visualize** it, to **communicate** it—that's going to be a hugely important skill in the next decade **"free" to whom?** because now we really do have **essentially free and ubiquitous data**. So the complimentary scarce factor is **"ubiquitous" about whom?** and extract value from it. **...to whose benefit?**

Hal Varian, Google's Chief Economist
The McKinsey Quarterly, Jan 2009



Life-size cutouts of Facebook CEO Mark Zuckerberg are displayed by a progressive advocacy group on the lawn of the U.S. Capitol on Tuesday.

Carolyn Kaster / Reuters

My Facebook Was Breached by Cambridge Analytica. Was Yours?

How to find out if you are one of the 87 million victims

ROBINSON MEYER | APR 10, 2018 | TECHNOLOGY

[Share](#) [Tweet](#) [...](#)

TEXT SIZE

- +



Psychology's Replication Crisis Can't Be Wished Away

It has a real and heartbreaking cost.

ED YONG | MAR 4, 2016 | SCIENCE

[Share](#) [Tweet](#) [...](#)

TEXT SIZE

- +

High potential for data abuse...

We move from data to information to knowledge to wisdom. And separating one from the other, being able to distinguish among and between them, that is, knowing the limitations and the danger of exercising one without the others, while respecting each category of intelligence, is generally what serious education is about.

Toni Morrison, American Novelist
The Source of Self Regard, 2019

How might we use **visualization**
to **empower understanding** of
data and analysis processes?

What is Visualization?

“Transformation of the symbolic into the geometric”

[McCormick et al. 1987]

“... finding the artificial memory that best supports our natural means of perception.” [Bertin 1967]

“The use of computer-generated, interactive, visual representations of data to amplify cognition.”

[Card, Mackinlay, & Shneiderman 1999]

Set A

X	Y
10	8.04
8	6.95
13	7.58
9	8.81
11	8.33
14	9.96
6	7.24
4	4.26
12	10.84
7	4.82
5	5.68

Set B

X	Y
10	9.14
8	8.14
13	8.74
9	8.77
11	9.26
14	8.1
6	6.13
4	3.1
12	9.11
7	7.26
5	4.74

Set C

X	Y
10	7.46
8	6.77
13	12.74
9	7.11
11	7.81
14	8.84
6	6.08
4	5.39
12	8.15
7	6.42
5	5.73

Set D

X	Y
8	6.58
8	5.76
8	7.71
8	8.84
8	8.47
8	7.04
8	5.25
19	12.5
8	5.56
8	7.91
8	6.89

Summary Statistics

$$u_X = 9.0 \quad \sigma_X = 3.317$$

$$u_Y = 7.5 \quad \sigma_Y = 2.03$$

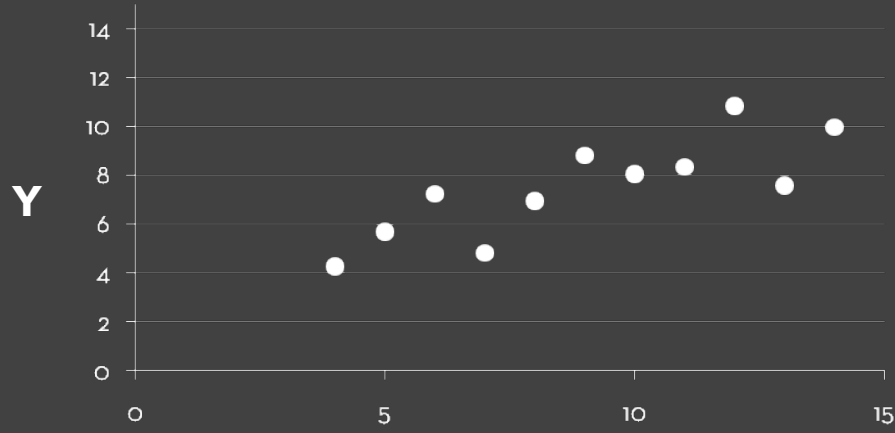
Linear Regression

$$Y = 3 + 0.5 X$$

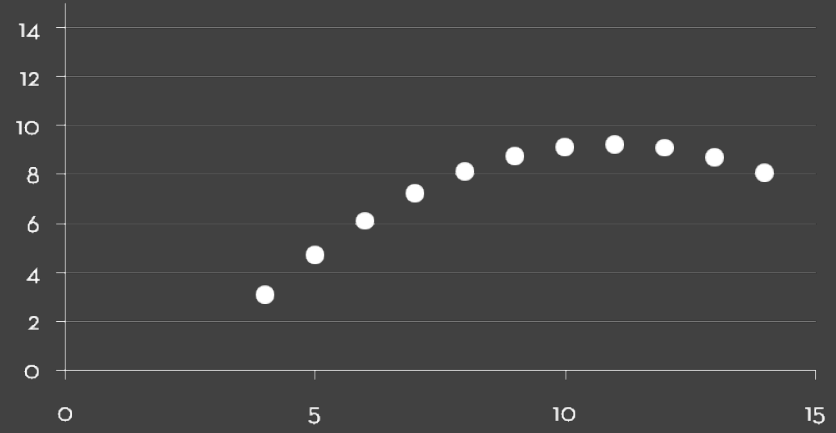
$$R^2 = 0.67$$

[Anscombe 1973]

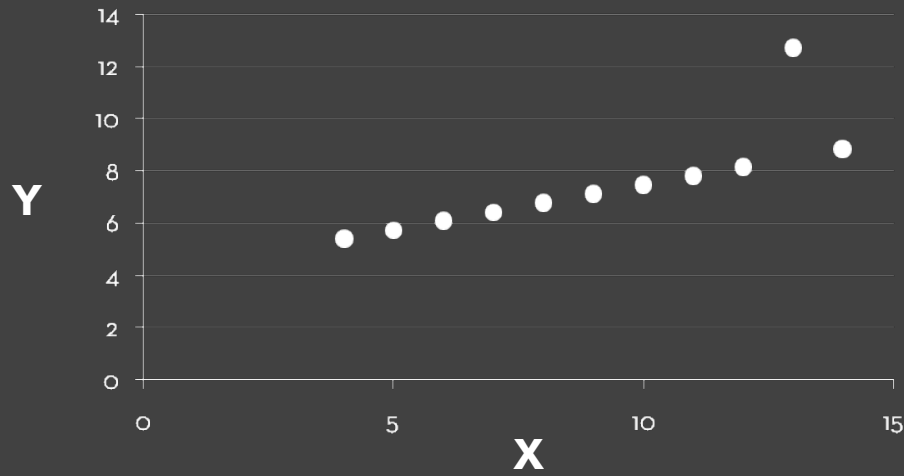
Set A



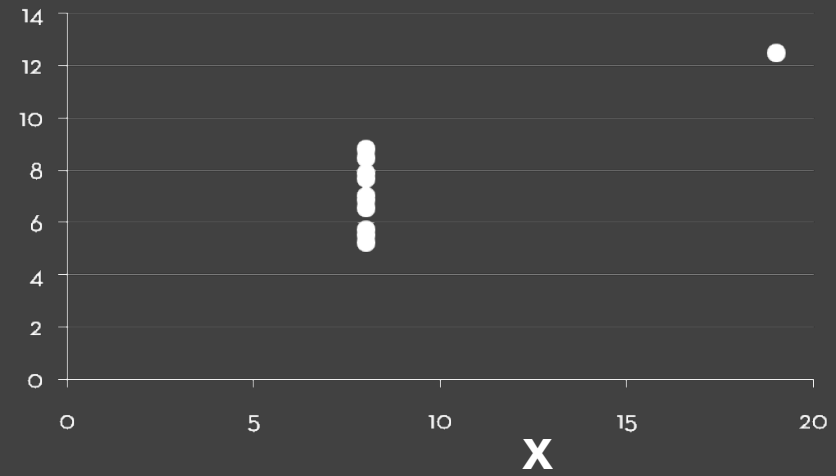
Set B

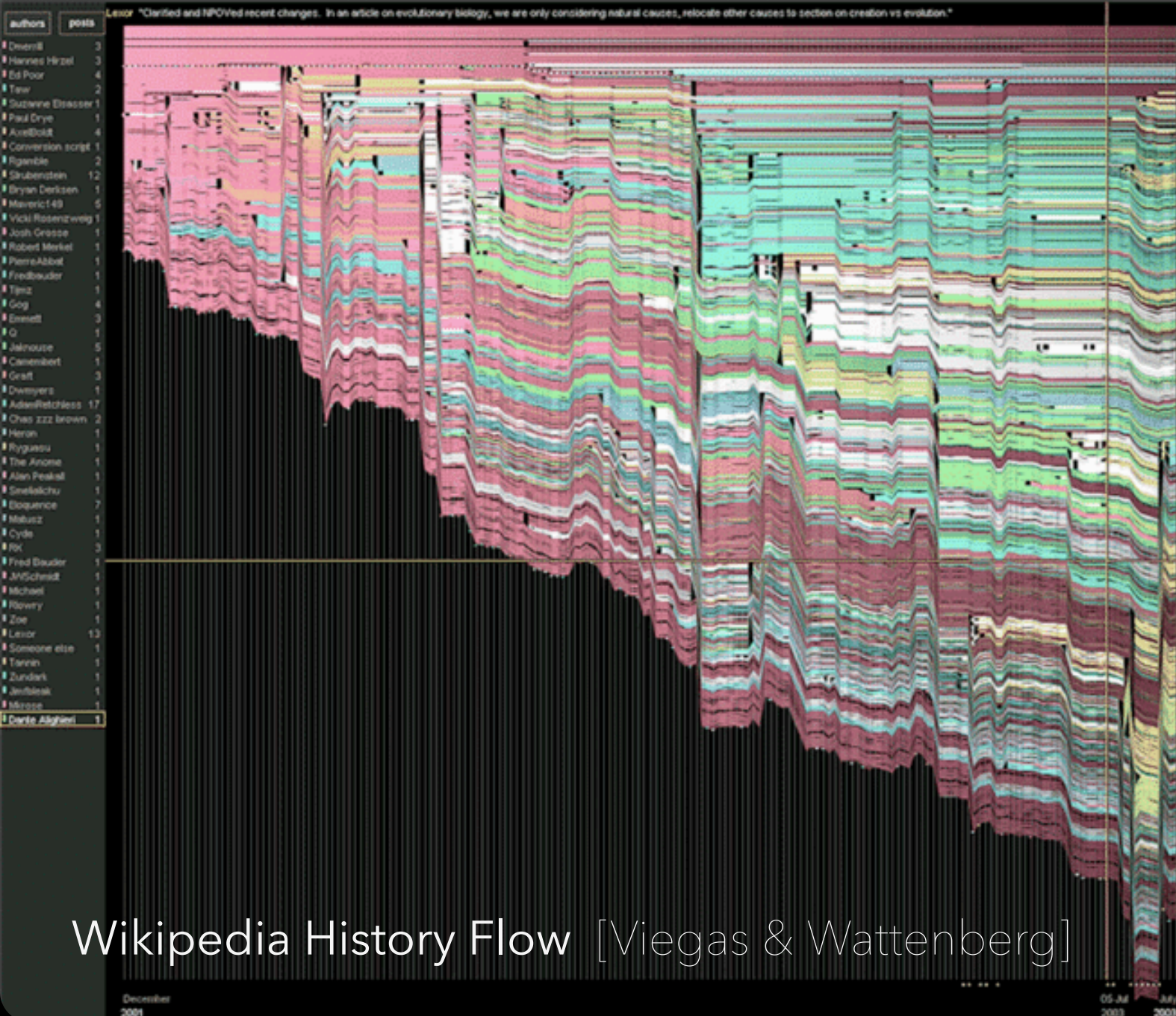


Set C



Set D





Therefore, over time, the types of orga have traits better *adapted* to their envi tend to become the dominant ones in an environment, while organisms poorly ad their environment will become extinct. *Natural selection* also provides for a me which life can sustain itself over time. Si long run, environments always change, successive generations did not develop which allowed them to survive and rep species would simply die out as their bi niches die out. Therefore, life is allowe over great spans of time, in the form of species. The central role of natural sele evolutionary theory has created a stron between that field and the study of acob

Genetic drift

Genetic drift describes changes in gene that cannot be ascribed to selective pres are due instead to events that are unrel inherited traits. This is especially impo mating populations, which simply cannot enough offspring to maintain the same g distribution as the parental generation. f fluctuations in gene frequency between generations may result in some genes d from the population. Two separate popu begin with the same gene frequency mu therefore, "drift" by random fluctuation divergent populations with different gene genes that are present in one have been other). *Rare sporadic events* (volcanic e meteor impact, etc.) might contribute to drift by altering the gene frequency over "normal" selective pressures.

Development of evolutionary

As science has uncovered more and mo information about the basic operations o as genetics and molecular biology, thes evolution have changed. The general tra been not to overturn well-supported the supplant them with more detailed and th more complex ones.

While transmutation was accepted by a number of scientists before 1859, it was publication of Charles Darwin's *The Ori Species* which provided the first cogent by which evolutionary change could per mechanism of *natural selection*. The ex outlines the major steps of evol Earth as expounded by this theory's pro

Following the dawn of *molecular biology*, clear that a major mechanism for variat population is the *mutagenesis* of DNA. A component to evolutionary theory is the *cell cycle*. DNA is copied fairly, but not e faithfully. When these rare copying erro they are said to introduce genetic mutas three general consequences relative to environment: good, bad, or neutral. B individuals with "good" mutations will ha stronger propensity to propagate, indivi "bad" mutations will have less of a chan successful reproduction, and those carry "neutral" mutations will have neither an nor a disadvantage. These definitions as the environment remains stable. Consid level of a single gene, these variants y described represent different genetic al. Following environmental change, alleles their classification of good, bad, or neut shift into one of the other categories. I carrying alleles formerly classified as e can be "good", as they bear favoura

Wikipedia History Flow [Viegas & Wattenberg]



Edit War...

Wikipedia History Flow [Viegas & Wattenberg]

Why Create Visualizations?

Why Create Visualizations?

Answer questions (or discover them)

Make decisions

See data in context

Expand memory

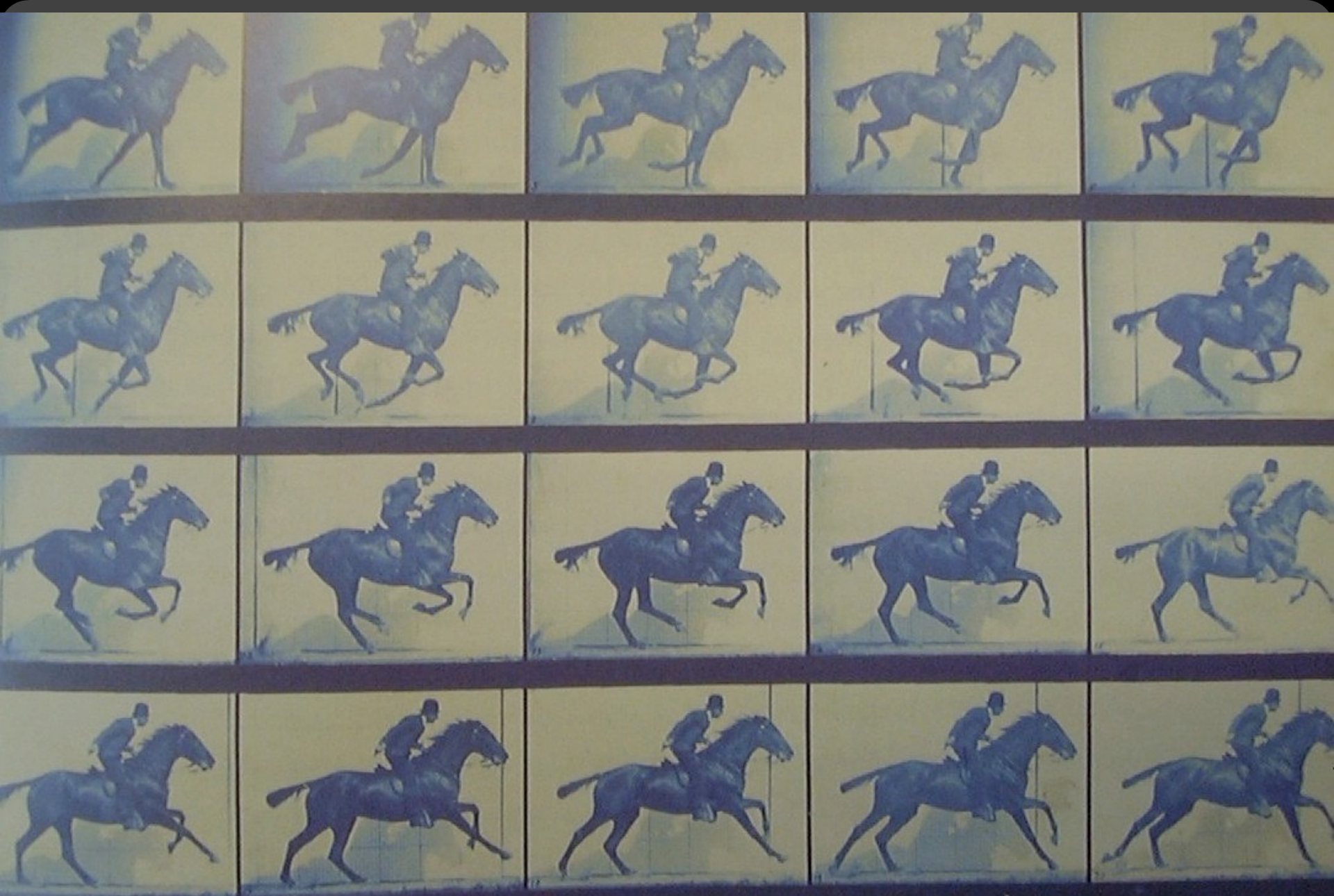
Support graphical calculation

Find patterns

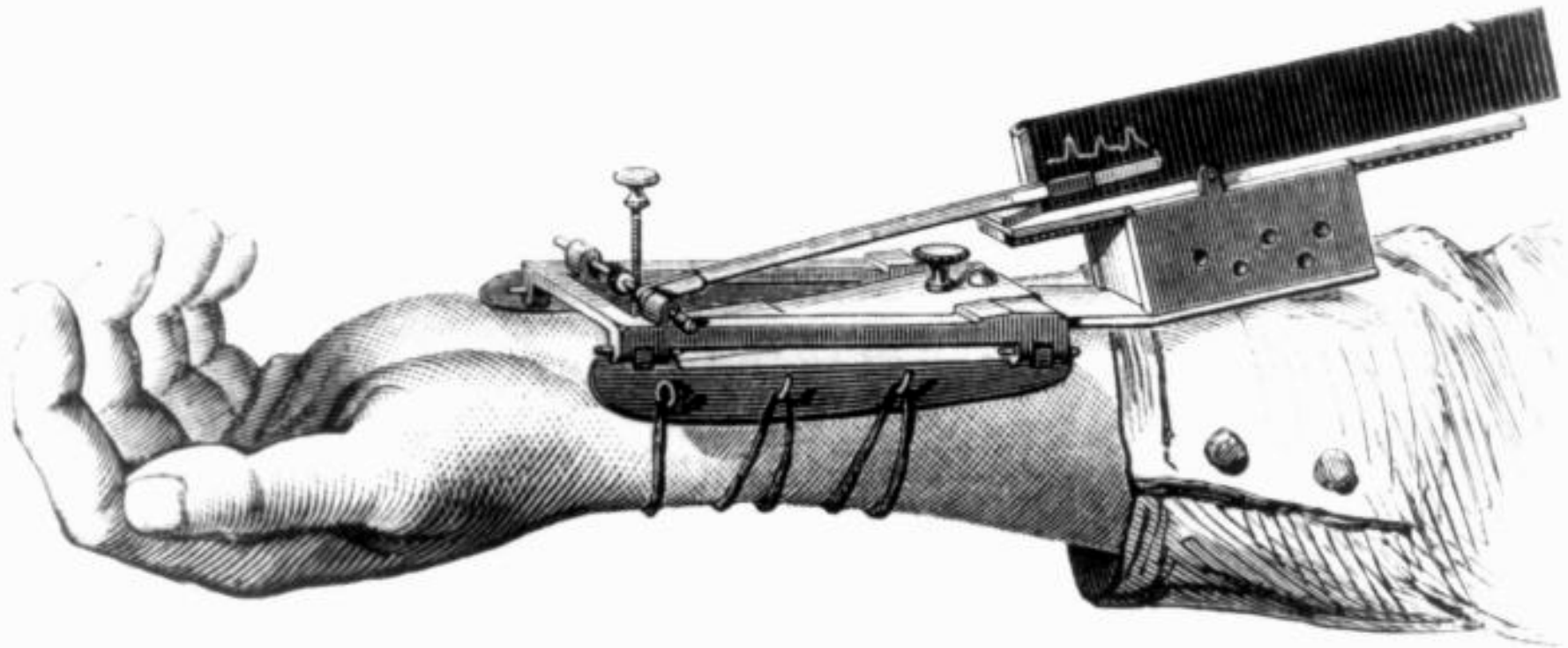
Present argument or tell a story

Inspire

Record Information

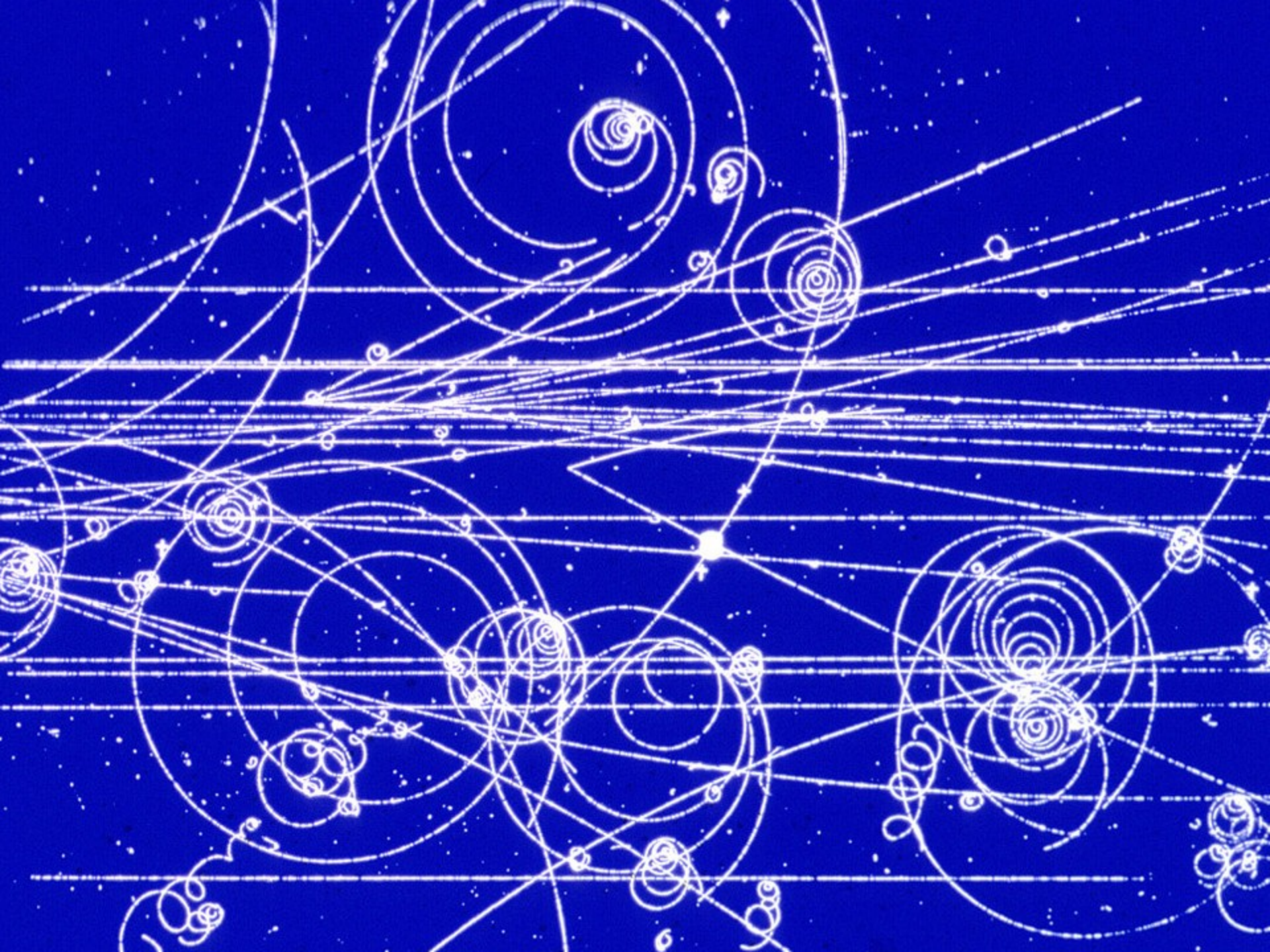


Gallop, Bay Horse "Daisy" [Muybridge]

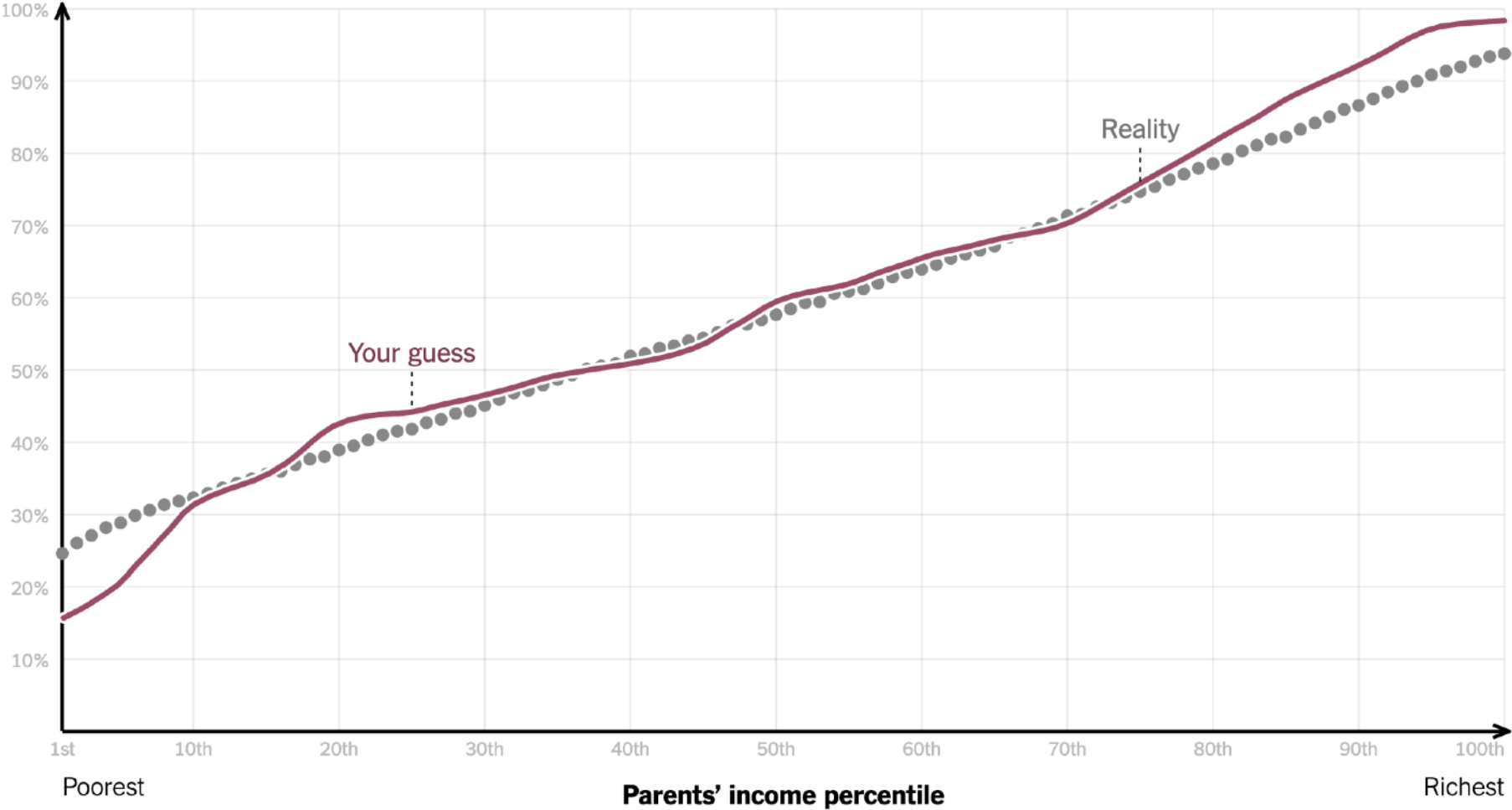


1.
Marey's **sphygmograph** in use,
1860. *La méthode graphique dans
les sciences expérimentales et
principalement en physiologie et en
médecine.*

E.J. Marey's sphygmograph [from Braun 83]



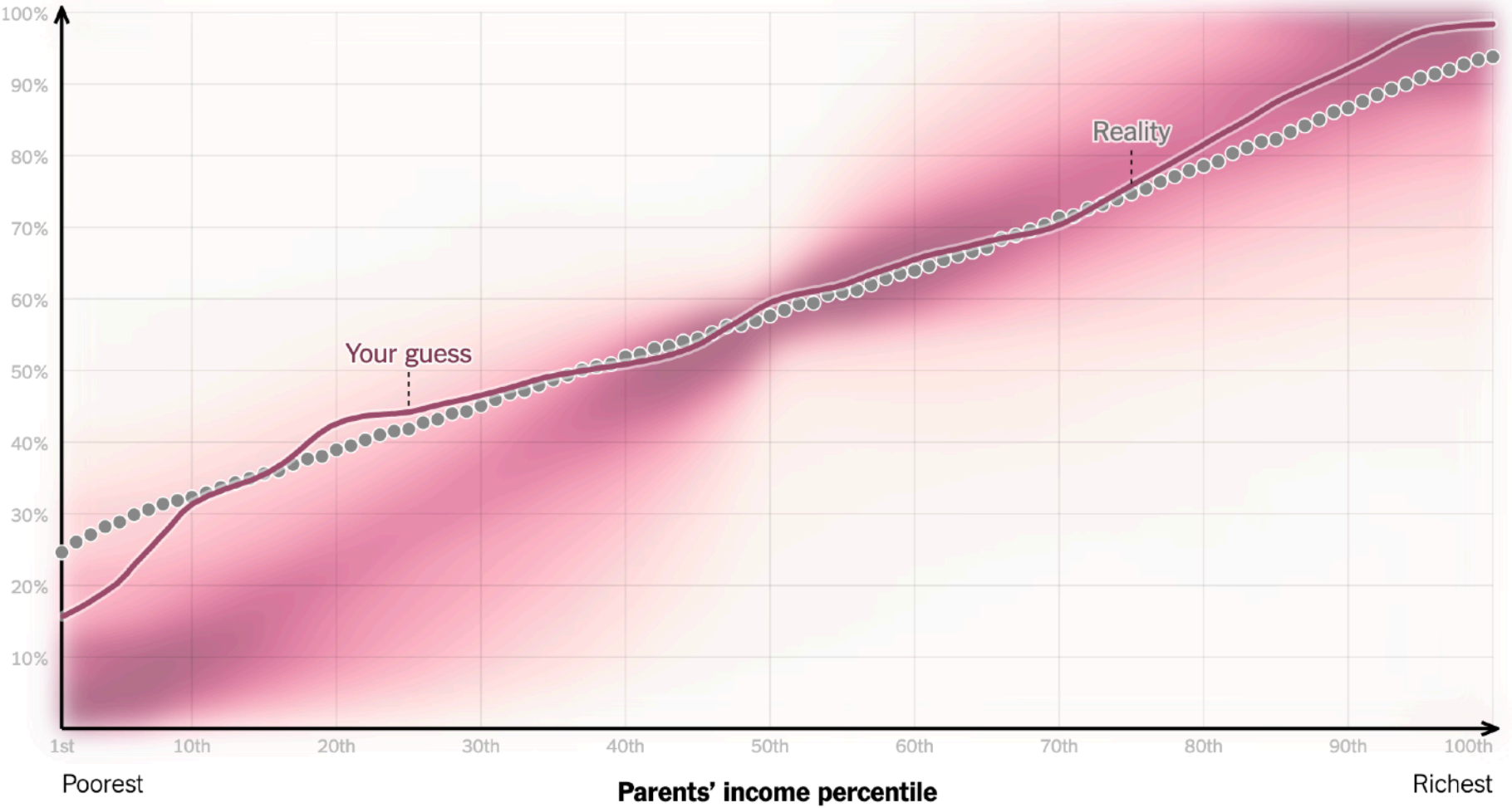
Percent of children who attended college



You Draw It: How Family Income Predicts Children's College Chances

[New York Times, May 28, 2015]

Percent of children who attended college

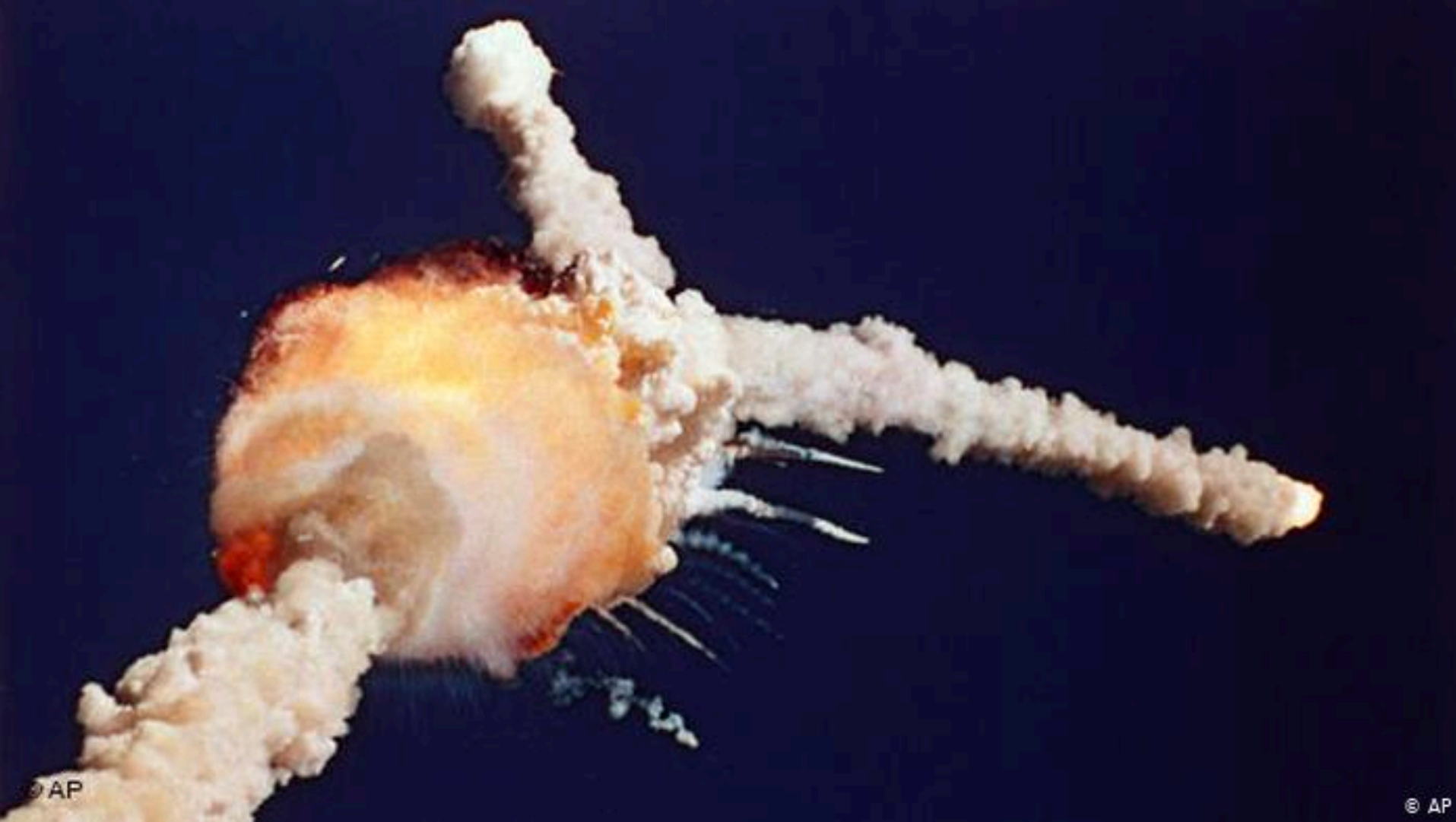


You Draw It: How Family Income Predicts Children's College Chances

[New York Times, May 28, 2015]

Support Reasoning





© AP

© AP

HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

1161
Oct 30, 1985
y

July

SRM No.	Cross Sectional View			Top View		Clocking Location (deg)
	Erosion Depth (in.)	Perimeter Affected (deg)	Nominal Dia. (in.)	Length Of Max Erosion (in.)	Total Heat Affected Length (in.)	
61A LH Center Field**	22A	None	None	0.280	None	36° - 66°
61A LH CENTER FIELD**	22A	NONE	NONE	0.280	NONE	338° - 18°
51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	163
51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	354
51C RH Center Field (sec)***	15B	None	45.0	0.280	None	354
41D RH Forward Field	13B	0.028	110.0	0.280	3.00	275
41C LH Aft Field*	11A	None	None	0.280	None	--
41B LH Forward Field	10A	0.040	217.0	0.280	3.00	351
STS-2 RH Aft Field	2B	0.053	116.0	0.280	--	90

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.
 **Soot behind primary O-ring.
 ***Soot behind primary O-ring, heat affected secondary O-ring.

Clocking location of leak check port - 0 deg.

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT NEAR OR BEYOND THE PRIMARY O-RING.

SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.

BLOW BY HISTORY

SRM-15 WORST BLOW-BY
 o 2 CASE JOINTS (80°), (110°) ARC
 o MUCH WORSE VISUALLY THAN SRM-22

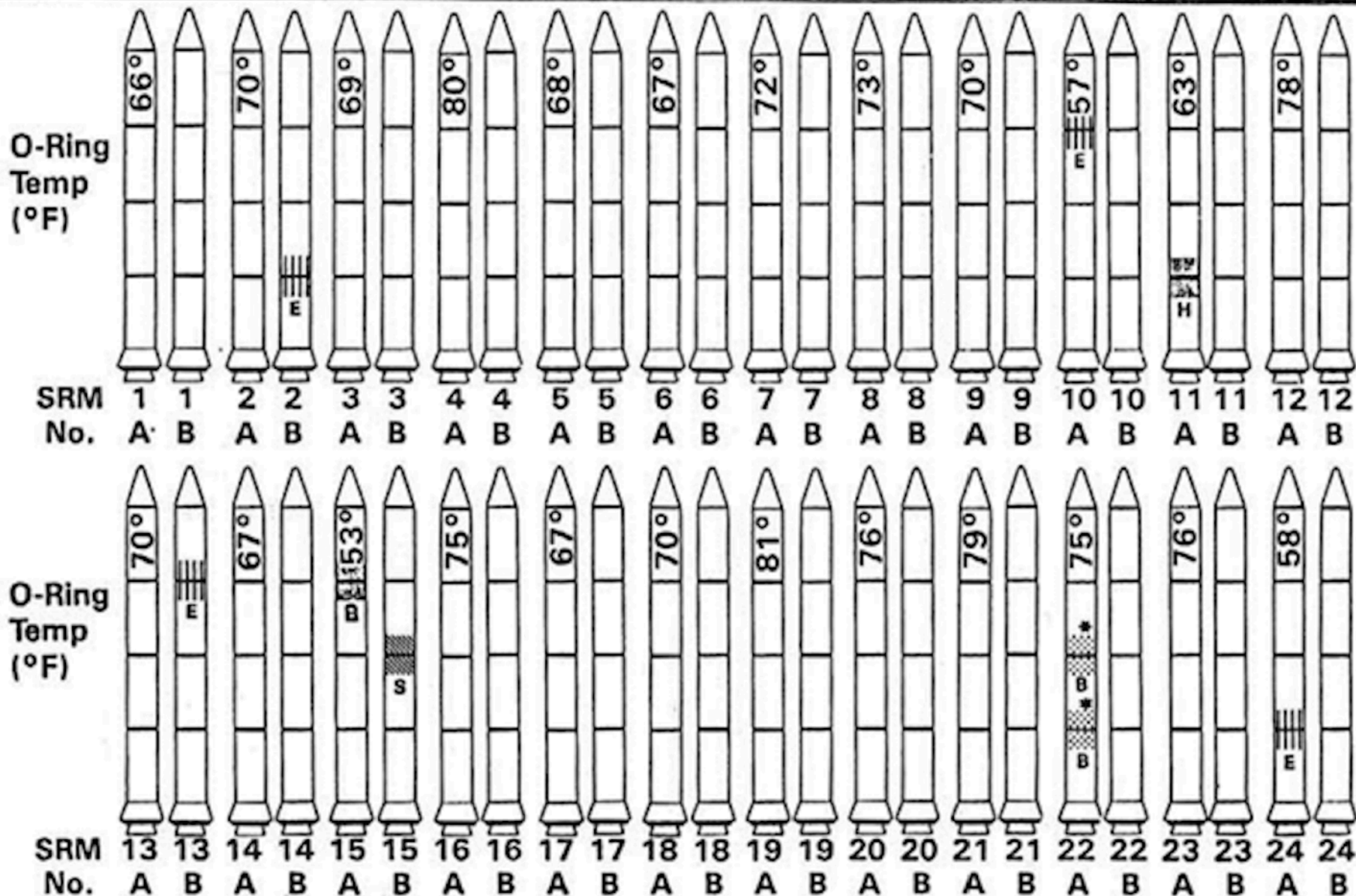
SRM 22 BLOW-BY
 o 2 CASE JOINTS (30-40°)

SRM-13A, 15, 16A, 18, 23A 24A
 o NOZZLE BLOW-BY

HISTORY OF O-RING TEMPERATURES (DEGREES - F)

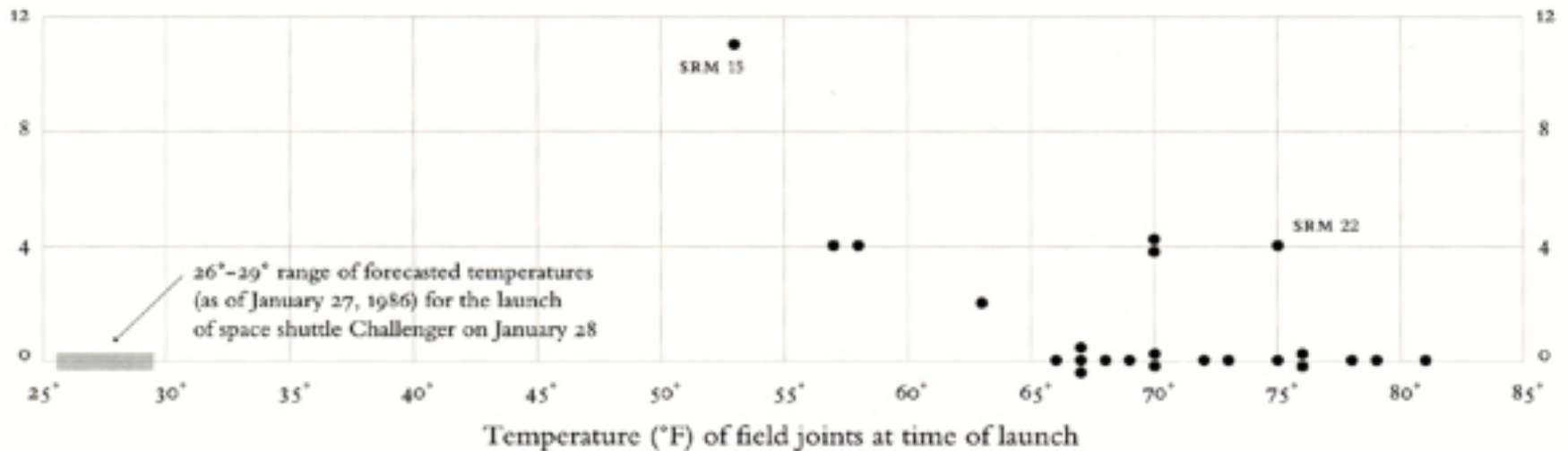
MOTOR	MBT	AMB	O-RING	WIND
DM-4	68	36	47	10 MPH
DM-2	76	45	52	10 MPH
QM-3	72.5	40	48	10 MPH
QM-4	76	48	51	10 MPH
SRM-15	52	64	53	10 MPH
SRM-22	77	78	75	10 MPH
SRM-25	55	26	29	10 MPH
			27	25 MPH

History of O-Ring Damage in Field Joints (Cont)



Make Decisions: Challenger

O-ring damage index, each launch



**But wait! What is an appropriate "damage index"?
Which temperatures, O-ring or outside air?**

Chart of temperatures vs. O-ring damage [Tufte 97]

Data in Context: Cholera Outbreak



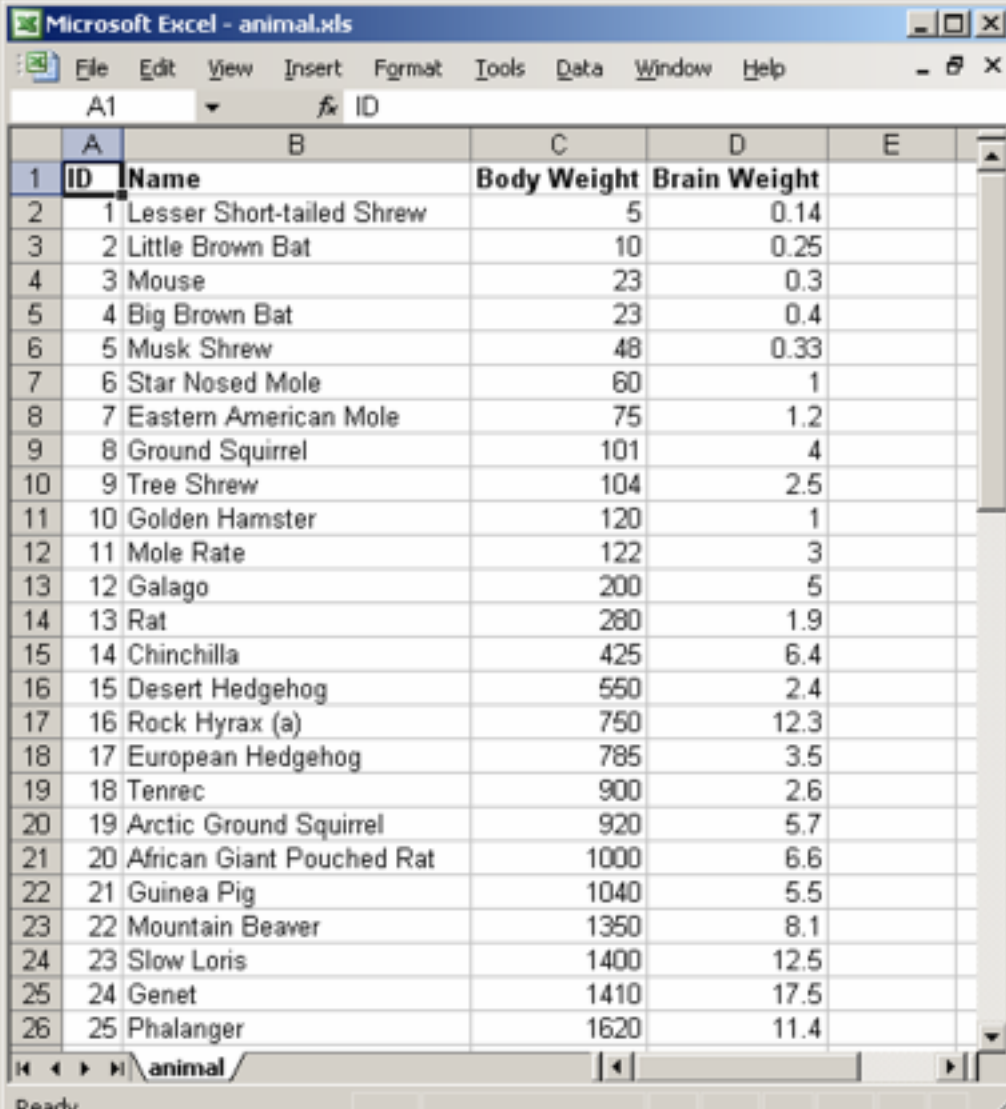
In 1854 John Snow plotted the position of each cholera case on a map. [from Tufte 83]

Data in Context: Cholera Outbreak



Used map to hypothesize that pump on Broad St. was the cause. [from Tufte 83]

Answer Questions: Brain Power?



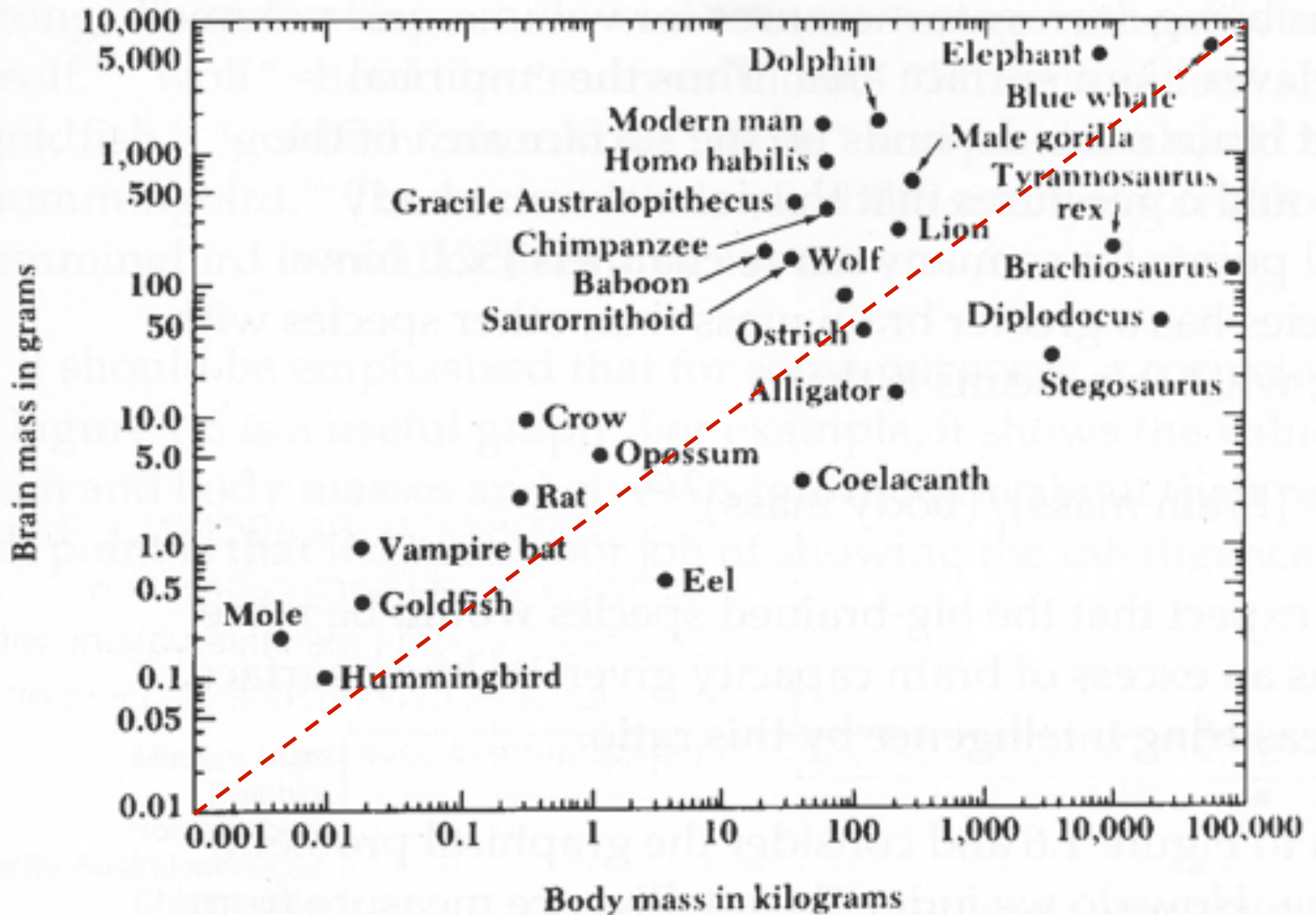
Microsoft Excel - animal.xls

File Edit View Insert Format Tools Data Window Help

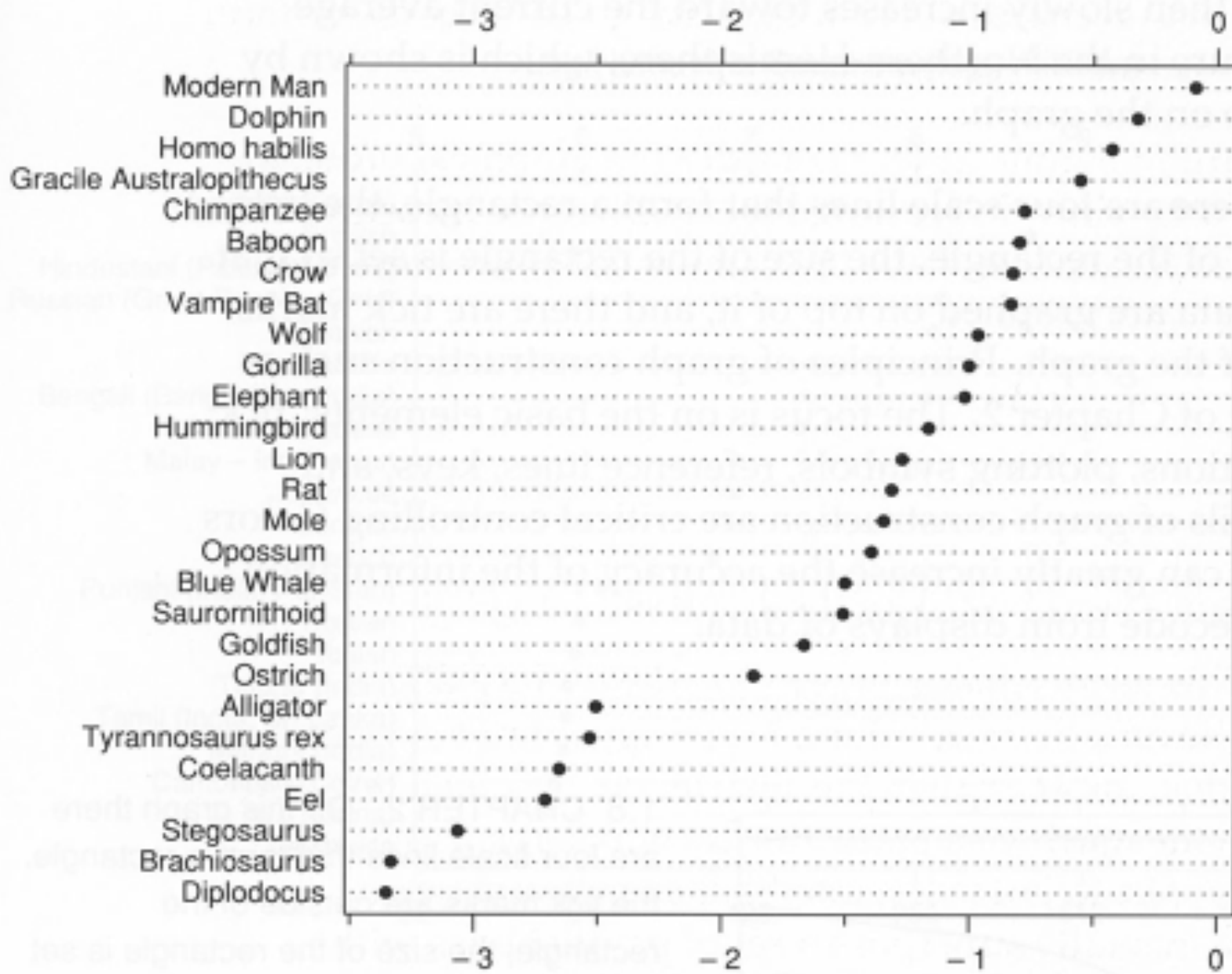
A1 fx ID

	A	B	C	D	E
1	ID	Name	Body Weight	Brain Weight	
2	1	Lesser Short-tailed Shrew	5	0.14	
3	2	Little Brown Bat	10	0.25	
4	3	Mouse	23	0.3	
5	4	Big Brown Bat	23	0.4	
6	5	Musk Shrew	48	0.33	
7	6	Star Nosed Mole	60	1	
8	7	Eastern American Mole	75	1.2	
9	8	Ground Squirrel	101	4	
10	9	Tree Shrew	104	2.5	
11	10	Golden Hamster	120	1	
12	11	Mole Rate	122	3	
13	12	Galago	200	5	
14	13	Rat	280	1.9	
15	14	Chinchilla	425	6.4	
16	15	Desert Hedgehog	550	2.4	
17	16	Rock Hyrax (a)	750	12.3	
18	17	European Hedgehog	785	3.5	
19	18	Tenrec	900	2.6	
20	19	Arctic Ground Squirrel	920	5.7	
21	20	African Giant Pouched Rat	1000	6.6	
22	21	Guinea Pig	1040	5.5	
23	22	Mountain Beaver	1350	8.1	
24	23	Slow Loris	1400	12.5	
25	24	Genet	1410	17.5	
26	25	Phalanger	1620	11.4	

Ready



The Dragons of Eden [Carl Sagan]



The Elements of Graphing Data

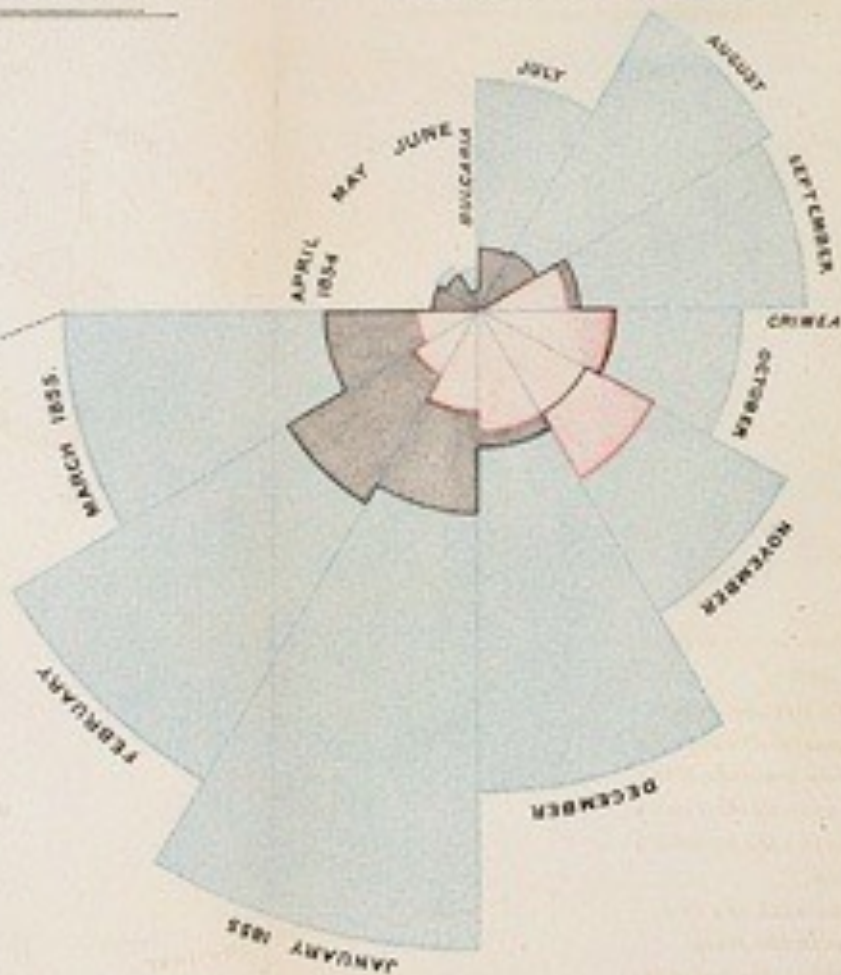
[Cleveland]

$\log_{10} \text{Brain Weight} - \frac{2}{3} \log_{10} \text{Body Weight}$

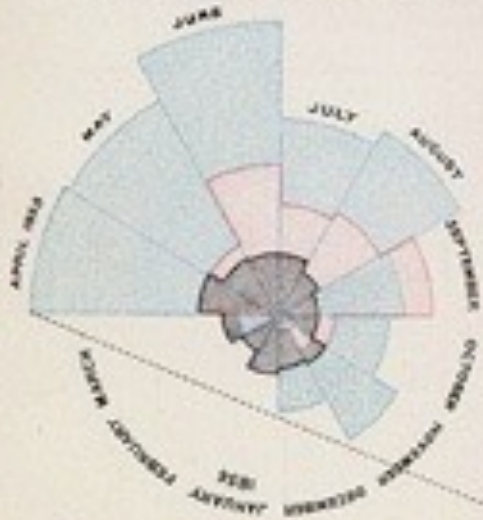
Convey Information

DIAGRAM OF THE CAUSES OF MORTALITY
IN THE ARMY IN THE EAST.

1.
APRIL 1854 TO MARCH 1855.



2.
APRIL 1855 TO MARCH 1856.

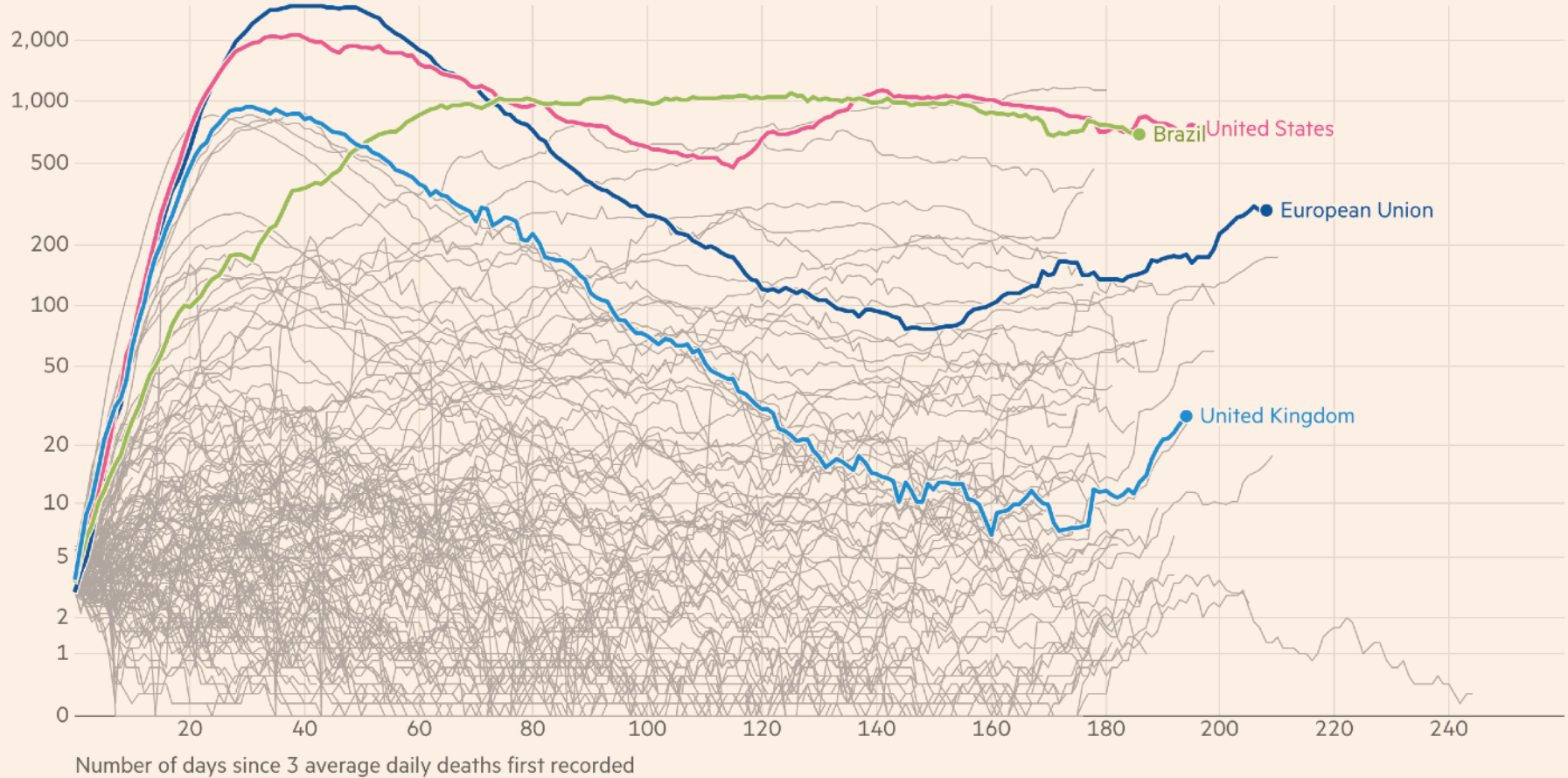


"to affect thro' the Eyes
what we fail to convey to
the public through their
word-proof ears"

1856 "Coxcomb" of Crimean War Deaths, Florence Nightingale

New deaths attributed to Covid-19 in European Union, United States, Brazil and United Kingdom

Seven-day rolling average of new deaths, by number of days since 3 average daily deaths first recorded



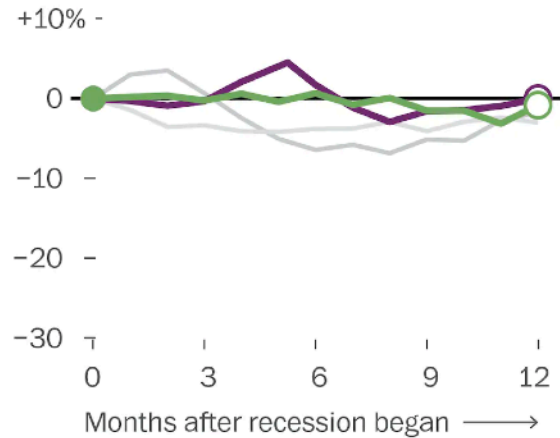
Source: Financial Times analysis of data from the European Centre for Disease Prevention and Control, the Covid Tracking Project, the UK Dept of Health & Social Care and the Spanish Ministry of Health.
Data updated September 25 2020 12.46pm BST. Interactive version: ft.com/covid19

FINANCIAL TIMES

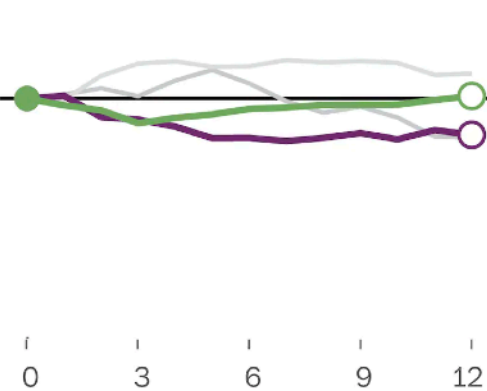
The coronavirus crisis is different

Job growth (or loss) since each recession began, based on weekly earnings

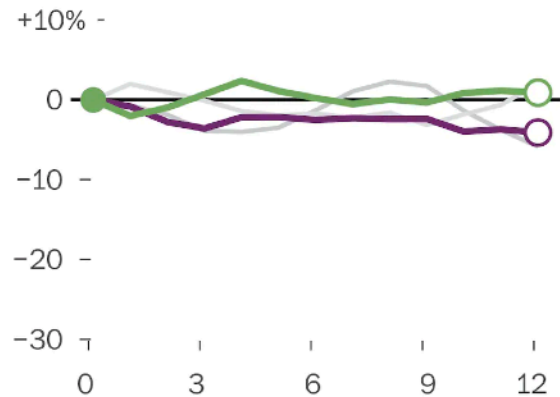
1990 recession



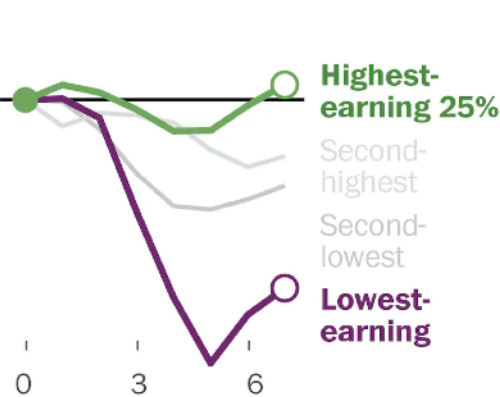
2001 recession



2008 recession



Coronavirus crisis



Notes: Based on a three-month average to show the trend in volatile data.

Source: Labor Department via IPUMS, with methodology assistance from Ernie Tedeschi of Evercore ISI

THE WASHINGTON POST

The Covid Economy

Washington Post

The Value of Visualization

Record information

Blueprints, photographs, seismographs, ...

Analyze data to support reasoning

Develop and assess hypotheses

Find patterns / Discover errors in data

Expand memory

Convey information

Communicate, inform, inspire

Collaborate and revise

Goals of Visualization Research

1 Understand how visualizations convey information

What do people perceive / comprehend?

How do visualizations inform mental models?

2 Develop principles and techniques for creating effective visualizations and supporting analysis

Leverage perception & augment cognition

Improve ties between visualization & mental model

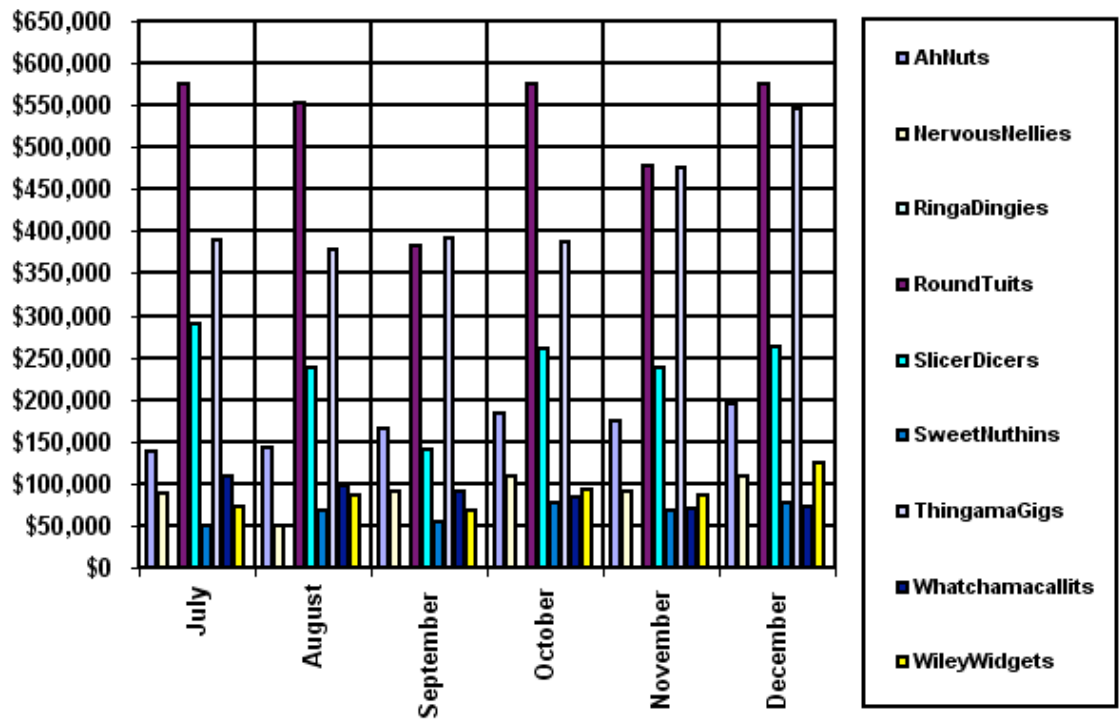
Course Topics

Data and Image Models

		LES VARIABLES DE L'IMAGE									
		POINTS			LIGNES			ZONES			
								12	14		
Z	XY 2 DIMENSIONS DU PLAN										
	TAILLE										
	VALEUR										
		LES VARIABLES DE SÉPARATION DES IMAGES						13			
	GRAIN										
	COULEUR										
	ORIENTATION										

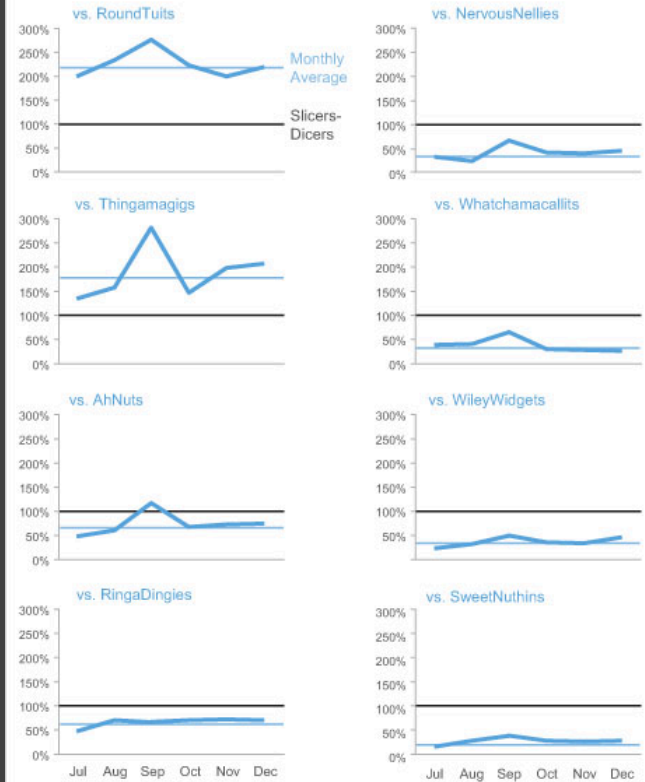
Visual Encoding Design

SlicerDicers' Sales Compared to Other Products



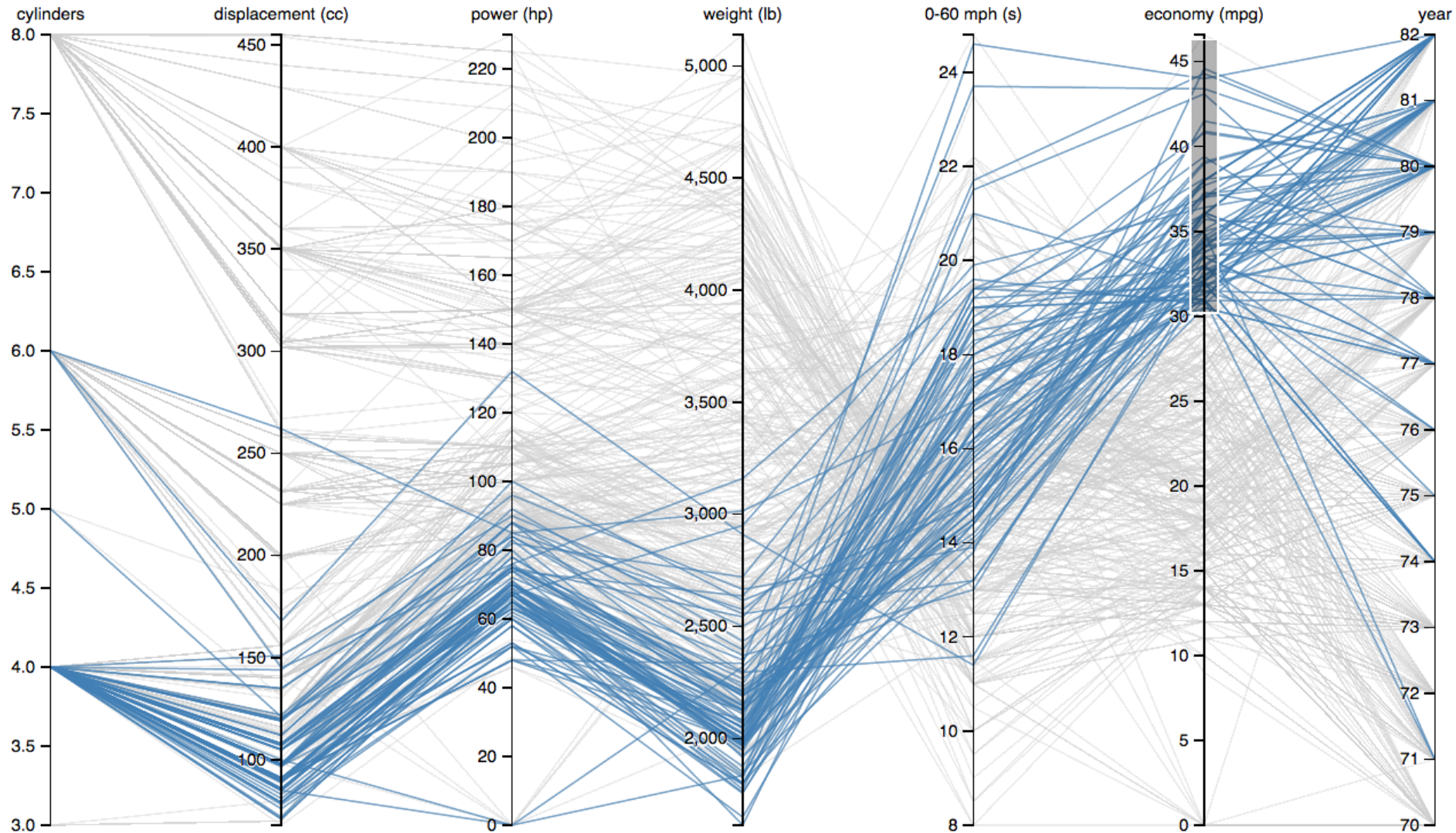
Problematic design

Sales of SlicersDicers Compared to Sales of Other Products
July - December, 2011

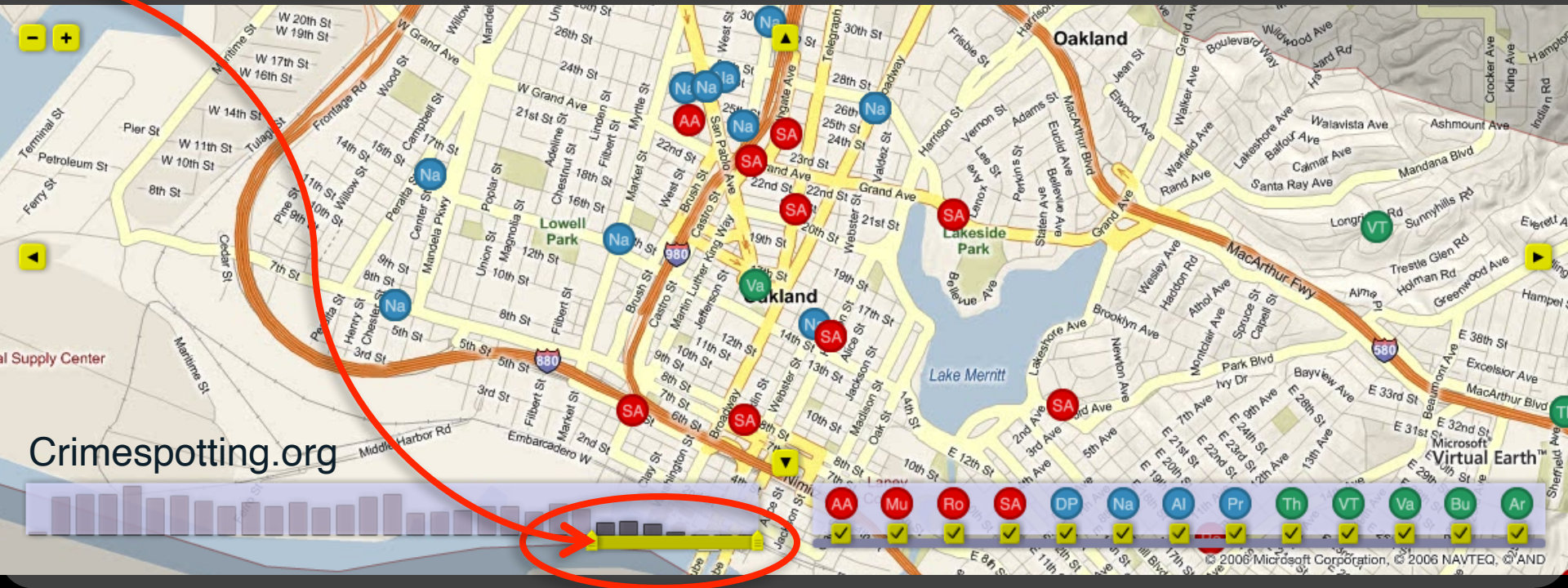
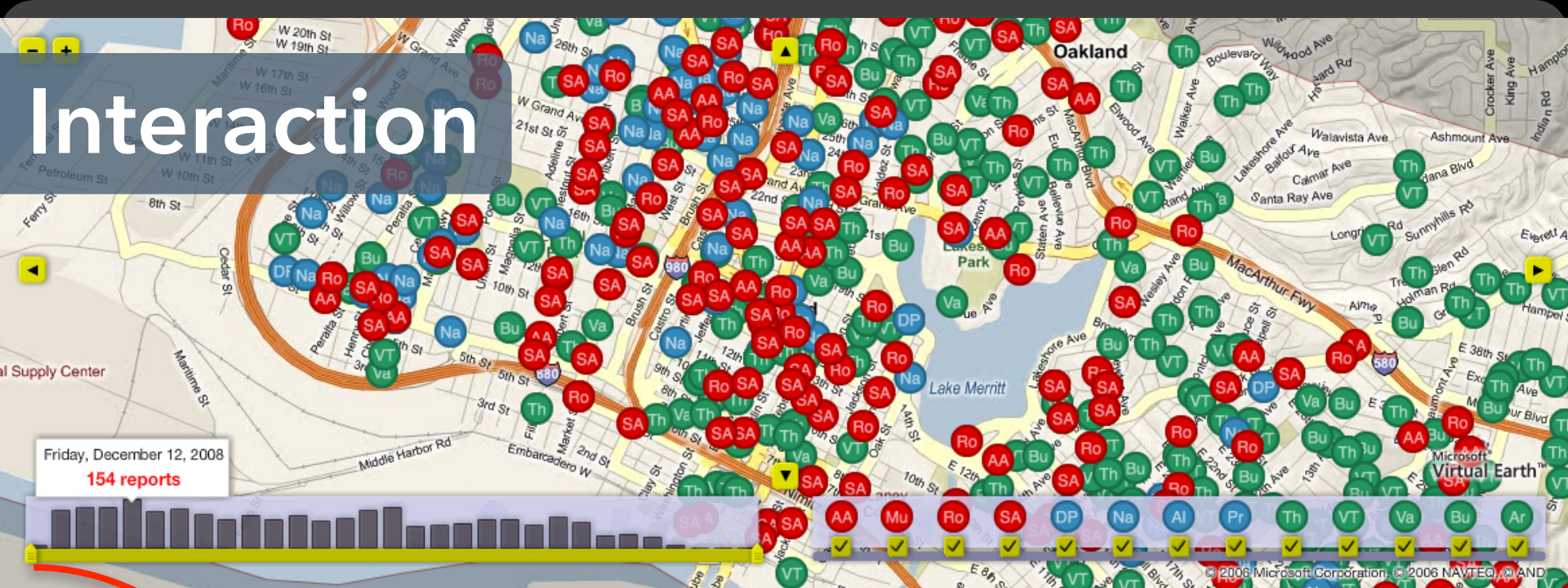


Redesign

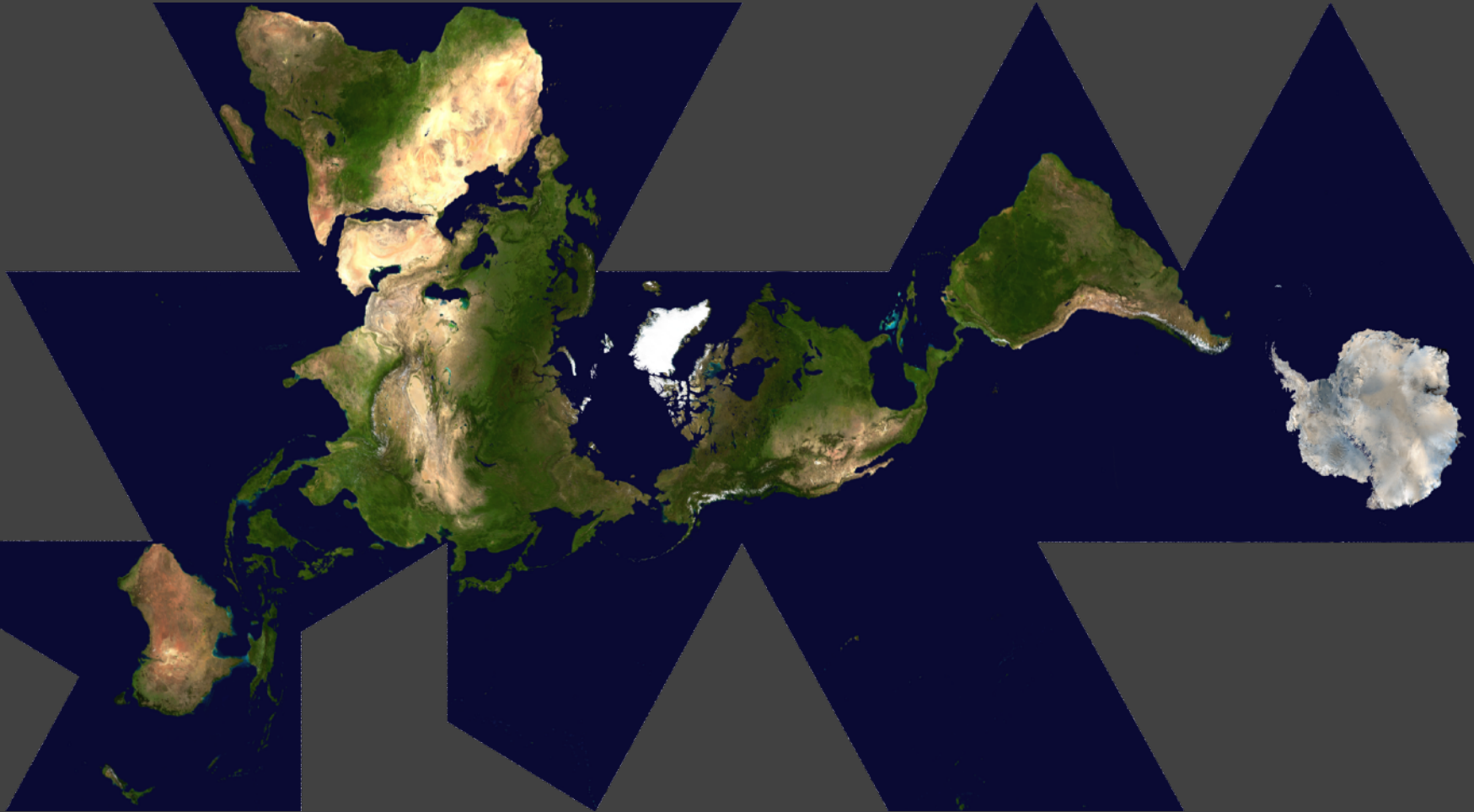
Exploratory Data Analysis



Interaction

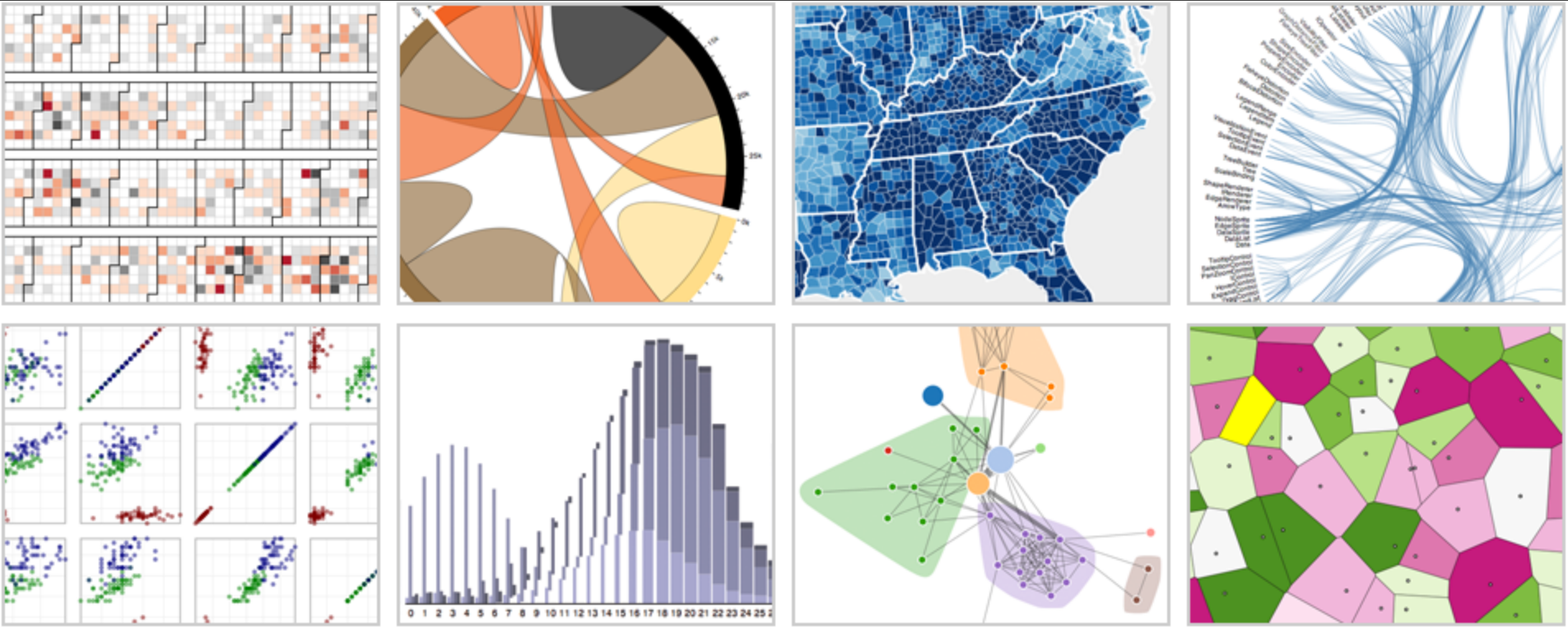


Maps



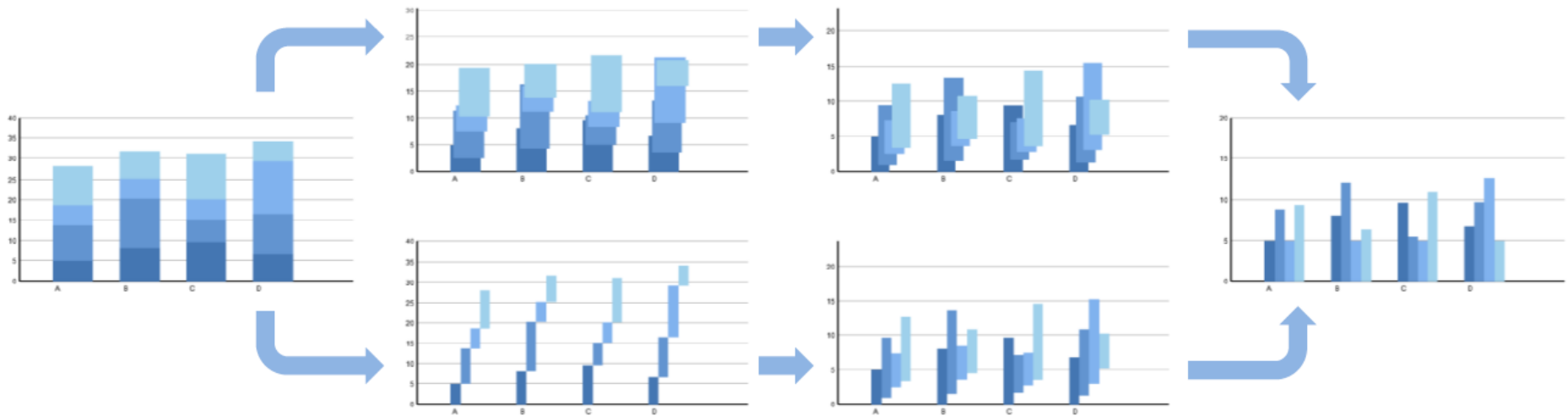
Dymaxion Maps [Fuller 46]

Visualization Software



D3: Data-Driven Documents
Vega-Lite / Altair

Animation

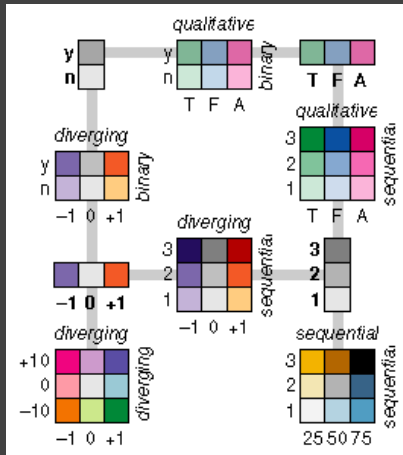
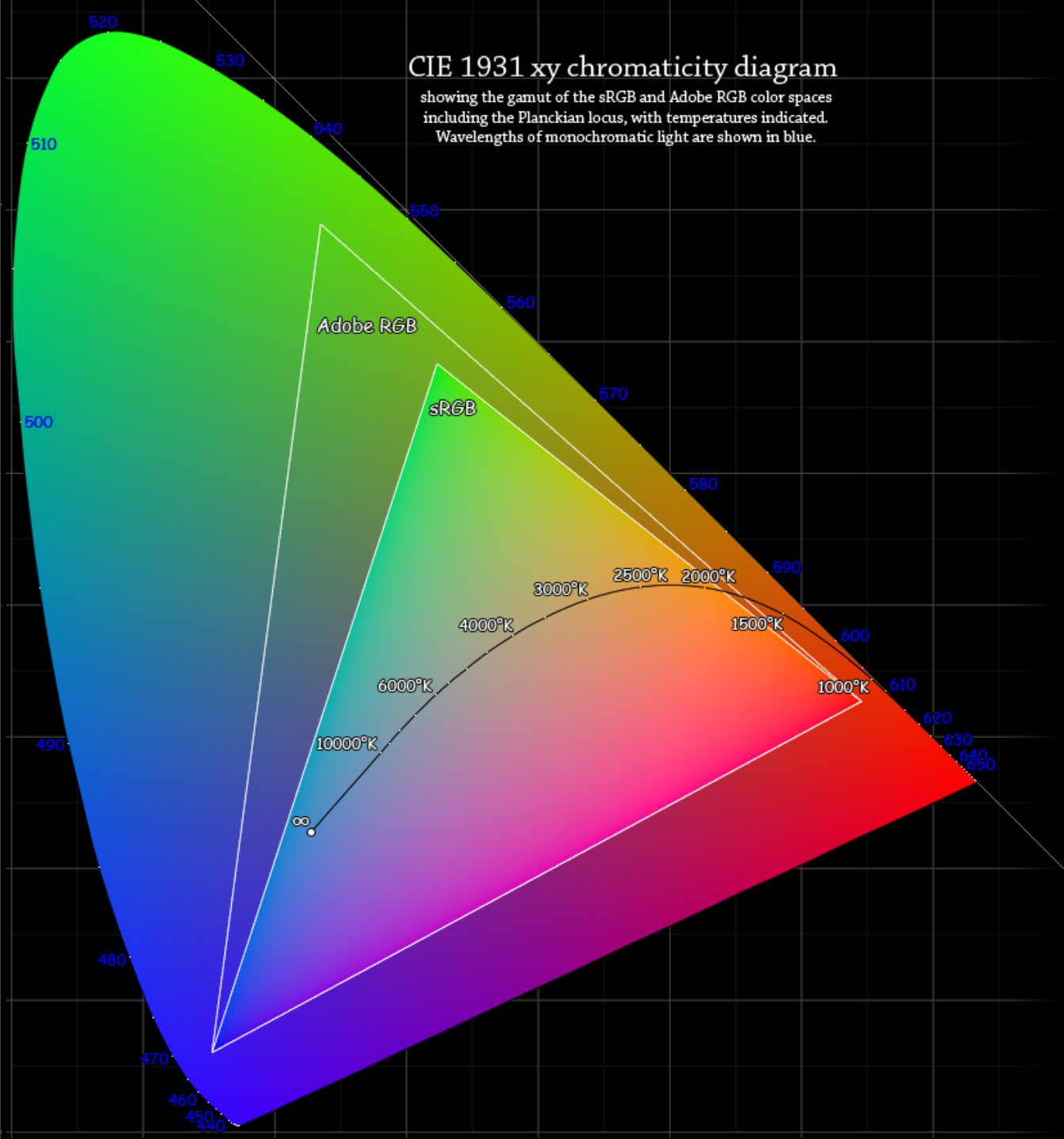


Animated transitions in statistical data graphics [Heer & Robertson 07]

Color

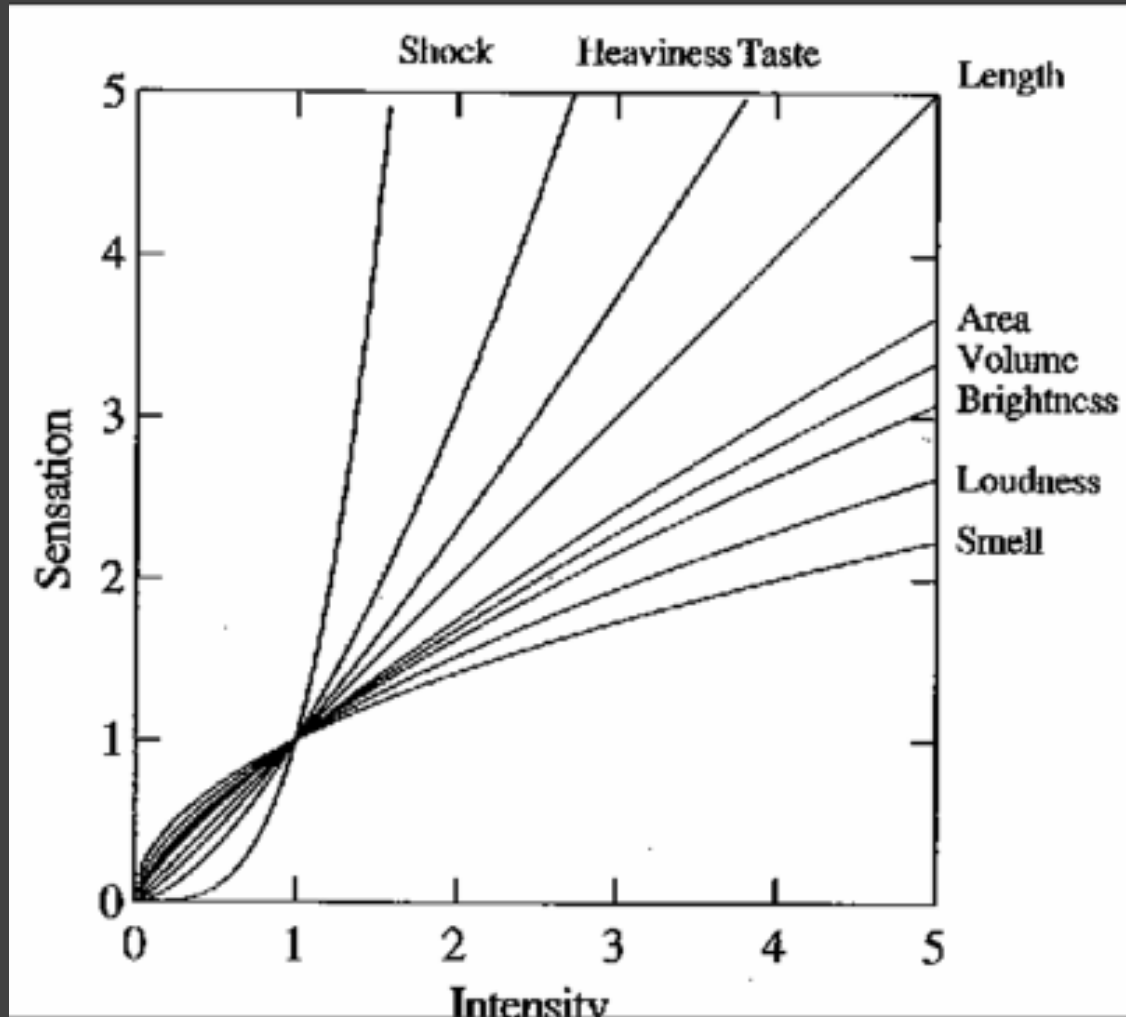
CIE 1931 xy chromaticity diagram

showing the gamut of the sRGB and Adobe RGB color spaces including the Planckian locus, with temperatures indicated. Wavelengths of monochromatic light are shown in blue.



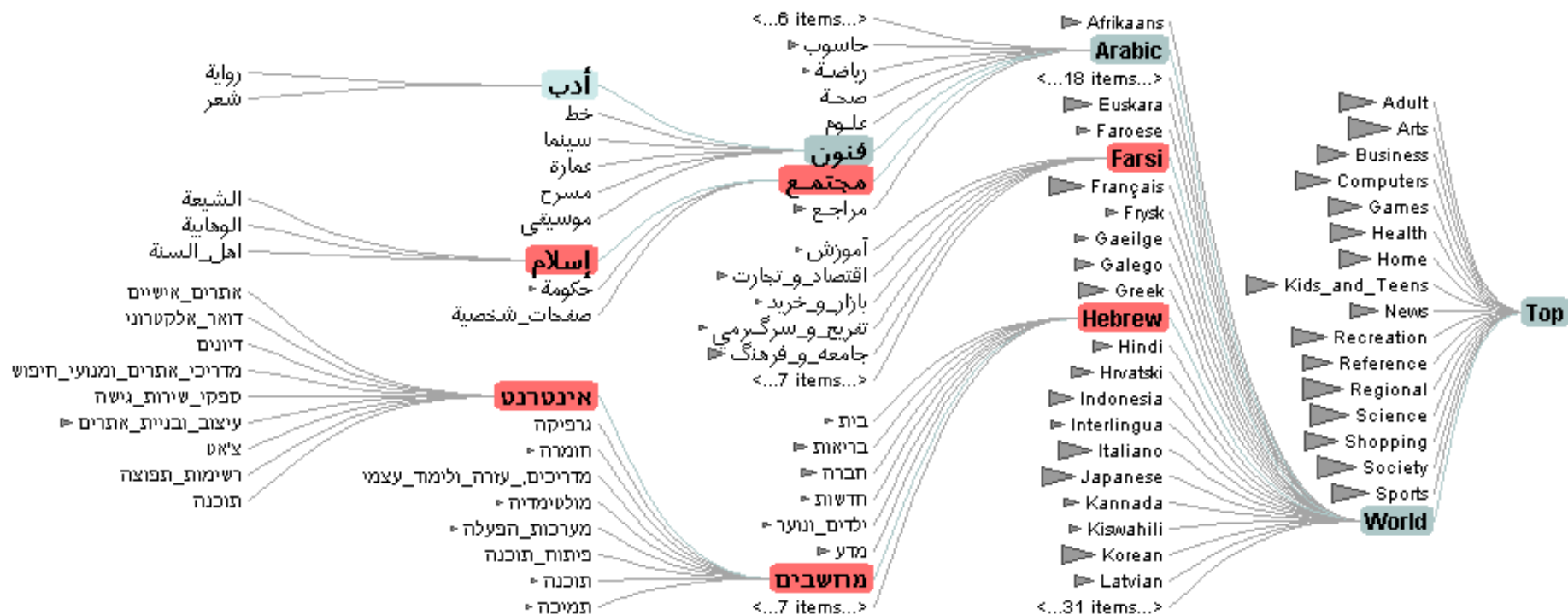
Color Brewer

Graphical Perception



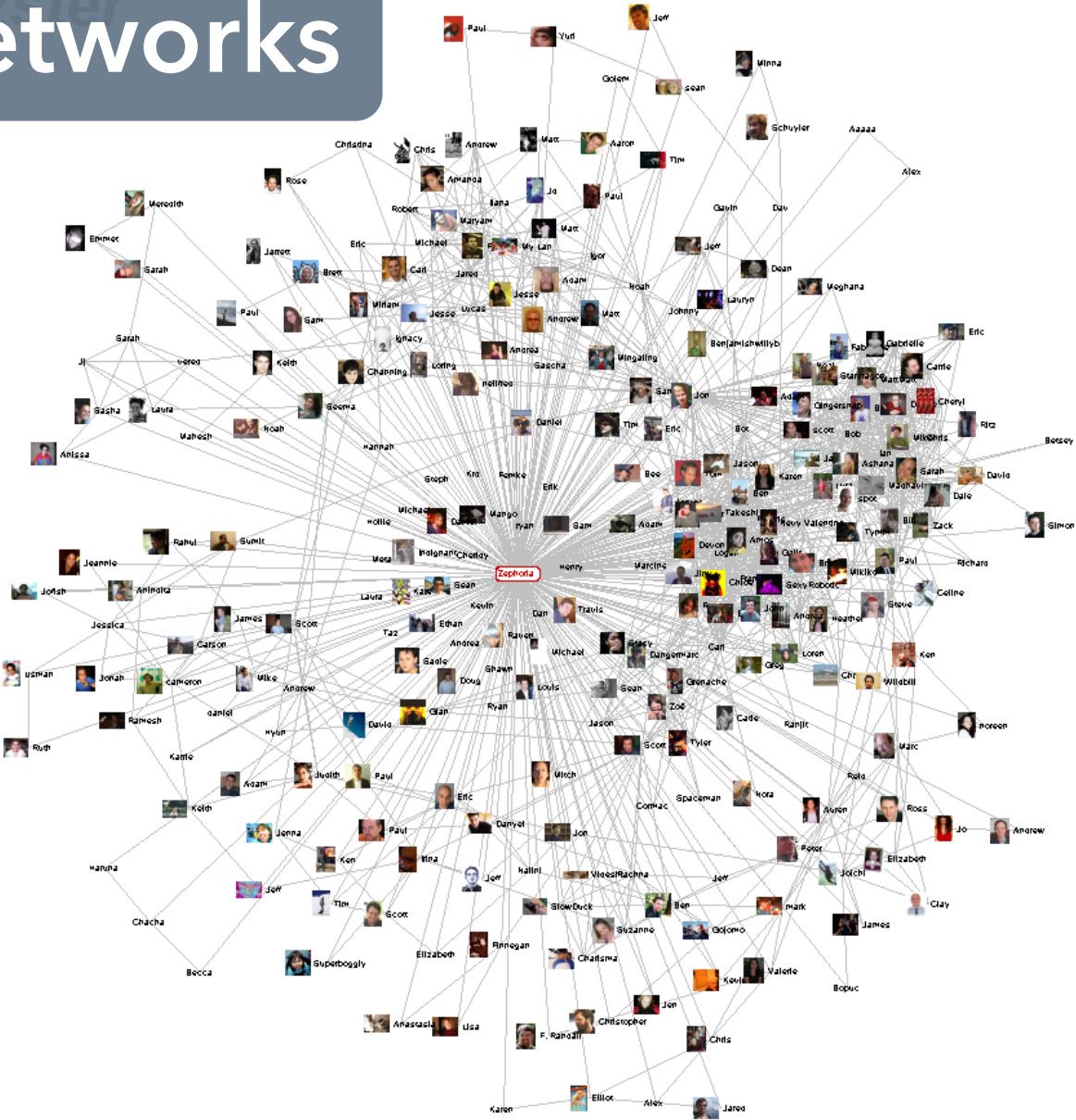
The psychophysics of sensory function [Stevens 61]

Hierarchies



Degree-Of-Interest Trees [Heer & Card 04]

Networks



community >>

Enable

search >>

Zephoria

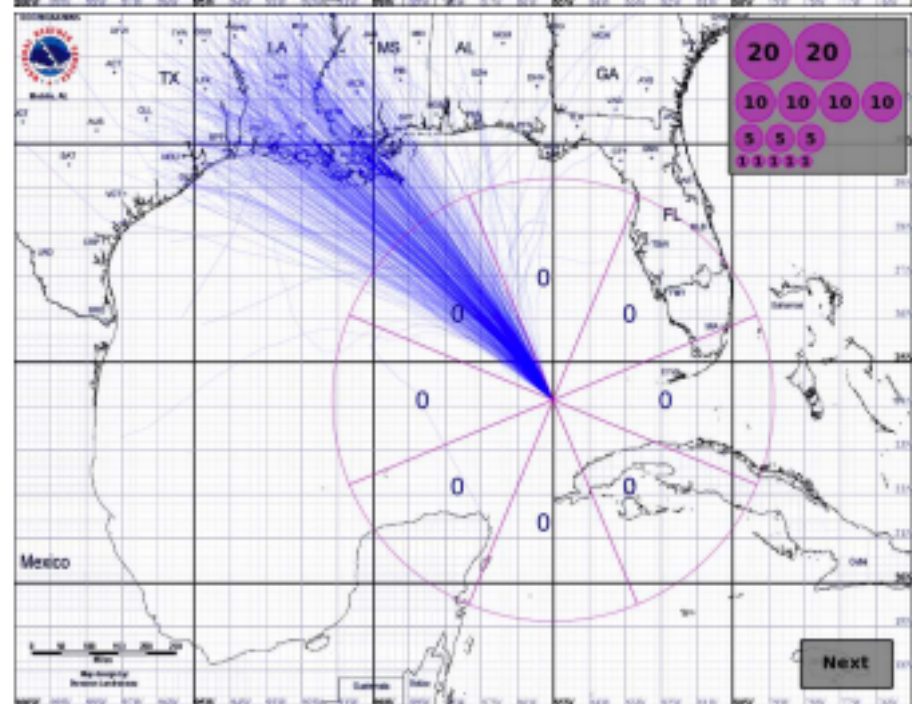
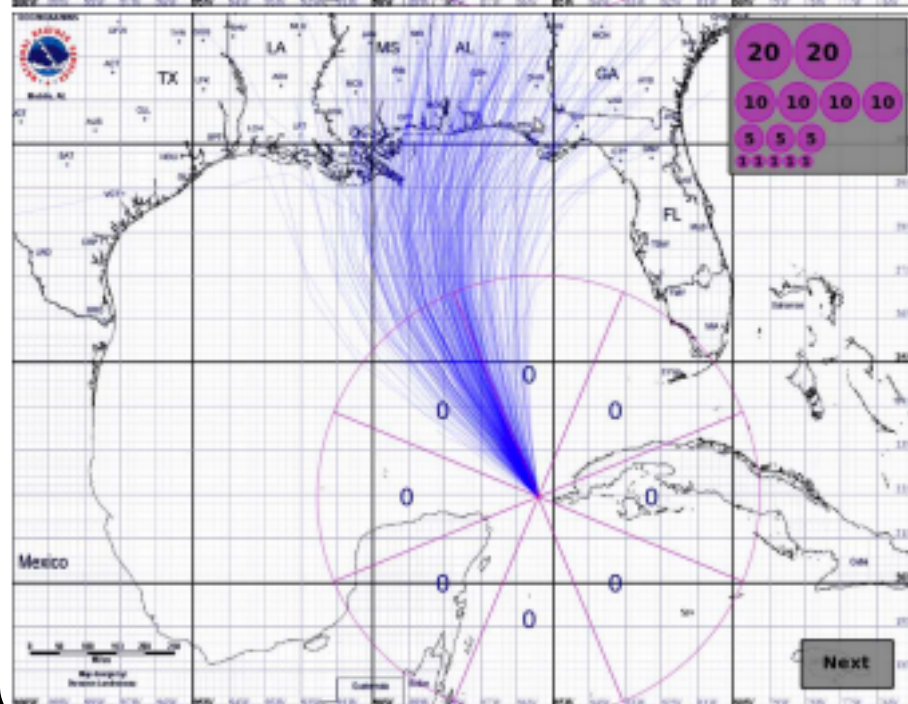
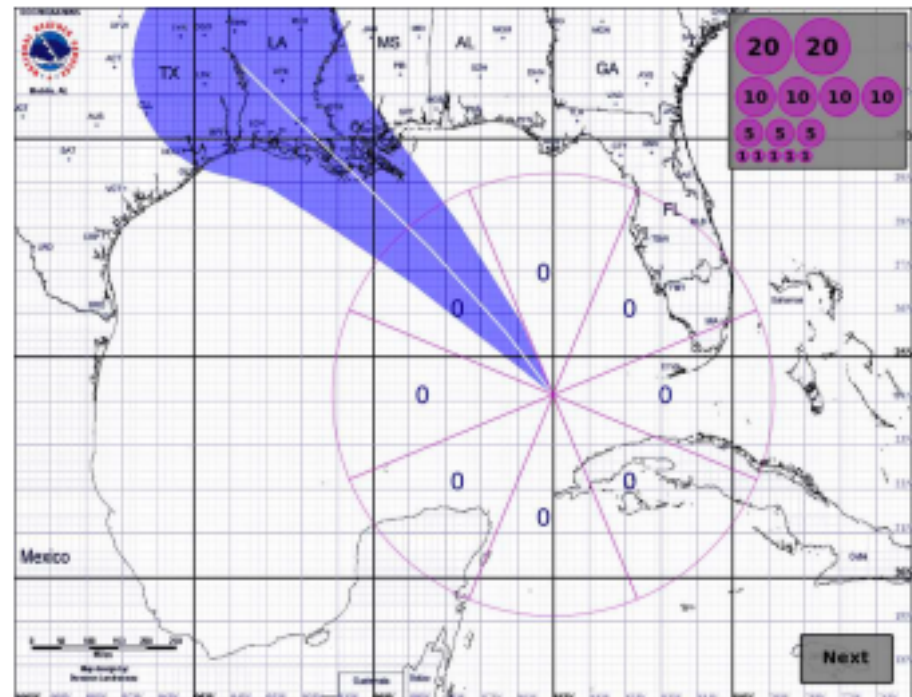
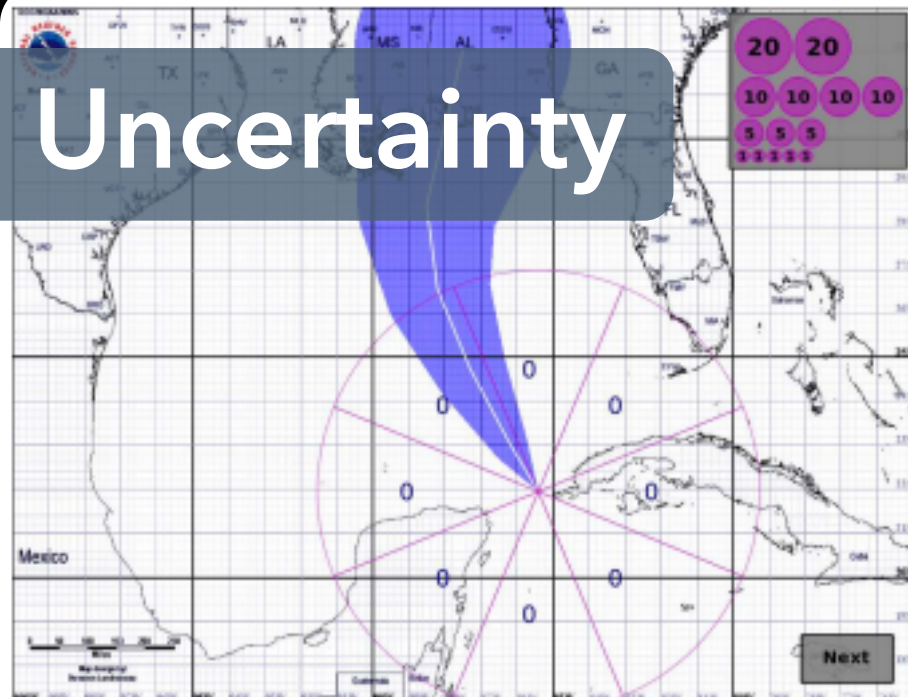
User ID	21721
Friends	<input type="checkbox"/> 266
Age	??
Gender	<input type="checkbox"/> Female
Status	<input type="checkbox"/> Single
Location	San Francisco, CA
Hometown	Lancaster, PA
Occupation	researcher: social networks, identity, context
Interests	apophenia, observing people, culture, questioning power, reading, buddhism, ipseity, computer-mediated communication, social networks, technology, anthropology, stumping
Music	psytrance/goa/trance [Infected Mushroom, Son Kite... Iboga/Digital Structures], Ani Difranco, downtempo, Thievery Corporation, Beth Orton, Morcheeba, Ween, White Stripes
Books	Authors: Erving Goffman, Stanley Milgram, Jeanette Winterson, Eric Schlosser, Leslie Feinberg, Dorothy Allison, Italo Calvino, Hermann Hesse
TV Shows	??
Movies	Koyaanisqatsi, Amelie, Waking Life, Tank Girl, The Matrix, Clockwork Orange, American Beauty, Fight Club, Boys Don't Cry
Member Since	??
Last Login	2003-10-21
Last Updated	2003-10-21
About	[Some know me as danah...]

I'm a geek, an activist and an academic, fascinated by people and society. I see life as a very large playground and enjoy exploring its intricacies. I revel in life's chaos, while simultaneously providing my own insane element.

My musings:
<http://www.zephoria.org/thoughts/>

Want to Meet Someone who makes life's complexities seem simply elegant.

Uncertainty

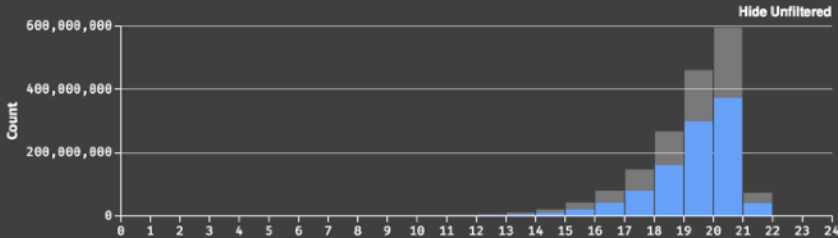


Scalability

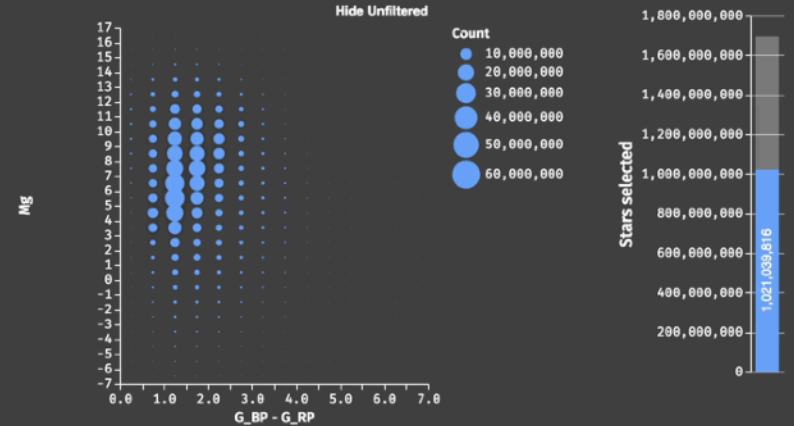
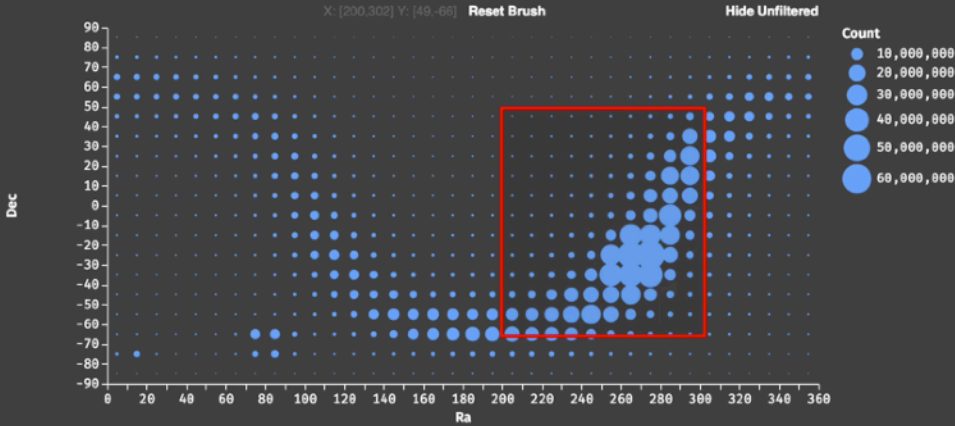
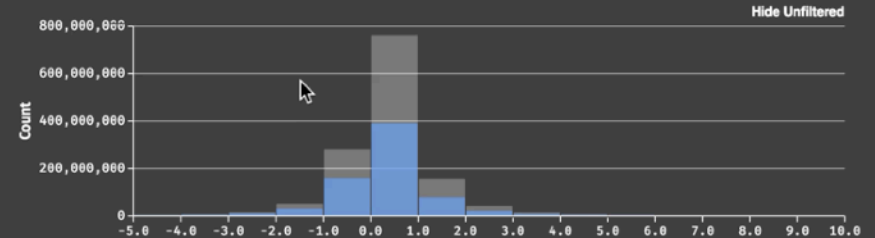
localhost:1234



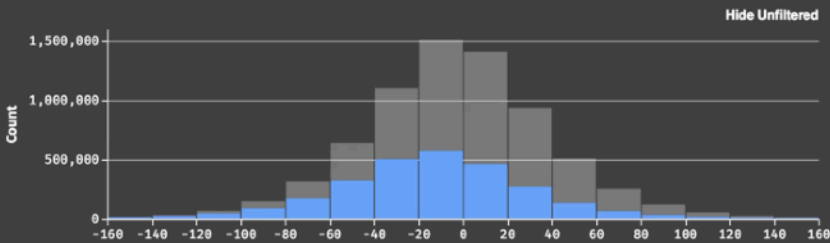
Magnitude



Parallax



Radial Velocity



Interactive querying of 1.7B stars
(1.2TB) in Falcon [Moritz et al. 2019]

Instructors

cse512@cs

Instructor

Jeffrey Heer

OH: Tue 10-11am

Teaching Assistants

Lisa Elkin

OH: Mon 2:30-3:30pm

Josh Horowitz

OH: Thu 1-2pm

Luke Snyder

OH: Online / By Appt.

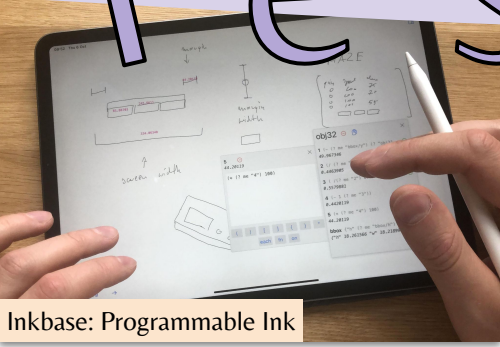
Madeleine

OH: Online / By Appt.

Grunde-McLaughlin

Josh Horowitz

research!



Inkbase: Programmable Ink

normalize

create a unit vector in the direction of v

$$\begin{matrix} x \\ y \end{matrix} \begin{matrix} 12 \\ 4 \end{matrix} \rightarrow \begin{matrix} x \\ y \end{matrix} \begin{matrix} 0.949 \\ 0.316 \end{matrix}$$

divide

length

12.649

bottom

Compute the length of a vector using the Pythagorean Theorem: $d = \sqrt{x^2 + y^2}$.

$$\begin{matrix} x \\ y \end{matrix} \begin{matrix} 12 \\ 4 \end{matrix} \rightarrow \text{Math.sqrt}(x ** 2 + y ** 2) \rightarrow 12.649$$

PANE: Programming with Visible Data



Dynamicland



notebook

input: func

output

value

output

$\text{onRight}(\text{a}), \text{onBottom}(\text{a})$

$G.\text{circle}().\text{fill}(\text{color})$

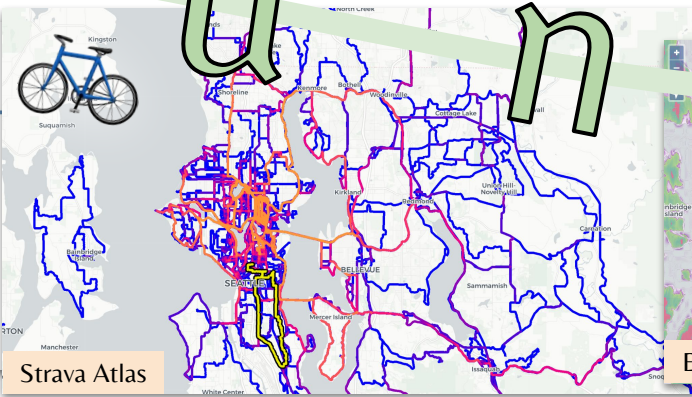
input: (@)

input: (1 C)

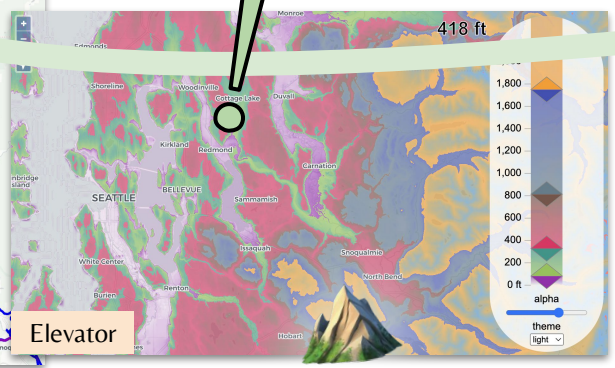
Engraft

fun!

Limits	2mi	4mi	8mi	16mi	(radius)	
1	1	1	1	1		New York
2	2	2	2	2		Los Angeles
13	3	4	12	12		San Francisco
22	4	5	5	11		Boston
5	5	6	4	4		Philadelphia
3	6	3	3	3		Chicago
Metropolous	5					Washington, DC



Strava Atlas



Elevator

Lisa Elkin (She/Her)



Academic Background

BMath, C&O and Pure Math, University of Waterloo, 2012

MET, Entertainment Technology, Carnegie Mellon, 2015

MMath, Computer Science, University of Waterloo, 2018

PhD, UW CSE, 2018 - ???

TA Experience

HCI, Data Viz, Linear Algebra, Calculus, Intro CS, CS for non-majors

Industry Internships

MSR 2018, Apple 2021, Meta 2022, Meta 2023

Winston Elkin

Academic Background

Doggy School Level 1*

PhD, UW CSE, 2019 - ???

Dissertation: Evaluating the Impact of Tree Species on a Dog's Desire to Pee on it: an Autoethnography

Industry Internships

Meta 2022, Meta 2023. Even has the badge to prove it.

* Indicates candidate did not complete all requirements but passed due to being very cute.



Luke Snyder

snyderl@cs.washington.edu

OH: Ed / By appointment



Research

- Visualization and HCI
- Dynamically Interactive Visualization (DIVI)
 - Automatically add interaction to static charts
 - uwdata.github.io/divi
- Chart augmentations to aid learning

Technical Experience

- JavaScript / web programming, D3, Vega-Lite

For Fun

- Music, running, new cultures (India, Australia)
- Progressive Jazz, Weather Report, Pat Metheny





Madeleine Grunde-McLaughlin

*3rd year PhD Student, UW CSE
mgrunde@cs.washington.edu
OH: Ed / By appointment*

Research background: Cognitive Science, uncertainty in Datavis, Computer Vision, Explainable AI

Current research: Decomposing tasks to help control LLMs

Hobbies: Cooking, crochet, gardening, music deep dives

Course Mechanics

You should expect to:

- 1 *Evaluate and critique* visualization designs
- 2 *Learn* visualization techniques & theory
- 3 *Implement* interactive data visualizations
- 4 *Develop* a substantial visualization project

Lectures, Activities & Office Hours

Course sessions will alternate among lecture and in-class activities. Thursdays will typically be activity days, but not always.

All lectures will be in-person and recorded.

Please attend in-person but **NOT** if you feel ill.

Office hours are a mix of in-person and Zoom.

Links for virtual office hours are on Canvas.

Use Ed to post questions and seek help!

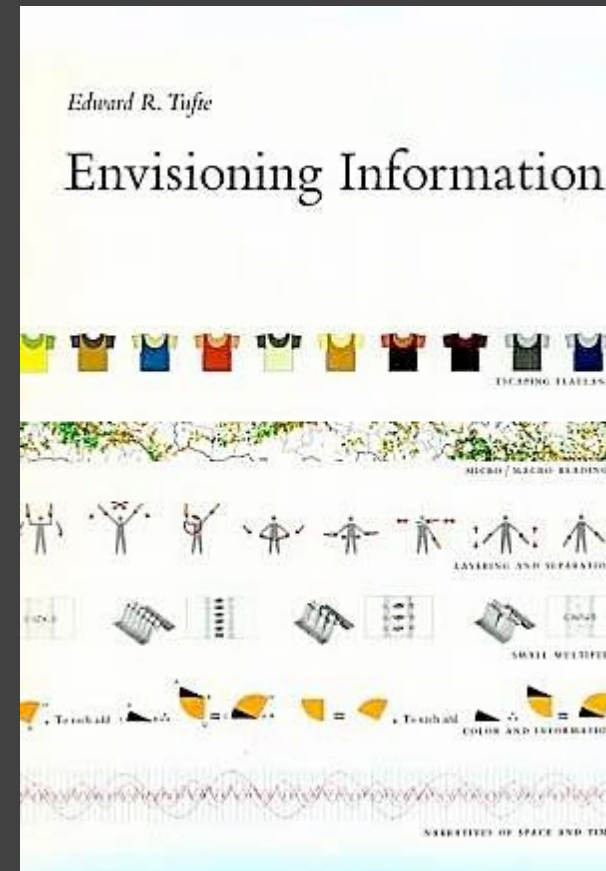
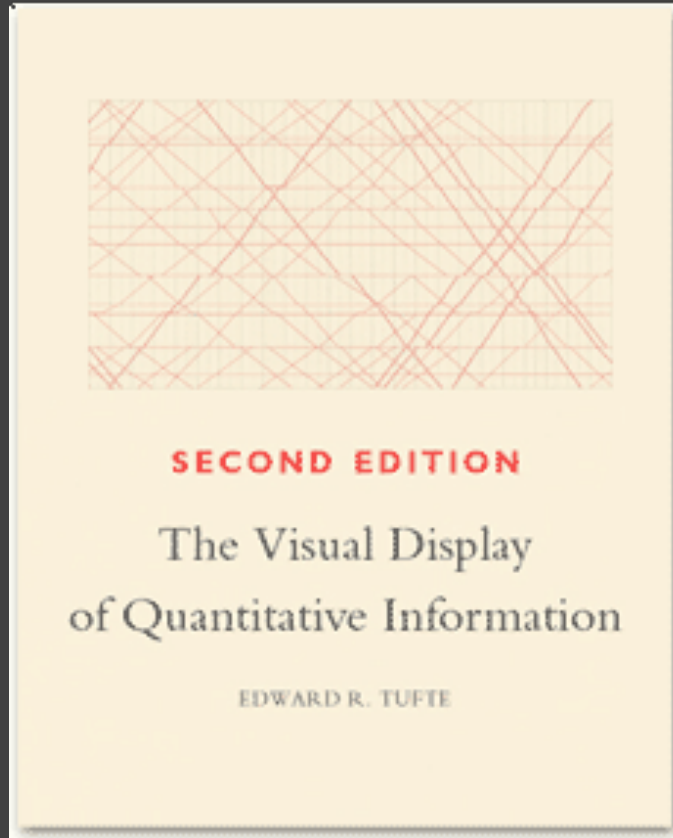
Readings

There is no one universal textbook on visualization!
So we will draw on books, notebooks, and linked articles...

Material in class will loosely follow readings.

Readings should be read by start of class.

"Textbooks"



See also: www.edwardtufte.com

Optional Book

An Introduction to Designing With D3



O'REILLY®

Scott Murray

Interactive Data Visualization for the Web, 2nd Edition

For learning D3!

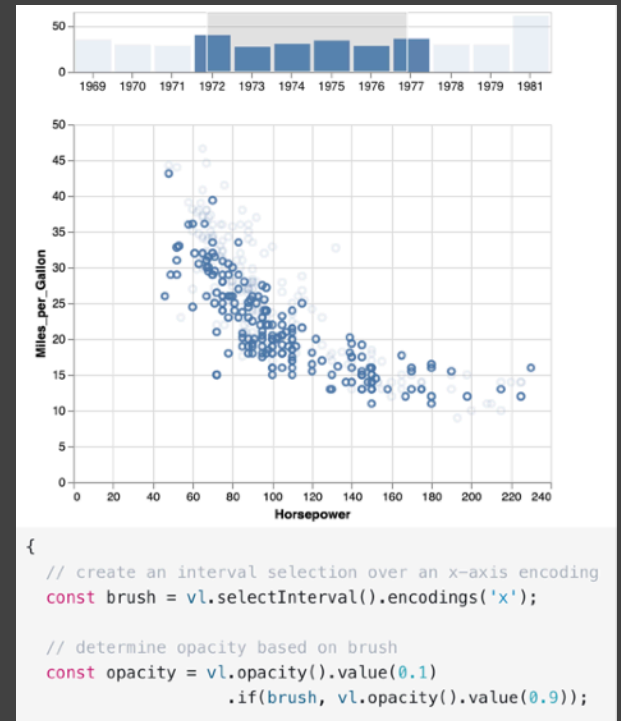
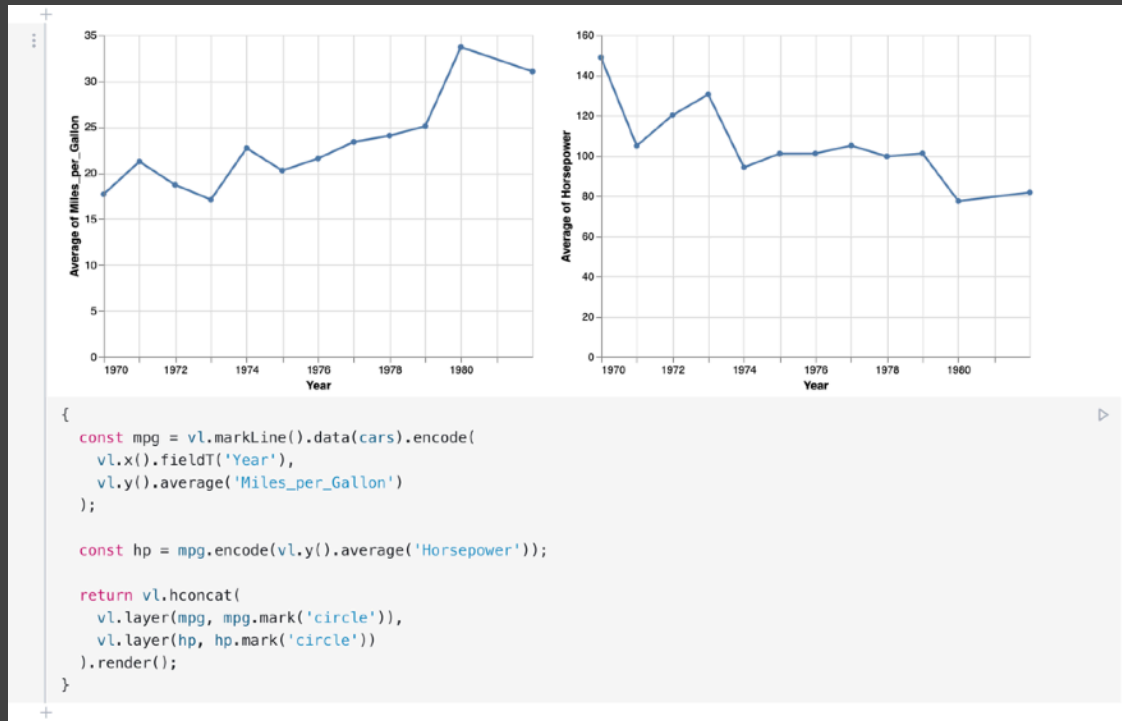
Book available online.

Code / examples on GitHub.

We will be using **D3 v7**.

<https://d3js.org>

Interactive Notebooks



Hands-on engagement with course concepts and visualization tools (Vega-Lite / Altair), in both JavaScript (Observable) *and* Python (Jupyter).

Assignments

CP Class Participation (10%)

A1 Expository Visualization (10%) - *Due 4/3*

A2 Deceptive Visualization (15%) - *Due 4/15*

Peer Review (5%) - *Due 4/23*

A3 Interactive Prototype (20%) - *Due 5/6*

Peer Review (5%) - *Due 5/11*

FP Final Project (35%)

Proposal - *Due 5/10*

Demonstration Video - *Due 5/29*

Final Prototype - *Due 6/3*

Grading Philosophy

A *great* submission gets a *great grade* (A- to A, 3.6 - 3.8), but an *exceptional* grade (A+, 3.9 - 4.0) requires *exceptional* effort.

Example: Typical A1 grades (out of 10 points).

Everyone starts with a high score (9/10).

We then *deduct* points for errors and also *add* points for going above and beyond the assignment requirements.

The median score for A1 is typically 8.5 out of 10, which maps to an A-.

Course Participation

Lecture attendance and engagement

In-class exercises: team submissions

Online quizzes, submitted on Canvas

Note: You may miss up to 2 lectures and up to 2 in-class exercise days without penalty.

Online Practice Quizzes

Weeks 1-8 have online quizzes to emphasize important concepts.

Quizzes are due Friday by 11:59pm. They can be retaken as many times as needed to get full points.

Quiz completion counts towards course participation. Quiz "points" will not be added directly to your course grade.

Final Project

Visualization research project on topic of choice

Initial **prototype** and **design reviews**

In-class demonstration **video** showcase

Submit and publish online (if feasible)

Projects from **previous classes** have been:

- Published as research papers
- Featured in the New York Times
- Released as successful open source projects

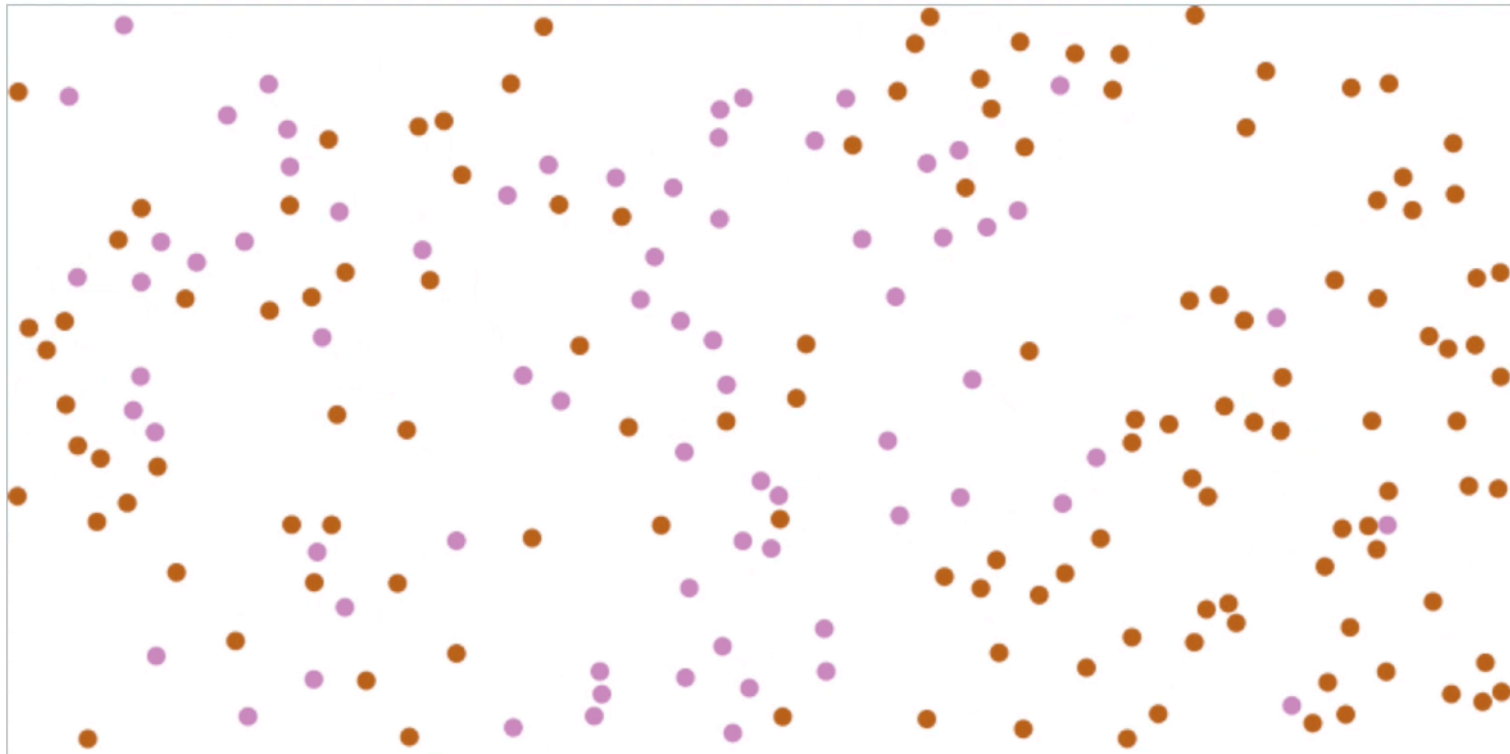
Why outbreaks like coronavirus spread exponentially, and how to “flatten the curve”

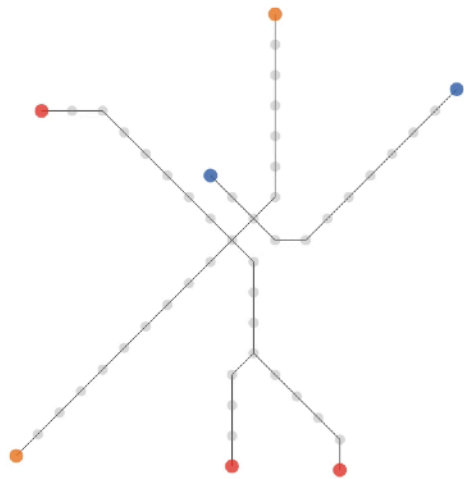
Harry Stevens, Washington Post 2020

Count

Recovered **73**
Healthy **0**
Sick **127**

Change over time

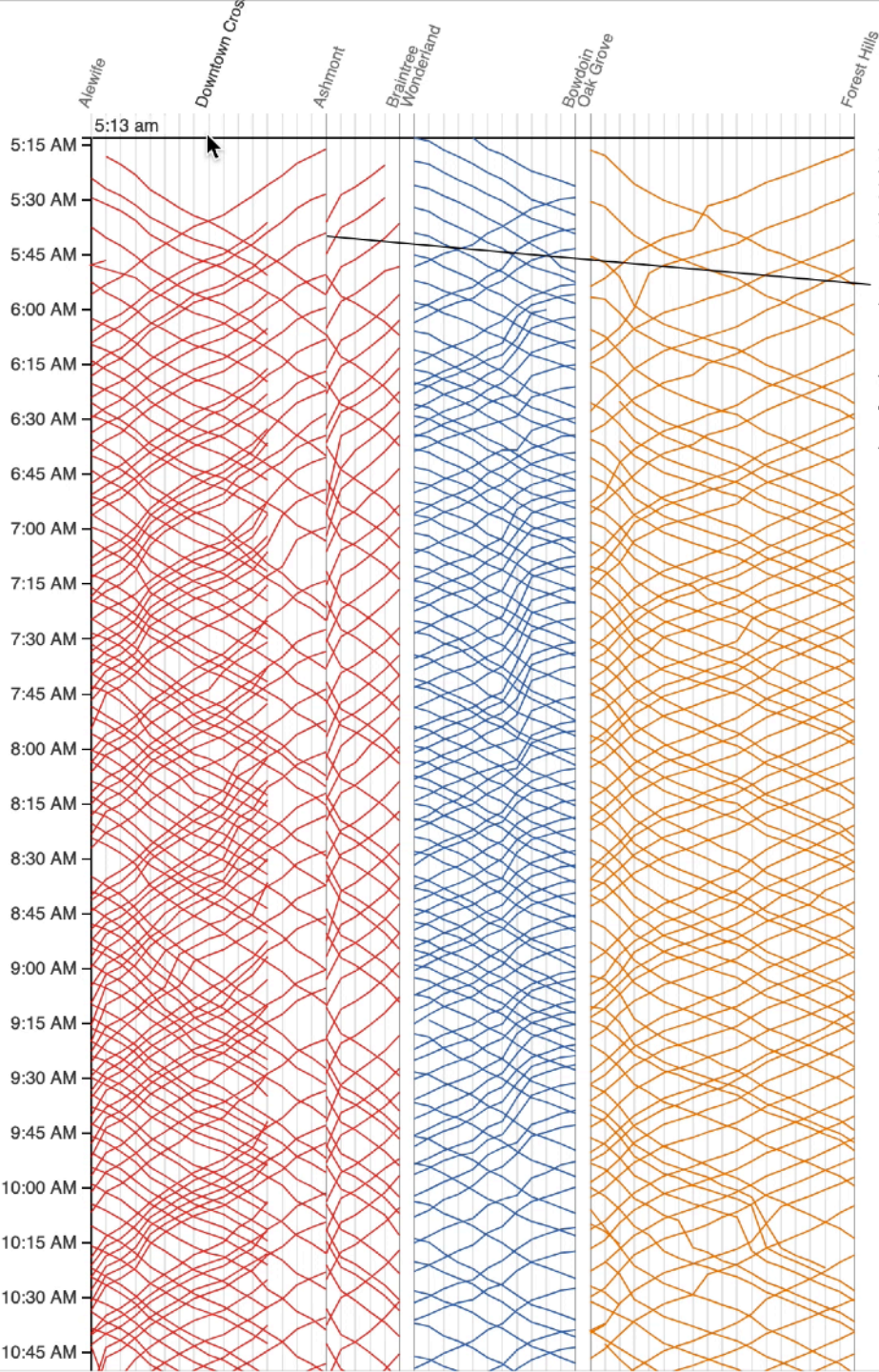




Locations of each train on the [red](#), [blue](#), and [orange](#) lines at 5:13 am. Hover over the diagram to the right to display trains at a different time.

Trains are on the right side of the track relative to the direction they are moving.

See the [morning rush-hour](#), [midday lull](#), [afternoon rush-hour](#), and the [evening lull](#).



Service starts at 5AM on Monday morning. Each line represents the path of one train. Time continues downward, so steeper lines indicate slower trains.

Since the red line splits, we show the Ashmont branch first then the Braintree branch. Trains on the Braintree branch "jump over" the Ashmont branch.

Train frequency increases around 6:30AM as morning rush hour begins.

MBTA Viz

Barry & Card

KEYBOARD WALKING

Passwords with a “keyboard walking” pattern start at an arbitrary key, then move in a direction (usually right or down) while continuing to hit keys. Sometimes this is combined with holding down the `SHIFT` key, so that some characters are uppercase or symbols to improve complexity.

While the generated password may seem to be random and unhackable, password crackers [check for these keyboard patterns](#) and guess them early on.

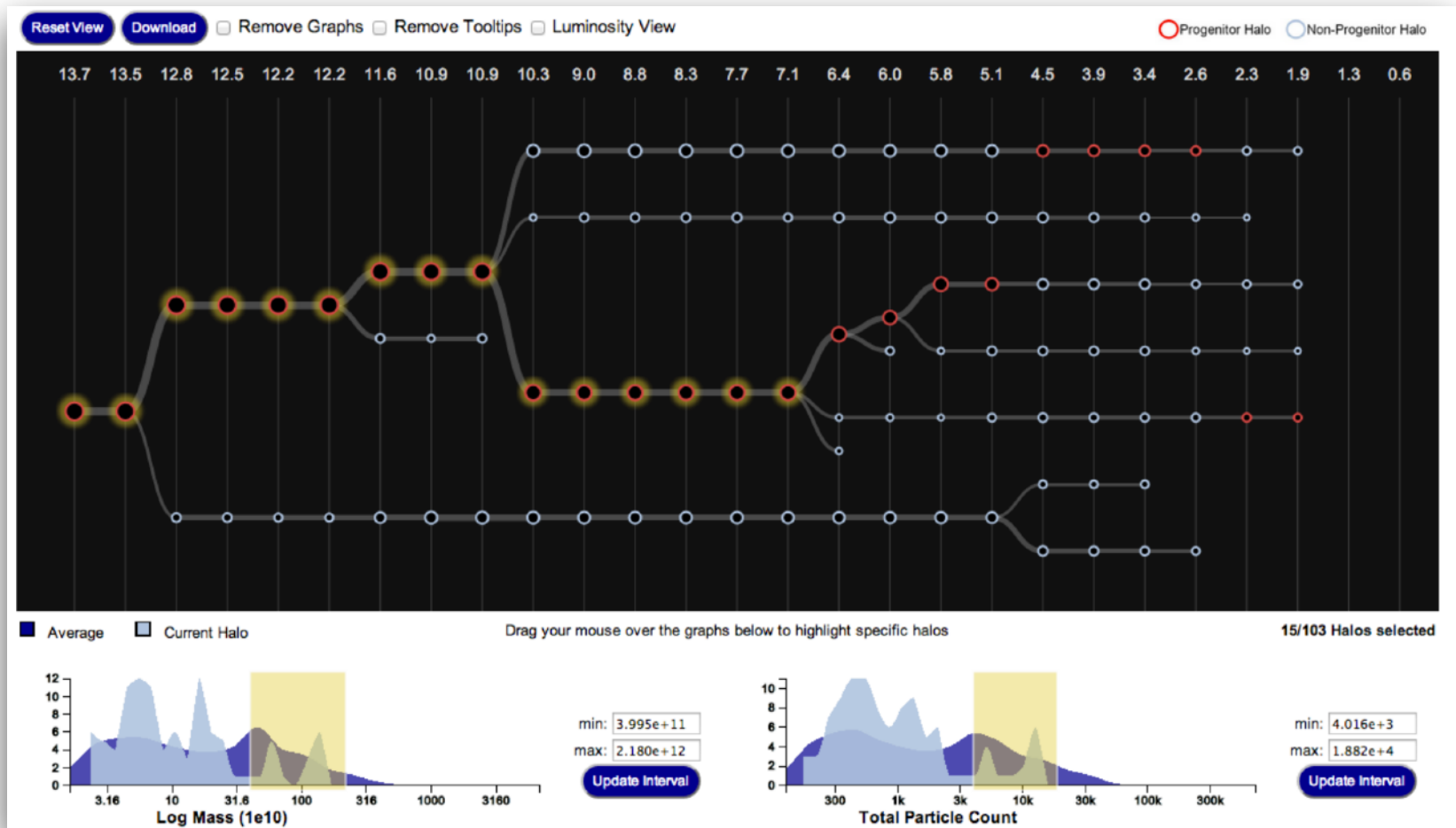
Many passwords in the leaked passwords dataset have a spatial pattern. Other than the numeric passwords like `123456`, common keyboard walking offenders include `qwerty` and `1qaz@wsx`.



Semantic Passwords

Vishal Devireddy (CSE 512, Spring '21)

Visualizing Galaxy Merger Trees

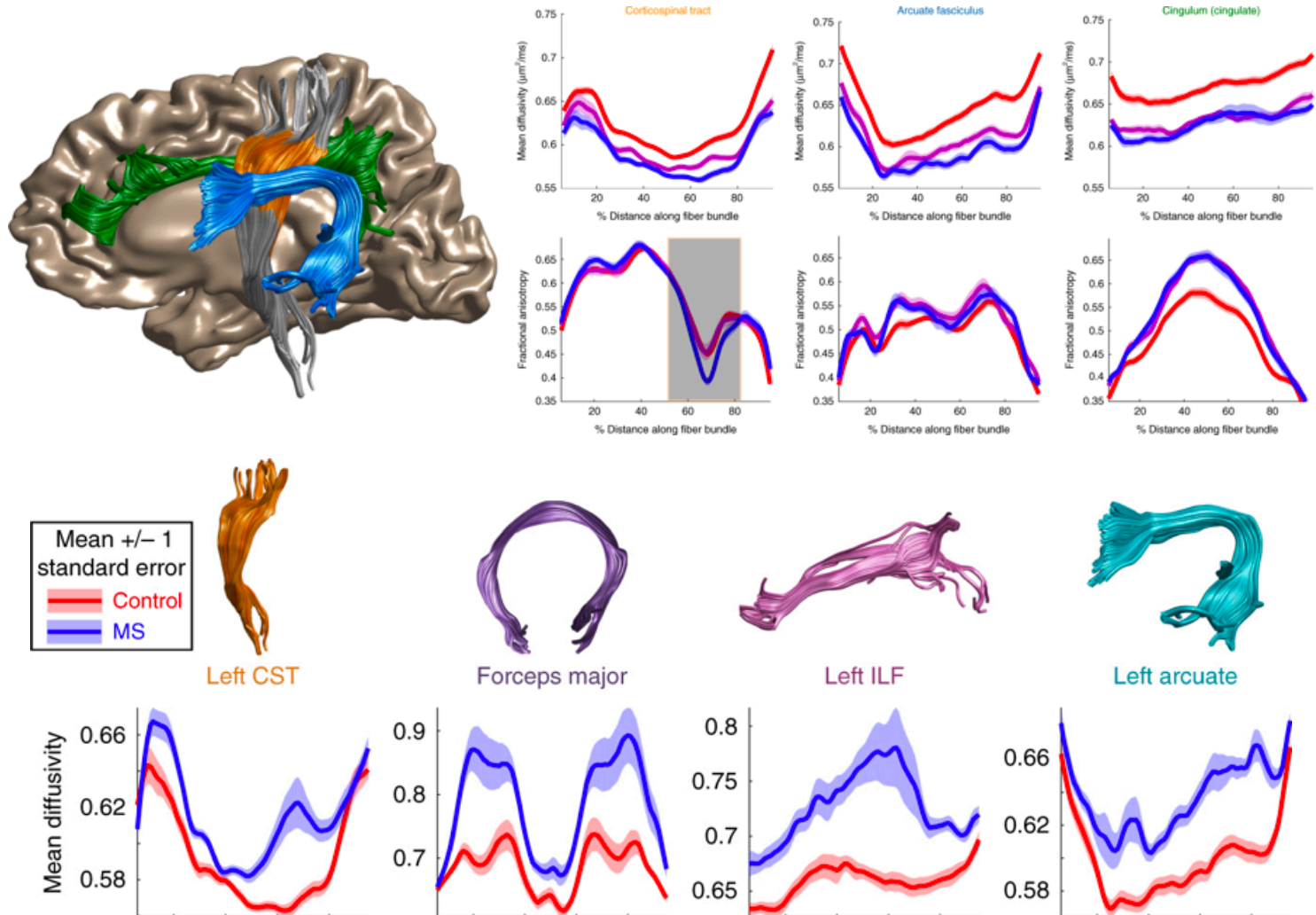


S. Loebman, J. Ortiz, L. Orr, M. Balazinska, T. Quinn et al. [SIGMOD '14]

A browser-based tool for visualization and analysis of diffusion MRI data

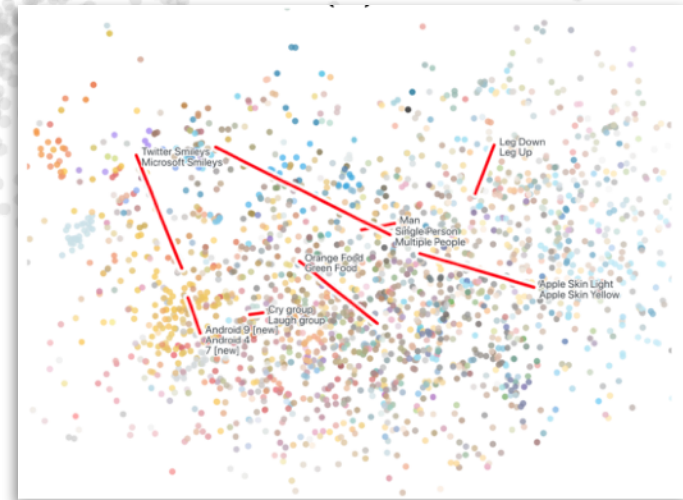
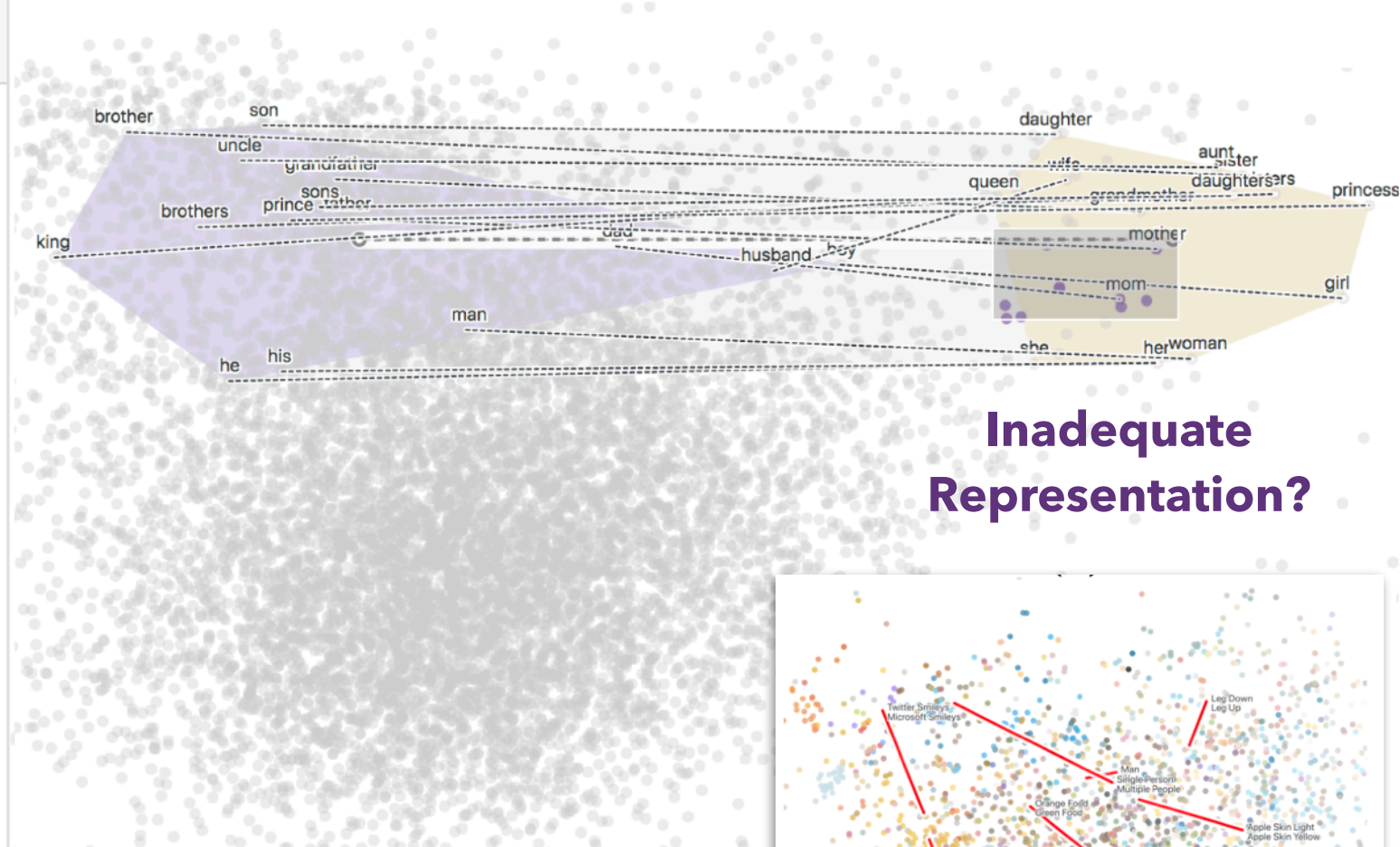
Article | OPEN | Published: 05 March 2018

Jason D. Yeatman , Adam Richie-Halford, Josh K. Smith, Anisha Keshavan & Ariel Rokem 



Brushed

- mother +
- ms. +
- wedding +
- pink **Bias?** +
- mom +
- nurse +
- bedroom +
- ladies +
- householder +
- butterfly +



Latent Space Cartography

Visual Analysis of Vector Space Embeddings

Yang Liu, Eunice Jun, Qisheng Li (CSE 512, Spring '18)

Visualizing the Republic of Letters

Daniel Chang, Yuankai Ge, Shiwei Song

Republic of Letters

1700



FILTER BY AUTHOR

Clear All

Damien Desormes
Daniel Cornabs
Daniel de Pury
Daniel Defoe
Daniel Malthus
Daniel Marc Antoine Chardon
Daniel Muller

TOP CITIES AND AUTHORS

Letters received Letters sent



A1: Expository Visualization

Design a static visualization for a data set.

The climate of a place can have a tremendous impact on people's lived experience. You will examine average monthly climate measurements for six major U.S. cities, roughly covering the edges of the continental United States.

You must choose the message you want to convey. What question(s) do you want to answer? What insight do you want to communicate?

A1: Expository Visualization

Pick a **guiding question**, use it to title your vis.

Design a **static visualization** for that question.

You are free to **use any tools** (inc. pen & paper).

Deliverables (via Gradescope; see A1 page)

Image of your visualization (PNG or JPG format)

Short description + design rationale (≤ 4 paragraphs)

Due by **11:59 pm, Wed Apr 3.**

Questions?