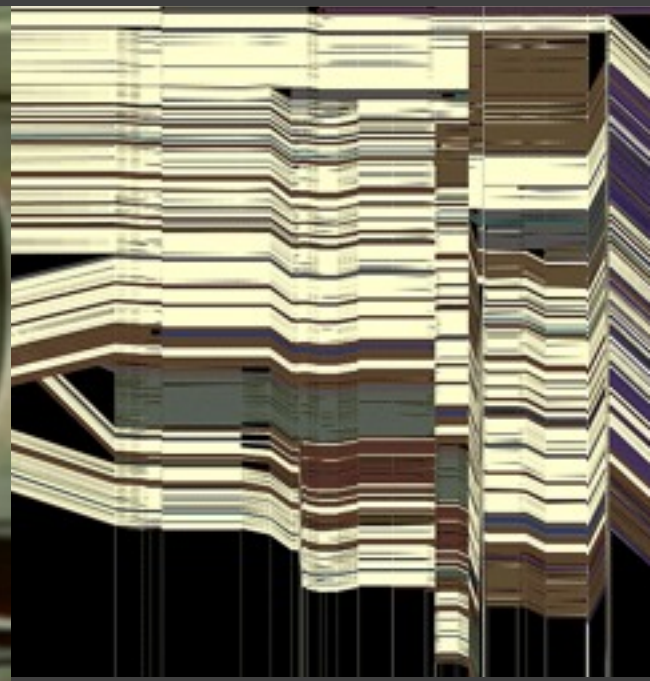
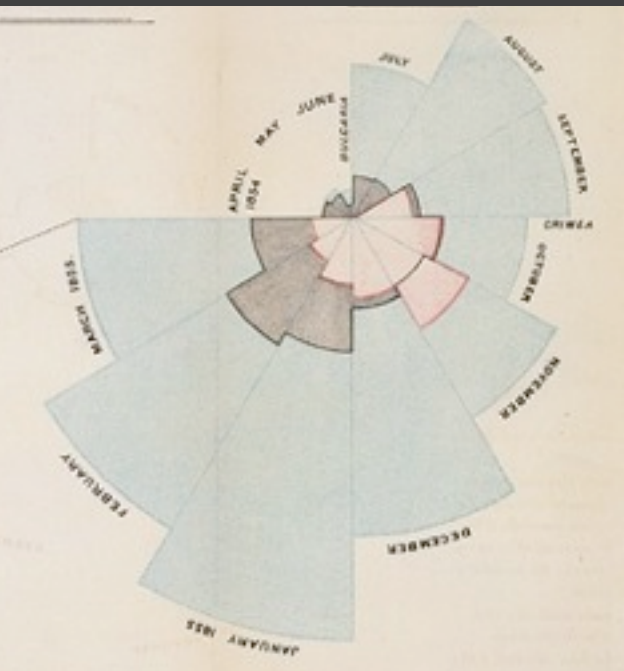


CSE512 :: 7 Jan 2014

The Value of Visualization



Jeffrey Heer University of Washington

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

2010: 1,200 exabytes
10x increase over 5 years

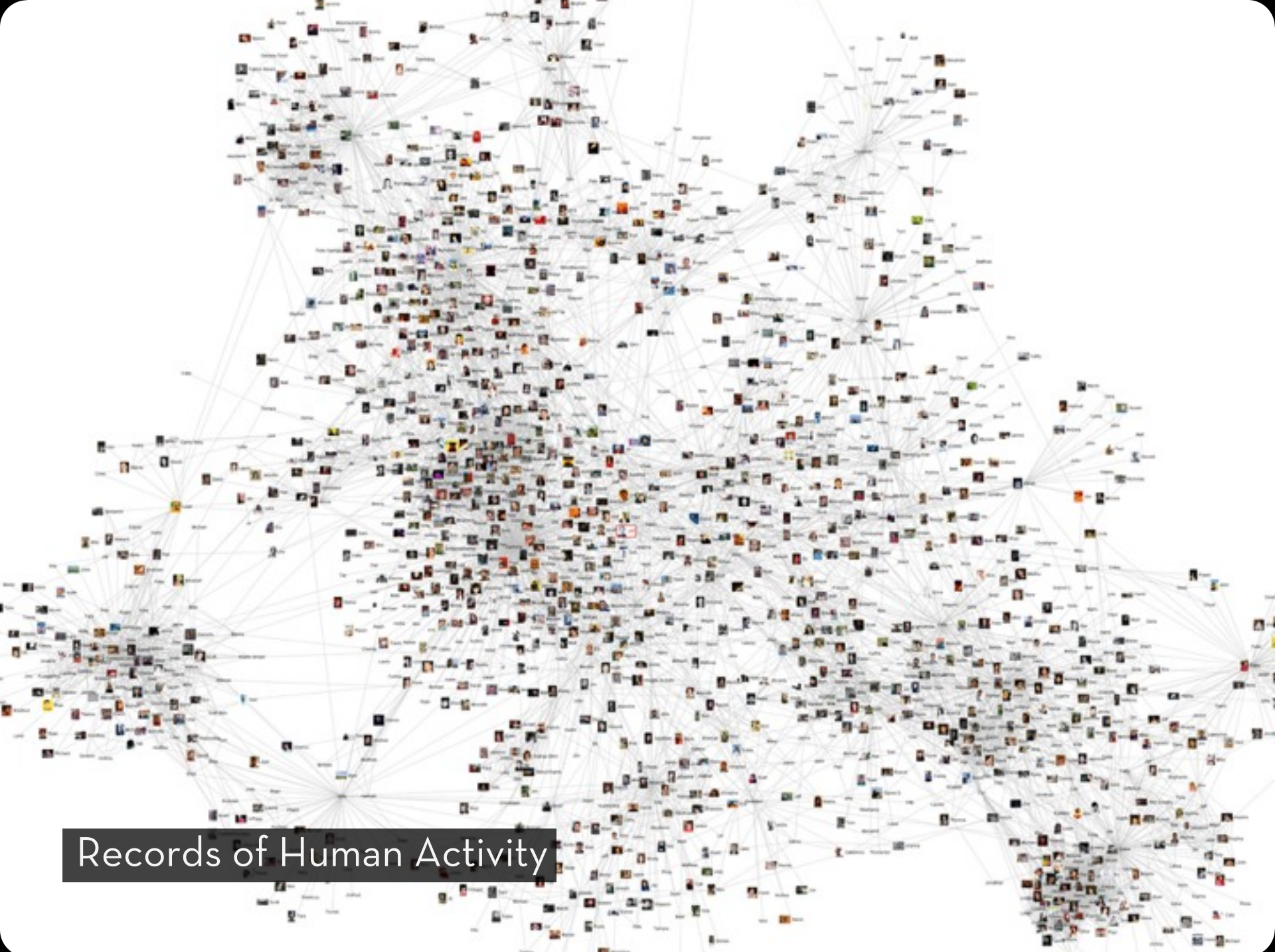
Gantz et al, 2008, 2010



Physical Sensors
Image courtesy cabspotting.org

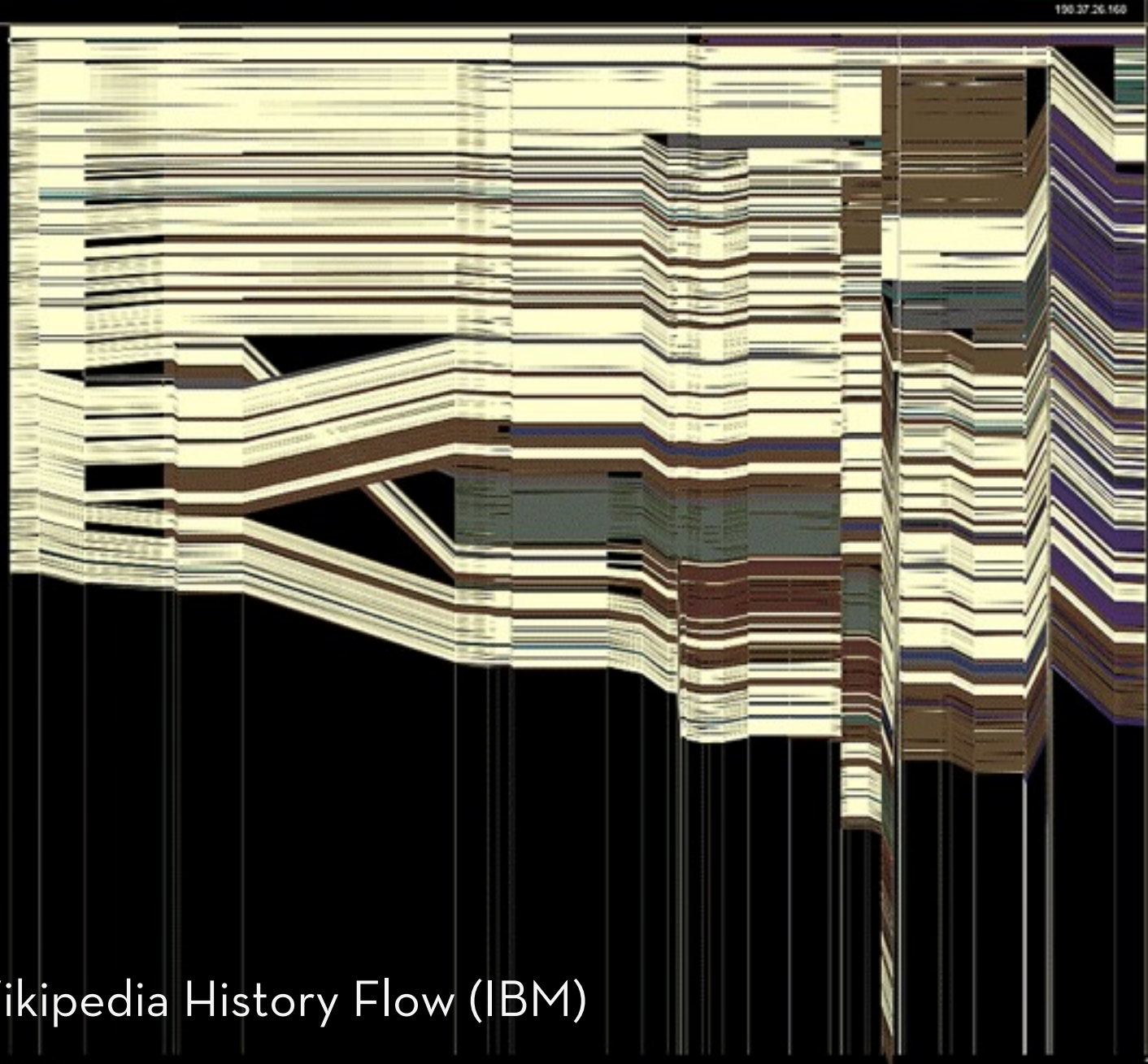


Health & Medicine



Records of Human Activity

- authors
- posts
- 1 Jurdak
- 1 The Cunctator
- 1 The Epopt
- 1 Conversion script
- 1 PK
- 1 Feeds
- 1 Ethand
- 1 Kagekaze/Arthon
- 1 Stephen Gilbert
- 1 Shuberstein
- 1 Monicorn
- 1 Joe
- 1 Derek Ross
- 1 Darbe Alghen
- 1 Mavenc149
- 1 Jzzbog
- 1 Jdel
- 1 Theartrope
- 1 Wesley
- 1 Deeneword
- 1 Steverigo
- 1 Camembert
- 1 Hephaestus
- 1 Zoo
- 1 MyRealDice
- 1 G-Man
- 1 Kingburke
- 1 Montprealis
- 1 H



Abortion
 (Revision as of 22:56:4 Jun 2003)

"Abortion," in its most commonly used sense, refers to the deliberate early termination of a pregnancy, resulting in the death of the embryo or fetus. [1] Medically, the term also refers to the early termination of a pregnancy by natural ("spontaneous abortion" or miscarriage, 1 in 5 of all pregnancies, usually within 12 weeks) or to the cessation of normal growth of a body part or organ. What follows is a discussion of the issues related to deliberate or "induced" abortion.

Methods
 Depending on the stage of pregnancy an abortion is performed by a number of different methods. The earliest terminations (before nine weeks) are a **chemical abortion** is the usual method, but **mifepristone** is usually the only legal method, although research has uncovered similar effects from **methotrexate** and **misoprostol**. Concurrent with chemical abortion and extending up to around the fifteenth week **suction-aspiration** vacuum abortion is the most common approach, replacing the more risky **dilation and curettage (D & C)**, from the fifteenth week up until around the eighteenth week a surgical **dilation and evacuation (D & E)** is used.

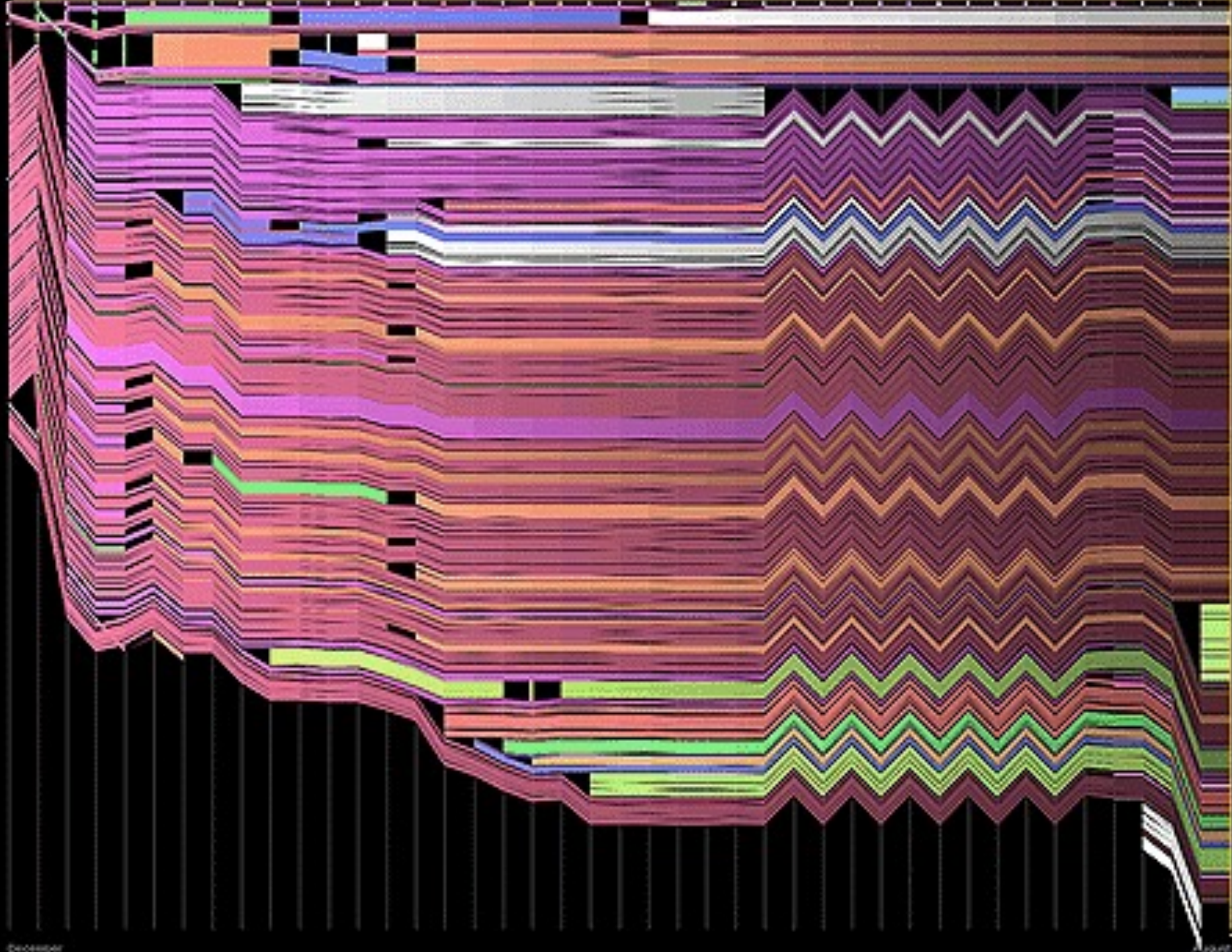
As the fetus size increases other techniques can be used to secure abortion in the third trimester. premature expulsion of the fetus can be tried with **prostaglandin**, this can be coupled with injecting the amniotic fluid with saline or urea solution. Very late abortions can be brought by the controversial **intrafetal potassium chloride (KCl)** or a **hysteroscopic abortion**, similar to **gynecoscopy**.

The controversy
 The morality and legality of abortion is a highly important topic in **applied ethics** and is also discussed by **legal scholars** and **religious philosophers**. Important facts about abortion are also reported by **sociologists** and **historians**.

Abortion has been common in most societies, although it has often been opposed by some institutionalized religions and governments. **century politics in the United States** and **European politics** became commonly accepted by the 20th century. Additionally, abortion is accepted in **China**, **India** and other populous countries. The **Catholic Church** remains opposed to the procedure, however, and in other countries notably the **United States** and the (predominantly Catholic) **Republic of Ireland**, the controversy is extremely active, to the extent that even the laws of the respective positions are subject to heated debate. While those on both sides of the debate are generally peaceful, if heated, in their defense of their positions, the debate is sometimes characterized by violence. Though true of both sides, this is more marked on the side of those opposed to abortion, because of what they see as the gravity and urgency of their views.

The central question
 The central question in the abortion debate is the clash of presumed or perceived rights. On the one hand, is a fetus (sometimes called the "unborn" or "pre-life"/"anti-abortion advocates") a human with a right to life, and if so, at what point in pregnancy does the fetus become human? On the other hand, is a fetus part of a woman's body?

Wikipedia History Flow (IBM)



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

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

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

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

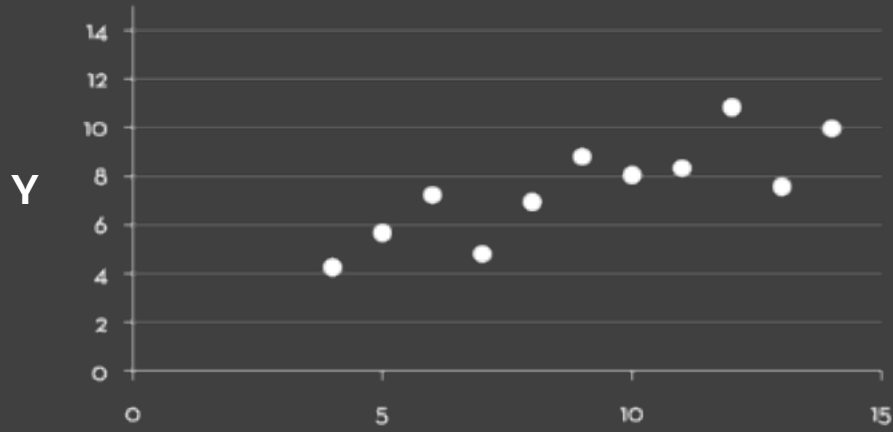
Linear Regression

$$Y = 3 + 0.5 X$$

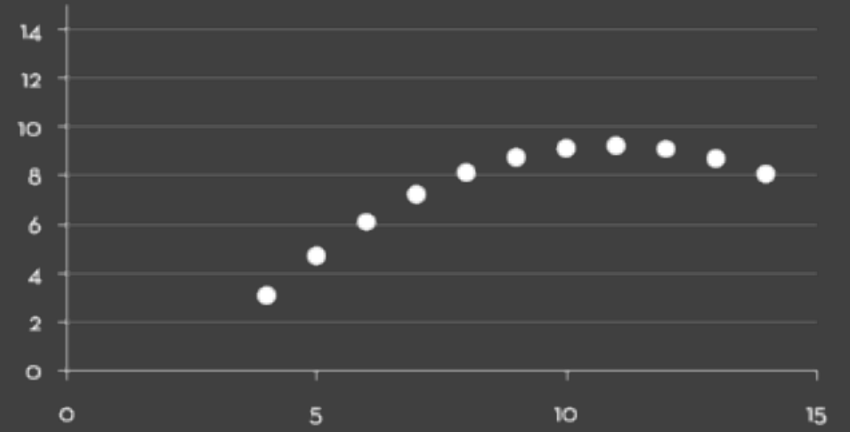
$$R^2 = 0.67$$

[Anscombe 73]

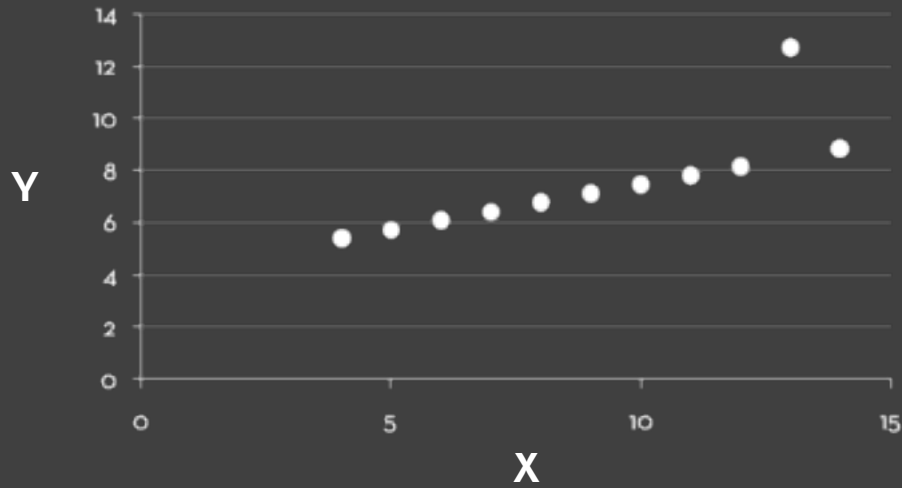
Set A



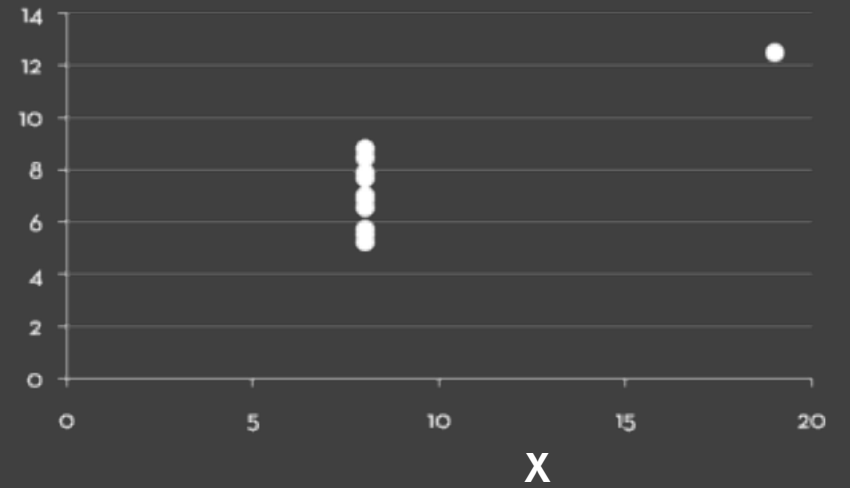
Set B



Set C



Set D



Why create visualizations?

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

The Value of Visualization

Record information

Blueprints, photographs, seismographs, ...

Analyze data to support reasoning

Develop and assess hypotheses

Discover errors in data

Expand memory

Find patterns

Communicate information to others

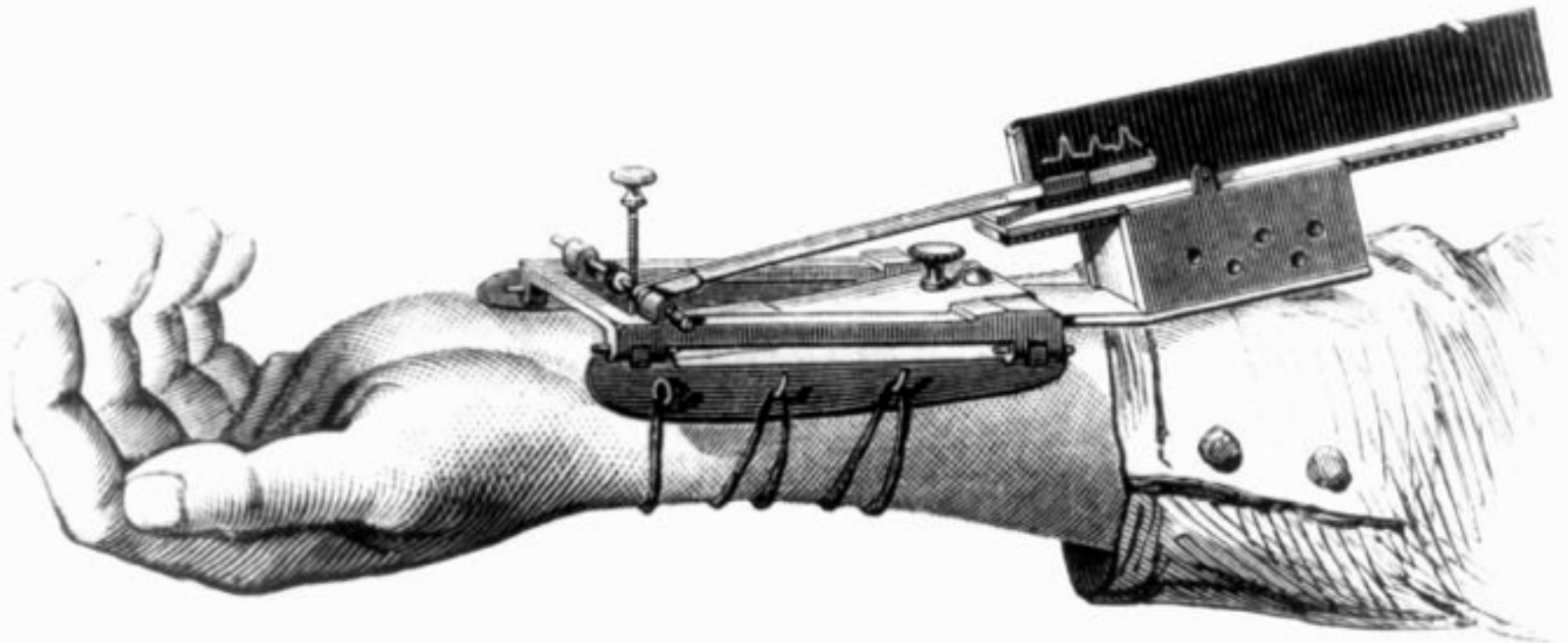
Share and persuade

Collaborate and revise

Record Information

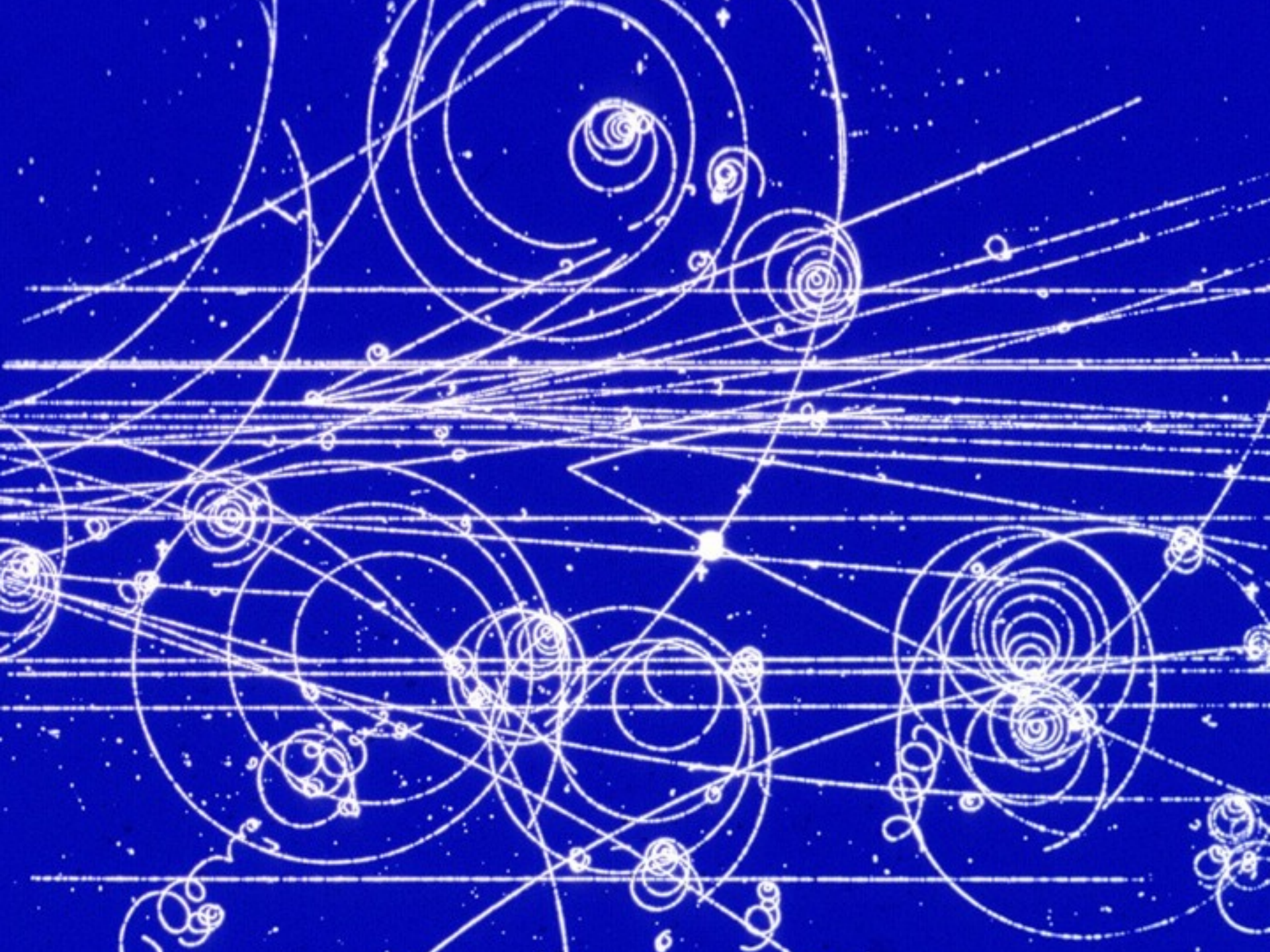


Gallop, Bay Horse "Daisy" [Muybridge 1884-86]



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

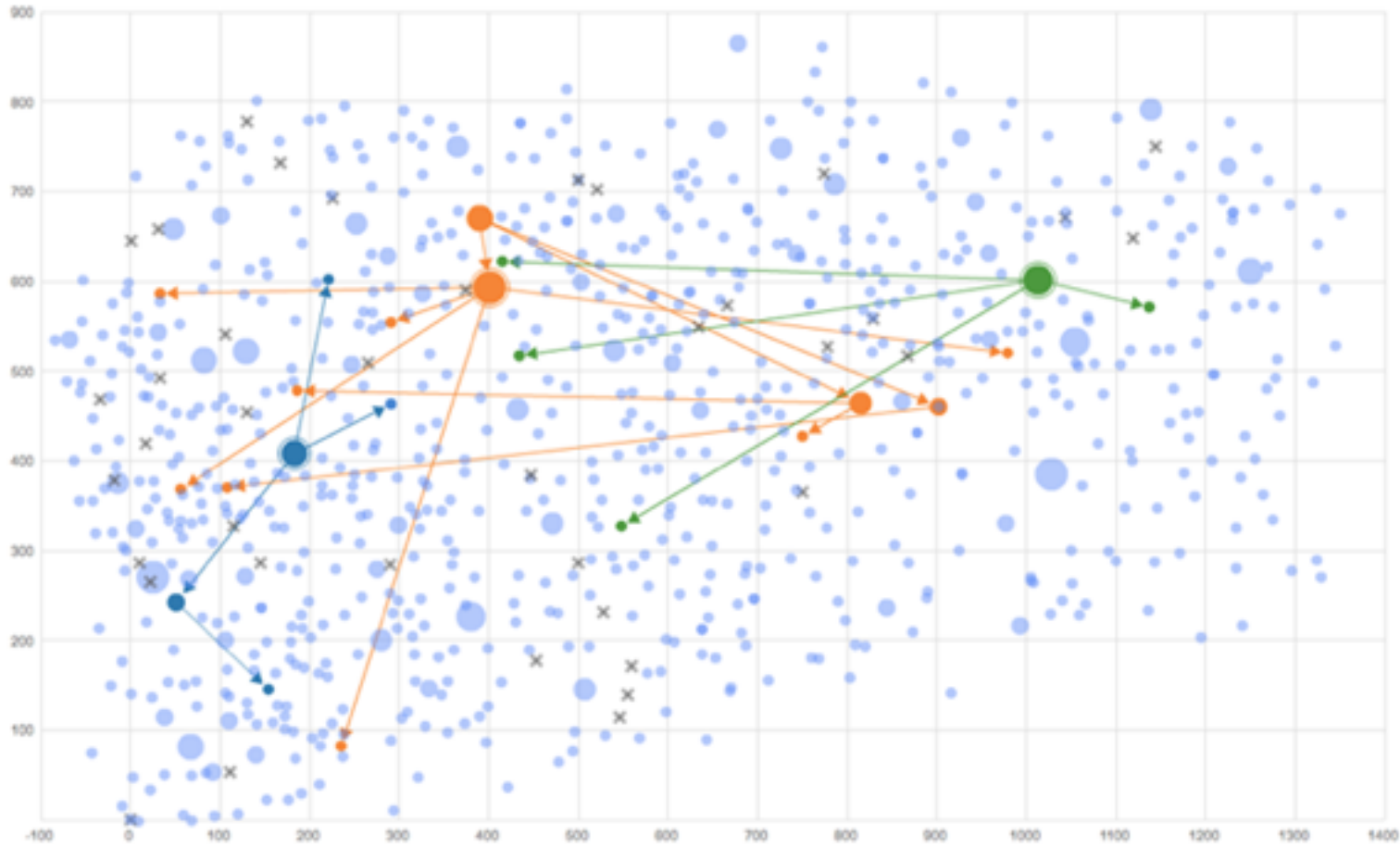
E.J. Marey's sphygmograph [from Braun 83]





Expected live in 06





id	E	N	first	last
1	838	413	2002	2004
2	399	126	2002	2003
3	333	146	2002	2008
4	56	333	2002	2003
5	9	543	2002	2008
6	141	451	2002	2008
7	434	517	2003	2008
8	1253	575	2003	2008
9	1160	442	2003	2004
10	758	575	2003	2008
11	435	776	2003	2008
12	-54	486	2003	2008
13	799	546	2003	2008
14	415	622	2003	2008
15	583	428	2003	2008
16	989	682	2003	2008
17	613	703	2003	2008
18	290	252	2003	2008
20	360	771	2004	2008
21	623	694	2004	2005
22	879	520	2004	2008
23	1144	523	2004	2008
24	594	312	2004	2008
25	463	264	2004	2008
26	597	673	2004	2008
27	425	738	2004	2008
28	431	661	2004	2008
29	853	306	2004	2008
30	130	130	1988	2008
31	270	565	1988	2008
32	326	483	2004	2008
33	255	552	1988	2008
34	260	566	2004	2008

Colony Viewer

Years 1995 - 2009

2 Years Gone First Seen Only

Support Reasoning

HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

	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.)	
1161 Oct 30, 1985 61A LH Center Field**	22A	None	None	0.280	None	None	36° -- 66°
61A LH CENTER FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338° -- 18°
51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	5.25	163
51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	58.75	354
51C RH Center Field (sec)***	15B	None	45.0	0.280	None	29.50	354
41D RH Forward Field	13B	0.028	110.0	0.280	3.00	None	275
41C LH Aft Field*	11A	None	None	0.280	None	None	--
41B LH Forward Field	10A	0.040	217.0	0.280	3.00	14.50	351
July 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 (90°), (110°) ARE
 o MUCH WORSE VISUALLY THAN SRM-22

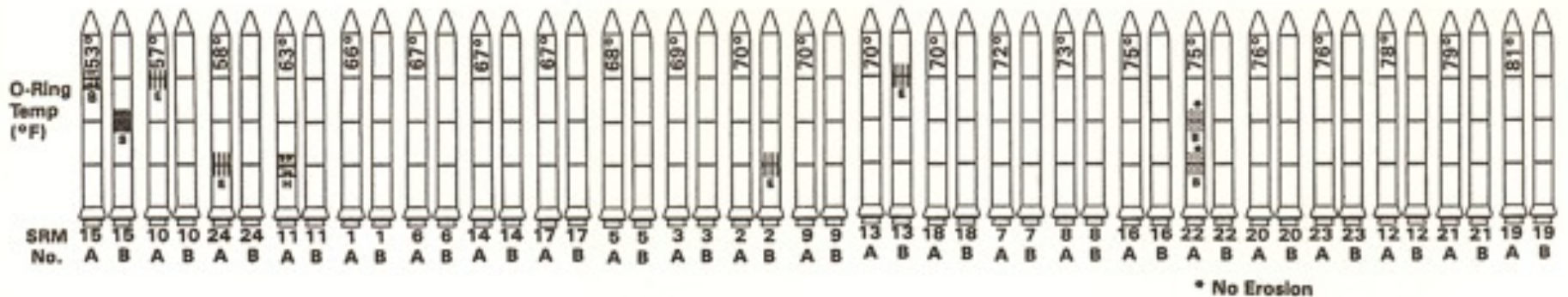
SRM 22 BLOW-BY
 o 2 CASE JOINTS (30-40°)

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

HISTORY OF O-RING TEMPERATURES (DEGREES - F)

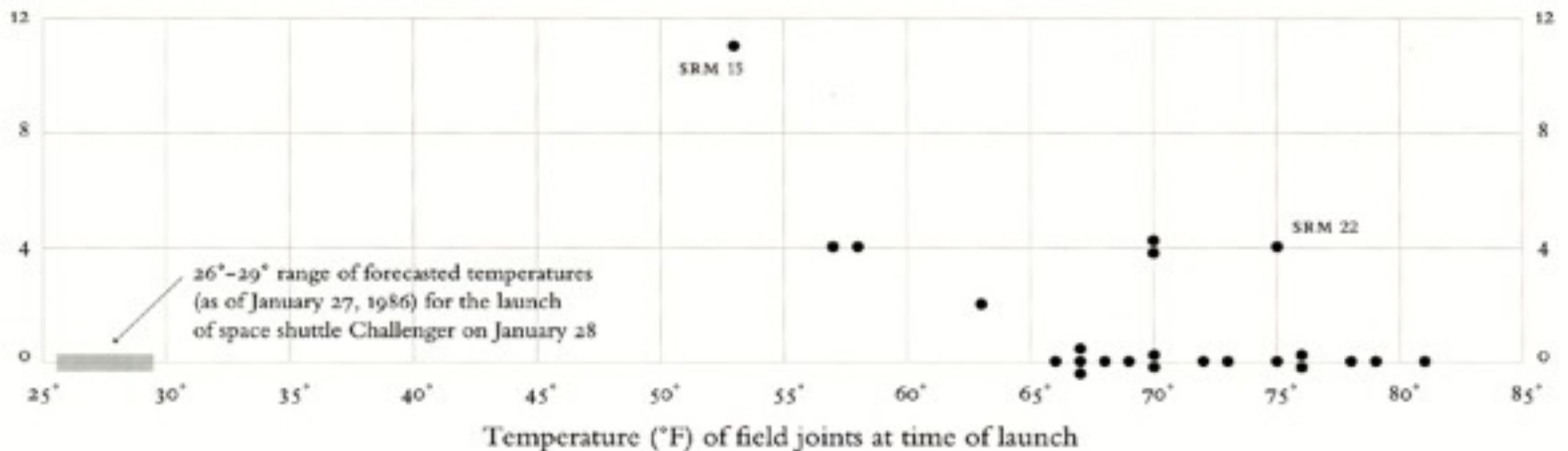
MOTOR	MBT	AMB	O-RING	WIND
DM-1	68	36	47	10 MPH
DM-2	76	45	52	10 MPH
QM-3	72.5	40	48	10 MPH
QM-4	76	48	51	10 MPH
SRM-15	52	64	53	10 MPH
SRM-22	77	78	75	10 MPH
SRM-25	55	26	29	10 MPH
			27	25 MPH

Make a decision: Challenger



Make a decision: Challenger

O-ring damage index, each launch



Visualizations drawn by Tufte show how low temperatures damage O-rings [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]

Expand memory: Multiplication

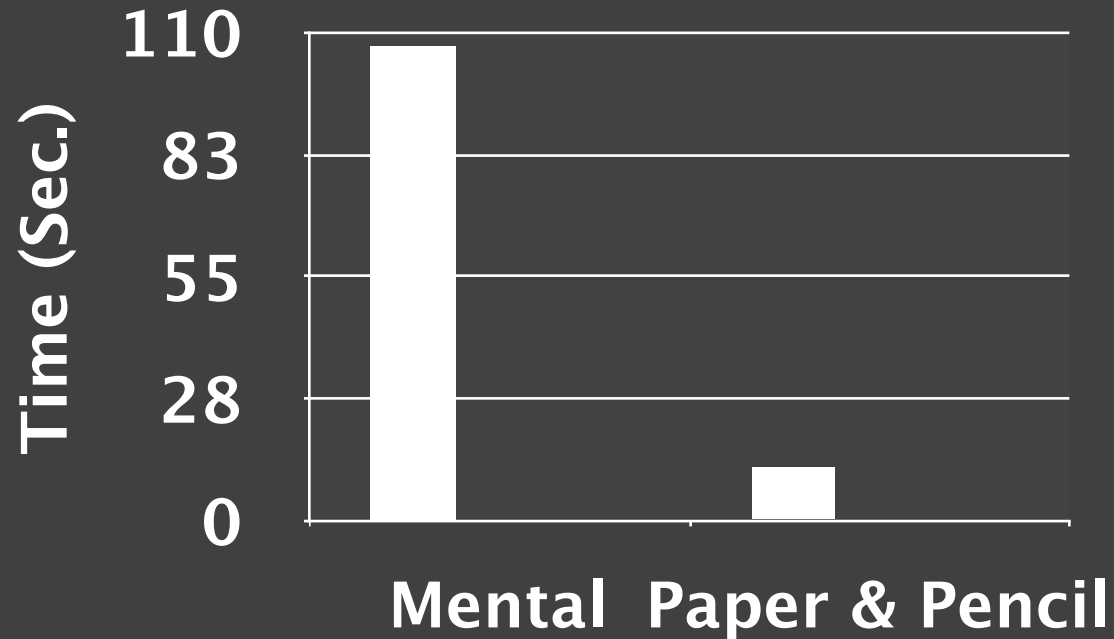
Class Exercise

Expand memory: Multiplication

$$\begin{array}{r} 34 \\ \times 72 \\ \hline \end{array}$$

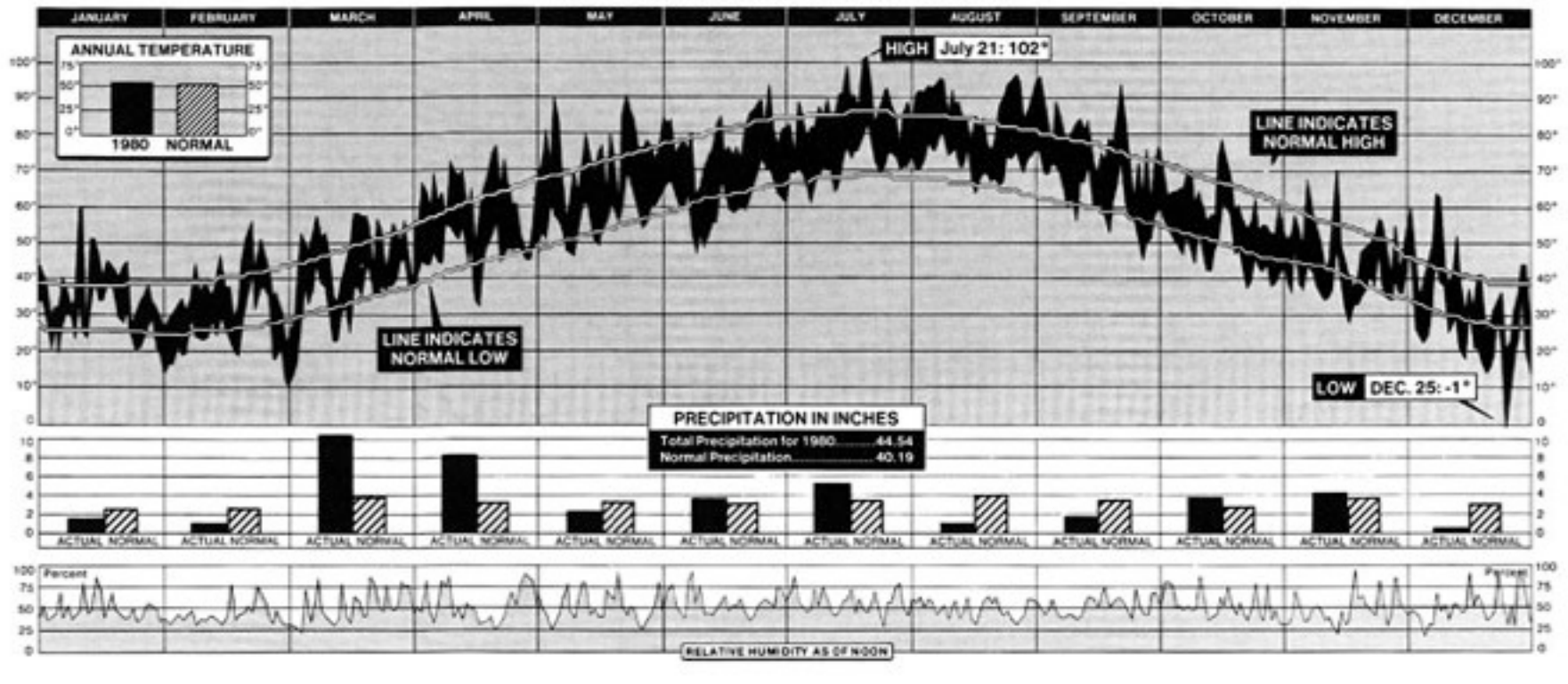
Expand memory: Multiplication

$$\begin{array}{r} 34 \\ \times 72 \\ \hline 68 \\ 2380 \\ \hline 2448 \end{array}$$



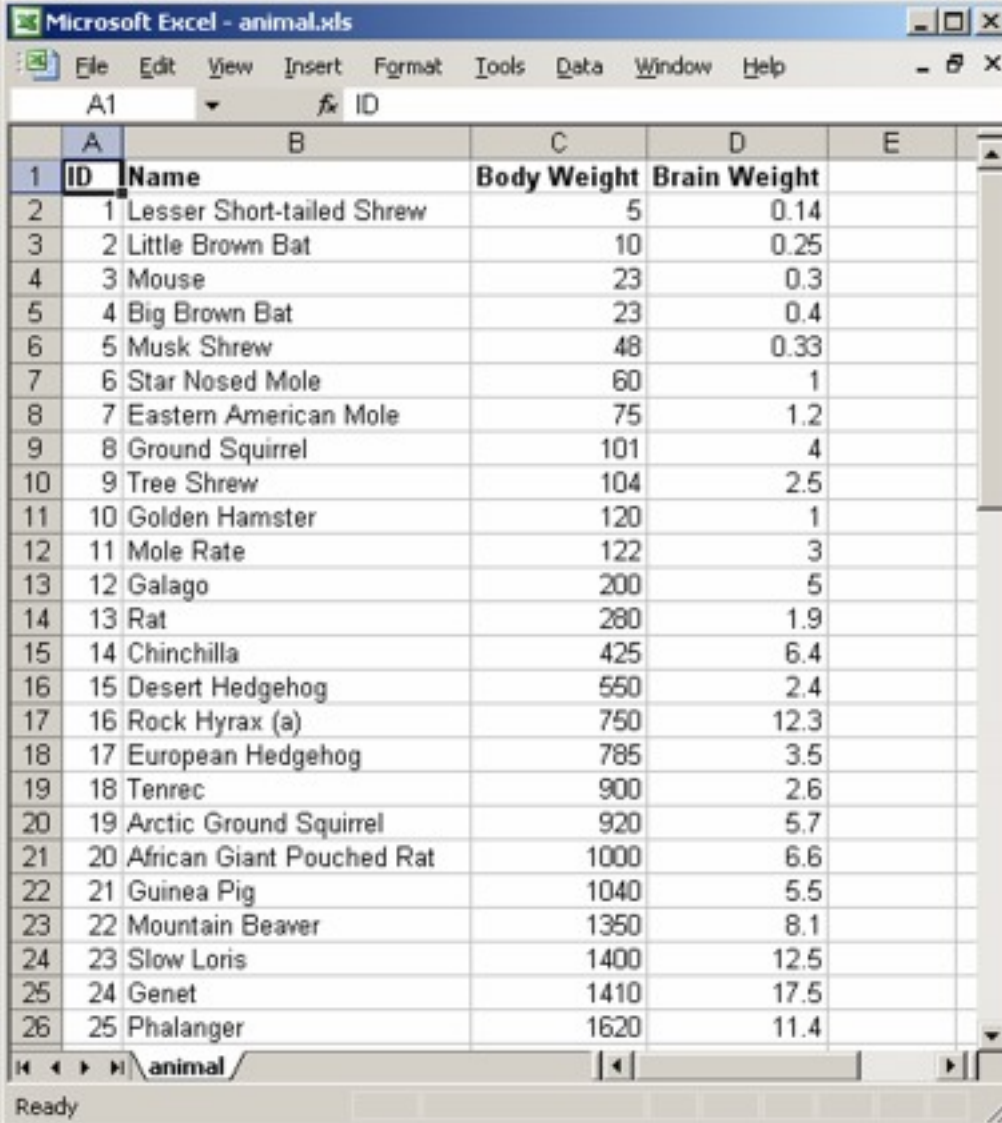
Find patterns: NYC weather

NEW YORK CITY'S WEATHER FOR 1980



From the New York Times 1981

The most powerful brain?



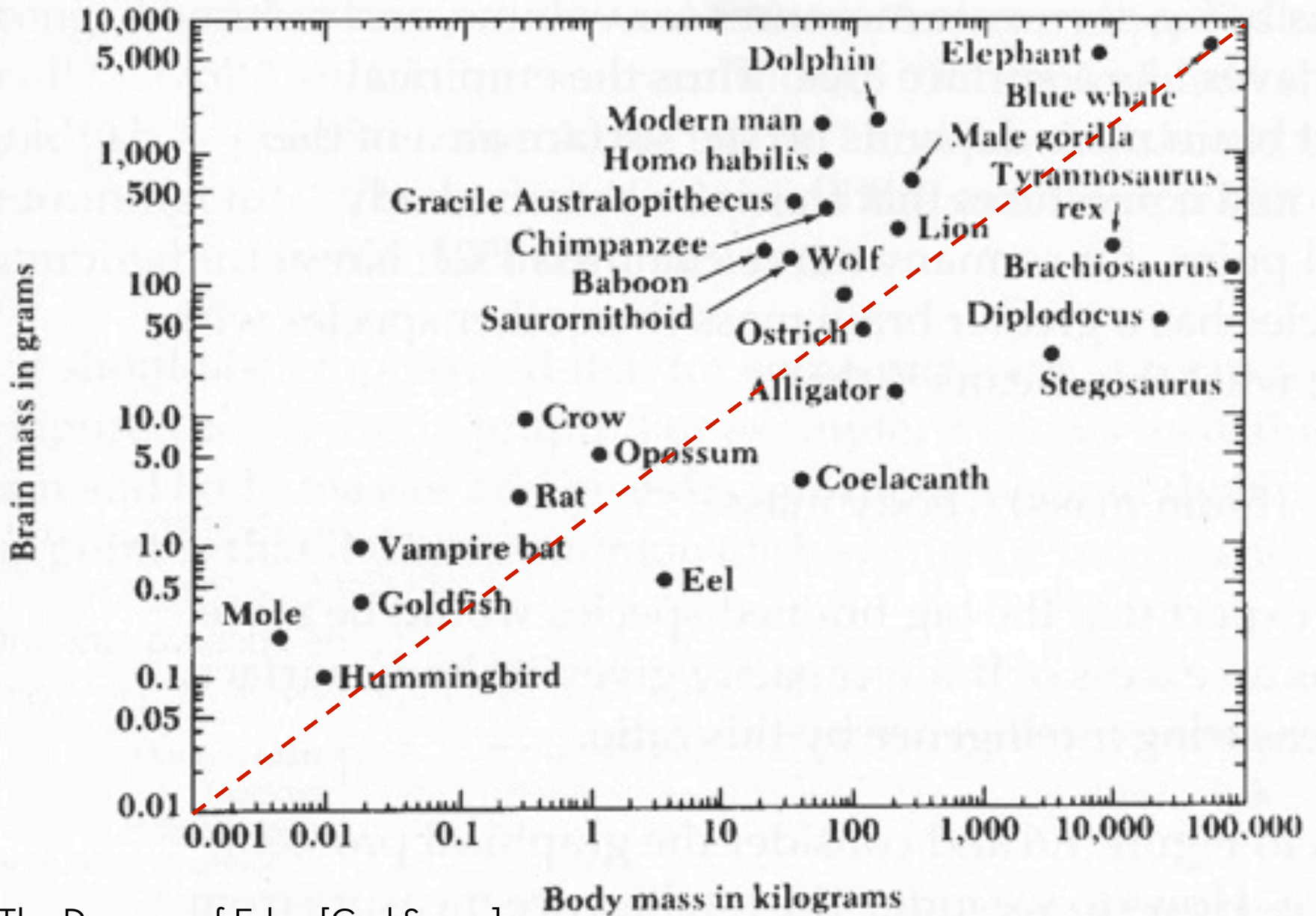
Microsoft Excel - animal.xls

File Edit View Insert Format Tools Data Window Help

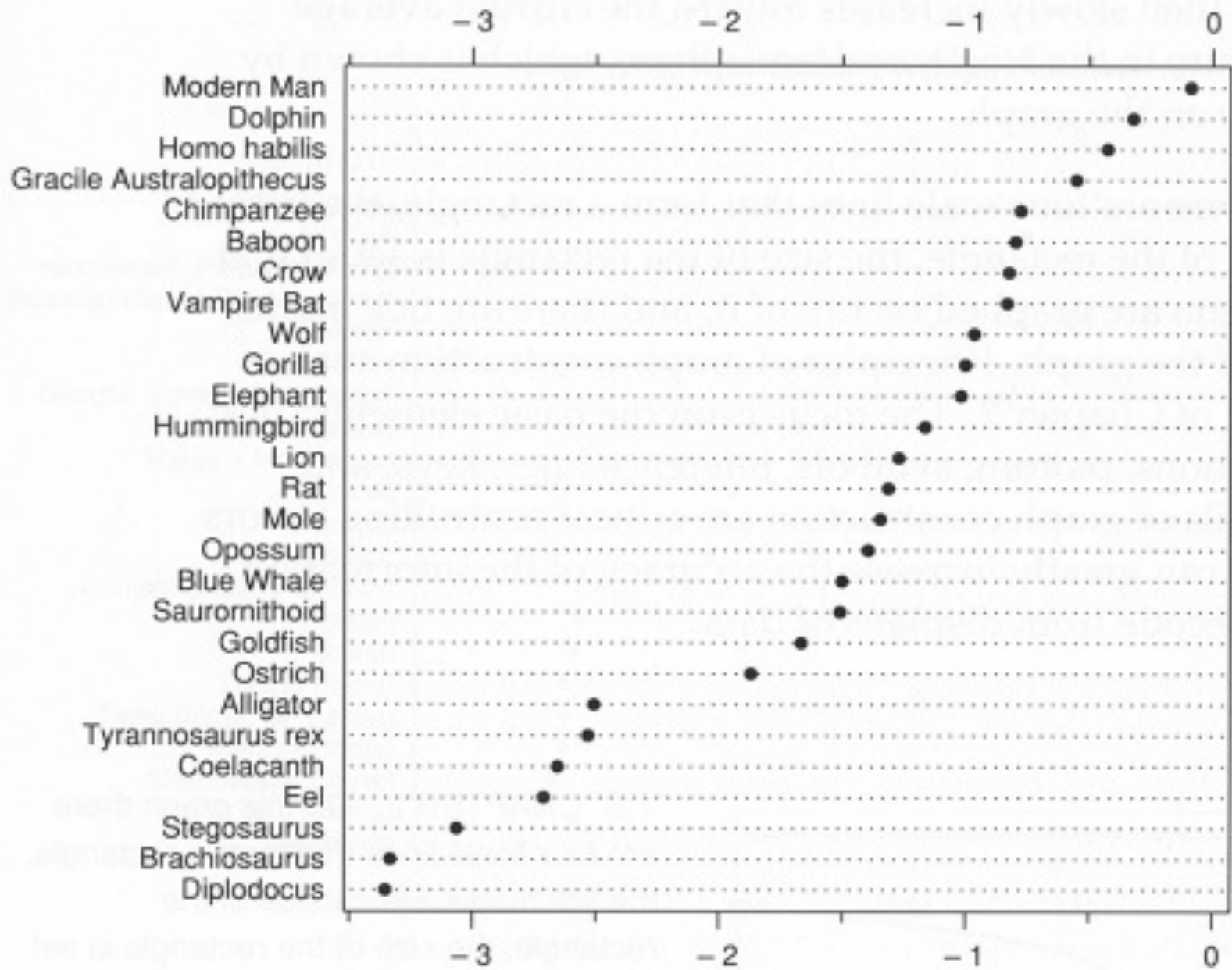
A1 ID

	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]

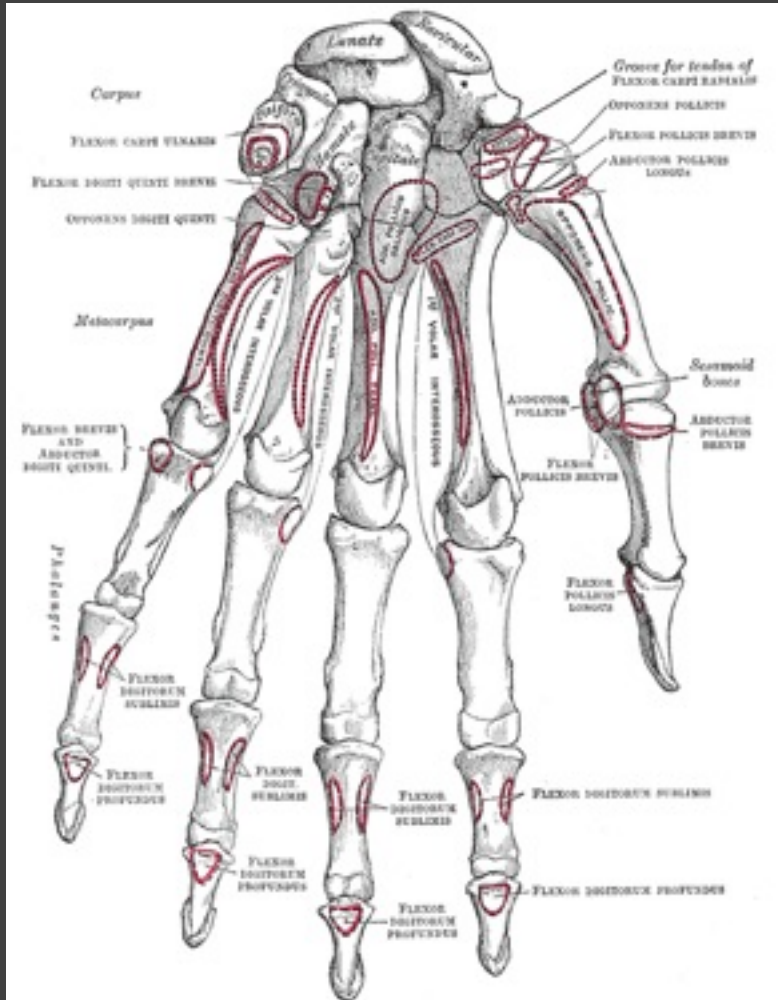


The Elements of Graphing Data
[Cleveland]

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

Convey Information to Others

Inspire



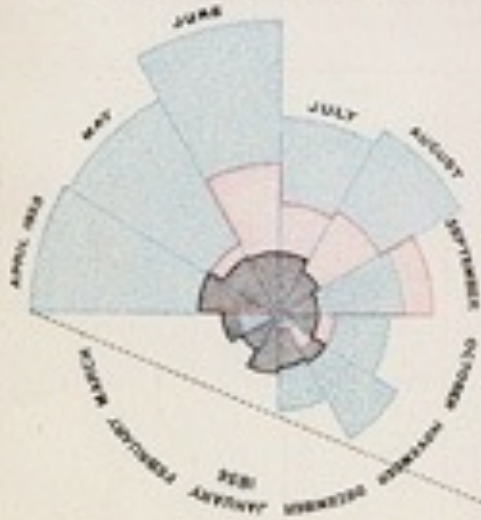
Bones in hand [from 1918 edition]



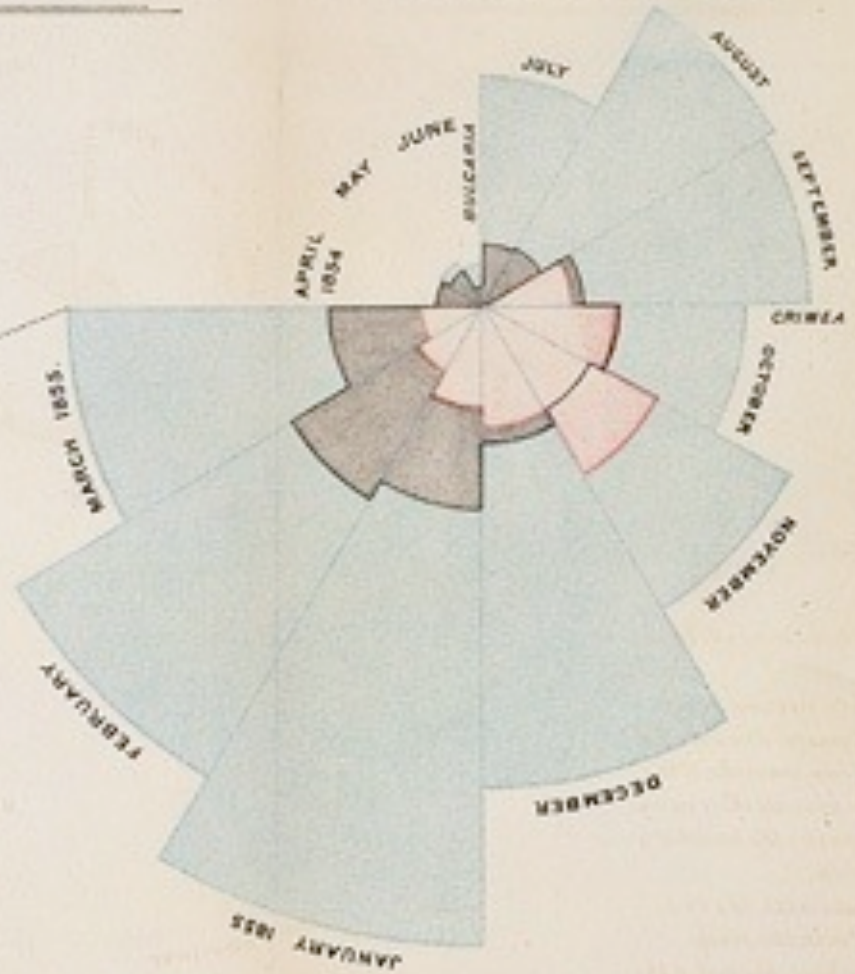
Double helix model [Watson and Crick 53]

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

2.
APRIL 1855 TO MARCH 1856.



1.
APRIL 1854 TO MARCH 1855.



“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

The Value of Visualization

Record information

Blueprints, photographs, seismographs, ...

Analyze data to support reasoning

Develop and assess hypotheses

Discover errors in data

Expand memory

Find patterns

Communicate information to others

Share and persuade

Collaborate and revise

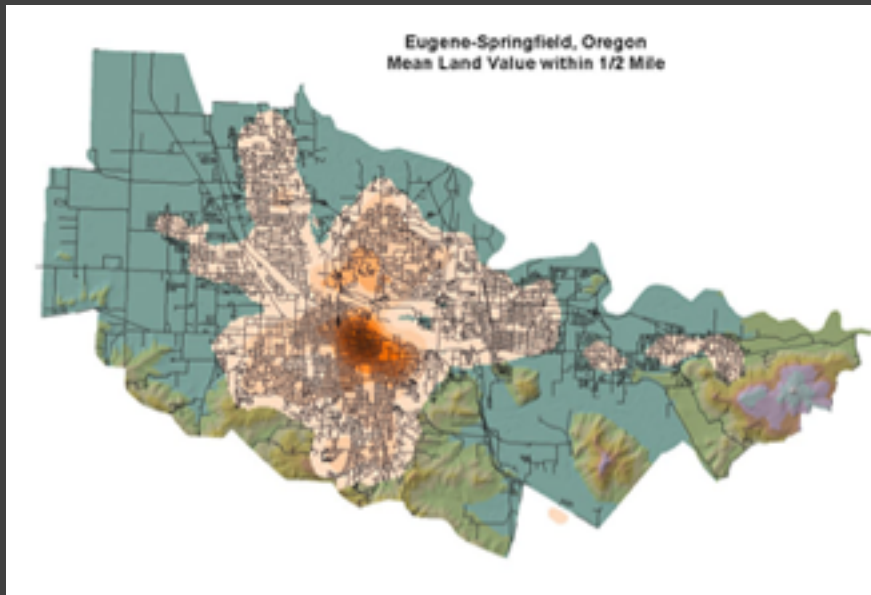
Visualization Research

Challenge

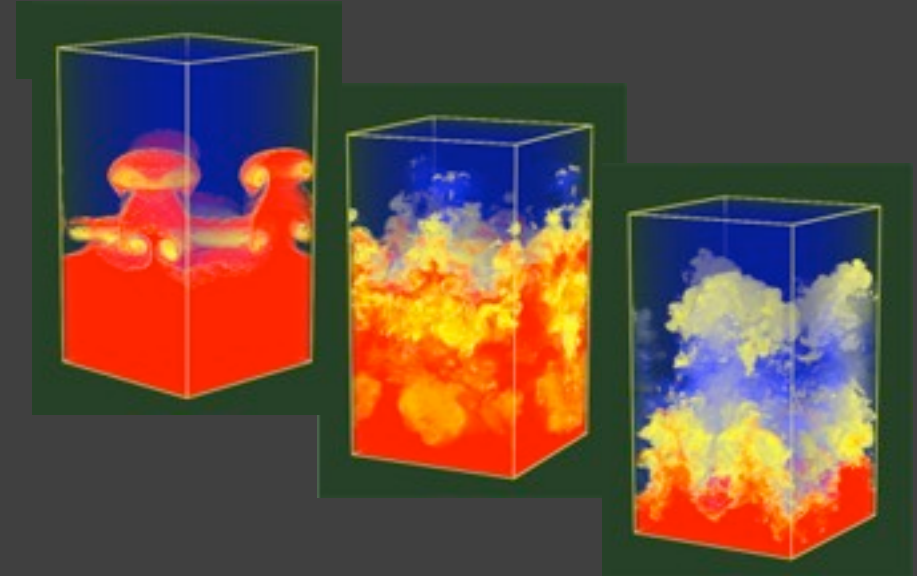
- More and more unseen data
 - Faster creation and collection

Challenge

- More and more unseen data
 - Faster creation and collection



Urban development planning
www.urbansim.org



Fluid flow
ctr.stanford.edu

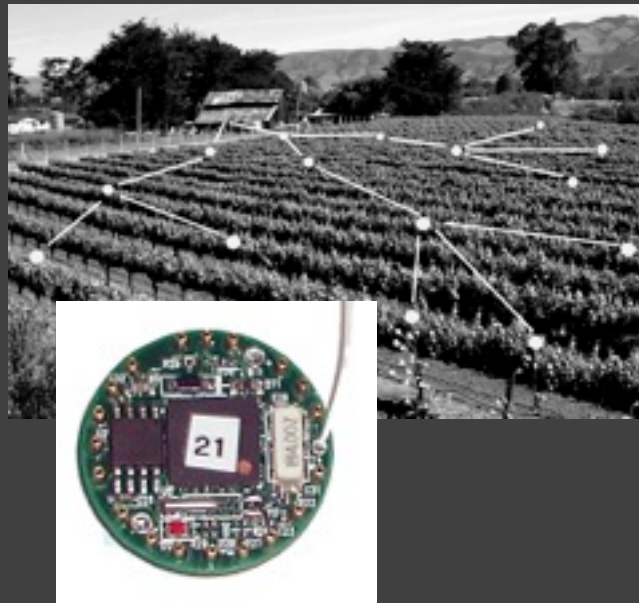
Simulation

Challenge

- More and more unseen data
 - Faster creation and collection



Sloan digital sky survey
www.sdss.org



Sensor networks [Hill 02]
www.xbow.com



Digital photography

Sensing

Challenge

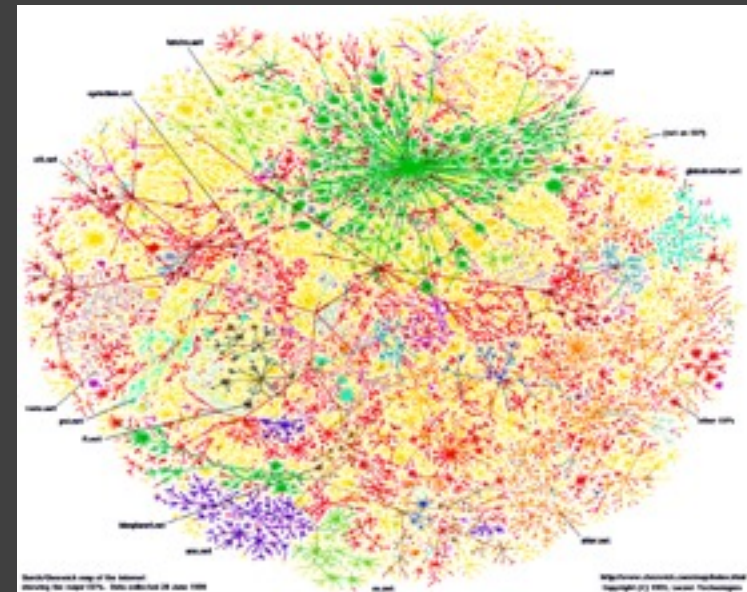
- More and more unseen data
 - Faster creation and collection
 - Faster dissemination



Photo sharing/annotation
flickr.com



Group Authoring
wikipedia.org



Map of the Internet [Cheswick 99]
research.lumeta.com

Internet

Challenge

More and more unseen data

- Faster creation and collection
- Faster dissemination

5 exabytes of new information in 2002 [Lyman 03]

161 exabytes in 2006 [Gantz 07]

1,200 exabytes in 2010 [Gantz 10]

Necessitates **better tools and algorithms** for
visually conveying information

Attention

“What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it.”



Herb Simon
as quoted by Hal Varian
Scientific American
September 1995

Goals of Visualization Research

- 1 Understand how** visualizations convey information
 - What do people perceive/comprehend?
 - How do visualizations correspond with mental models?
- 2 Develop principles and techniques** for creating effective visualizations and supporting analysis
 - Amplify perception and cognition
 - Strengthen tie between visualization and mental models

Course Topics

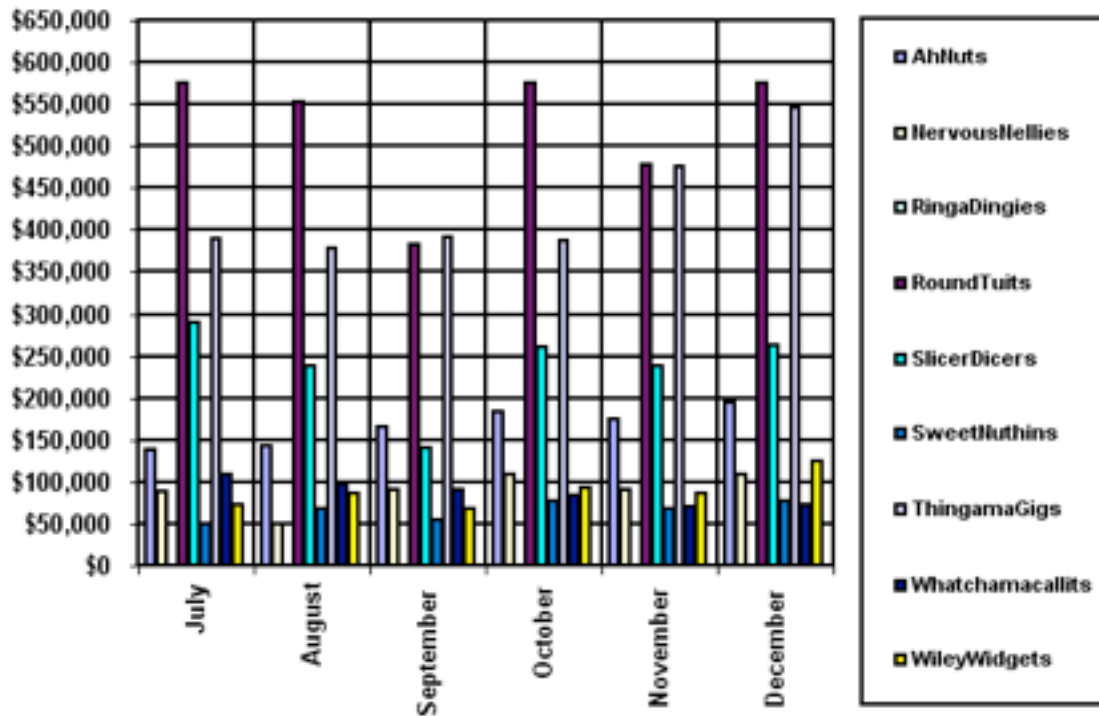
Data and Image Models

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

Sémiologie Graphique [Bertin 67]

Visualization (Re-)Design

SlicerDicers' Sales Compared to Other Products



Problematic design

Sales of SlicerDicers Compared to Other Products

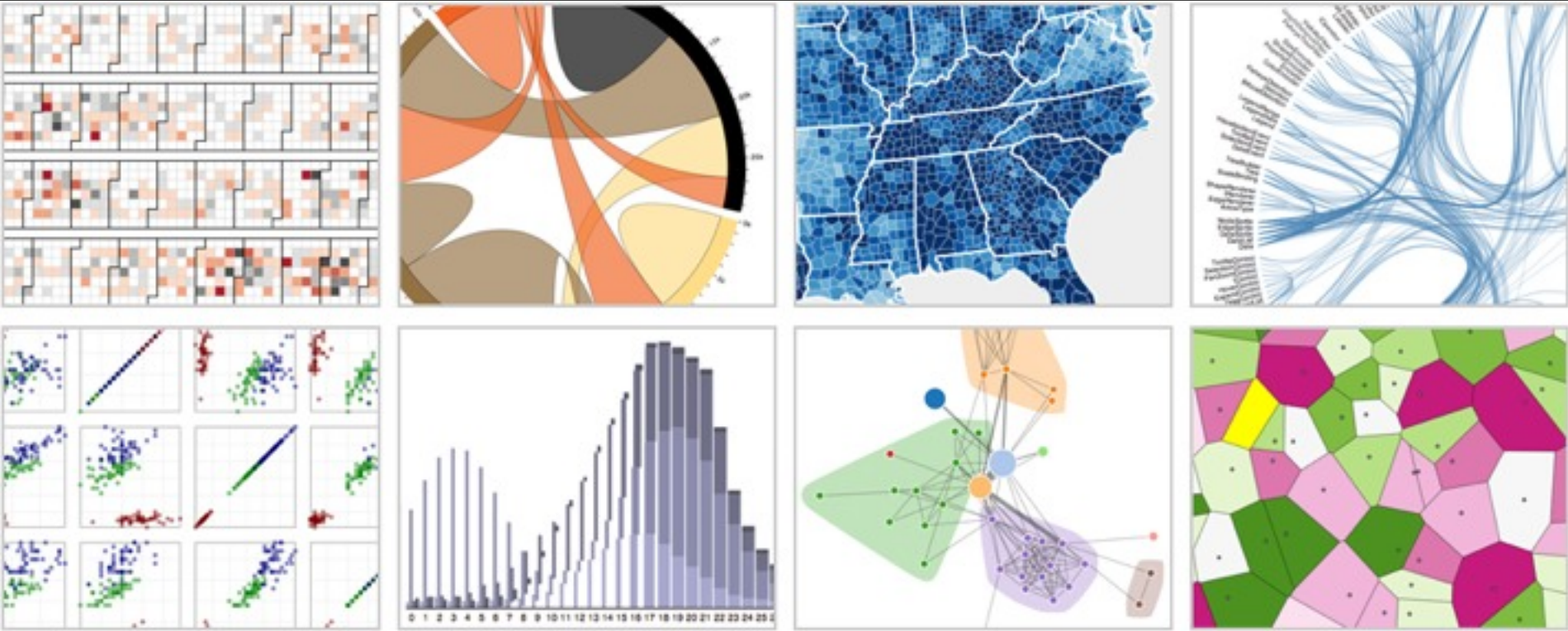
July - December, 2003

(SlicerDicers' sales are displayed as black reference lines of 100%; the red bars represent the average monthly sales percentage for July through December.)



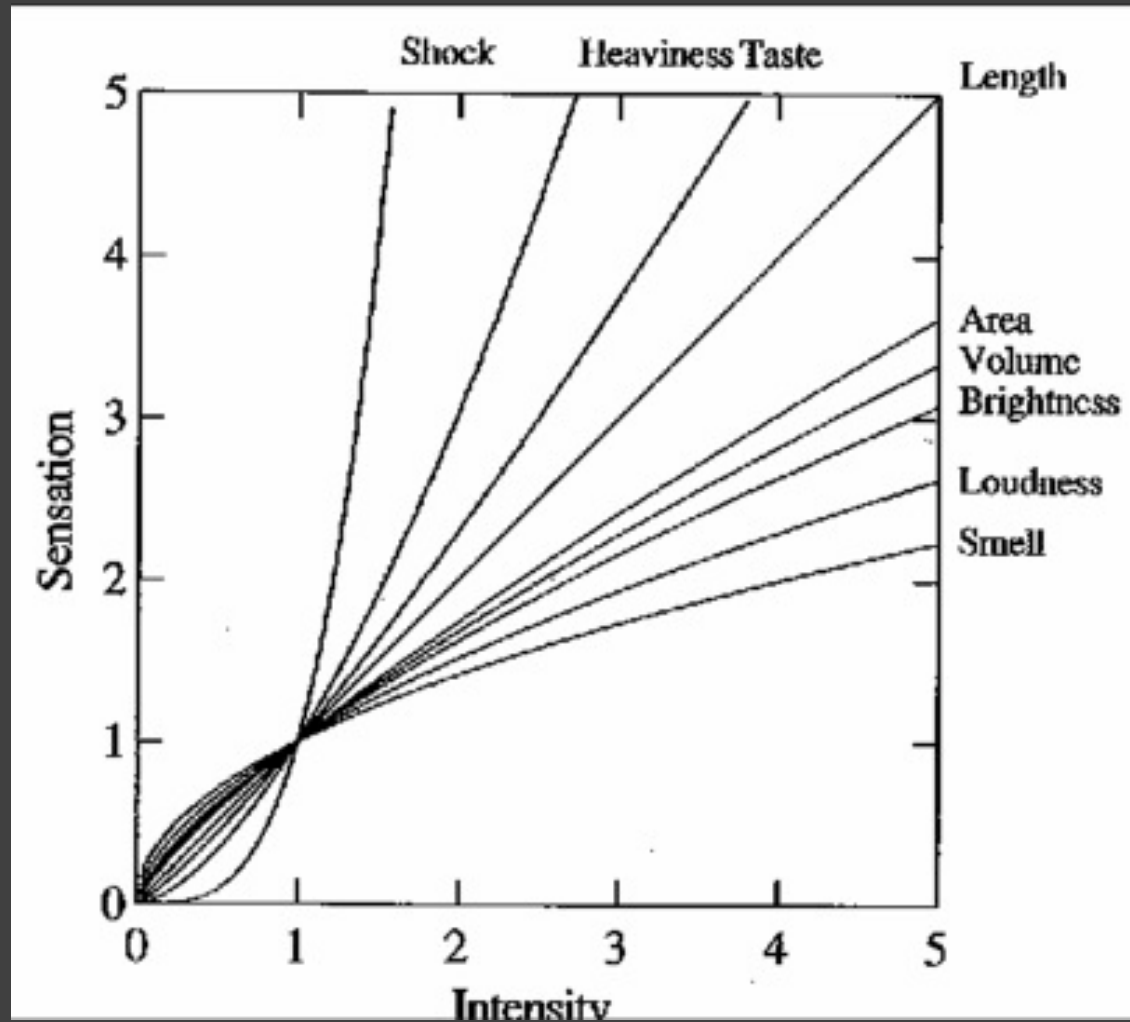
Redesign

Visualization Software



D3: Data-Driven Documents

Graphical Perception

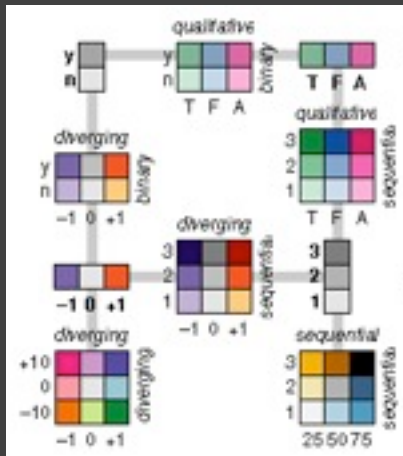
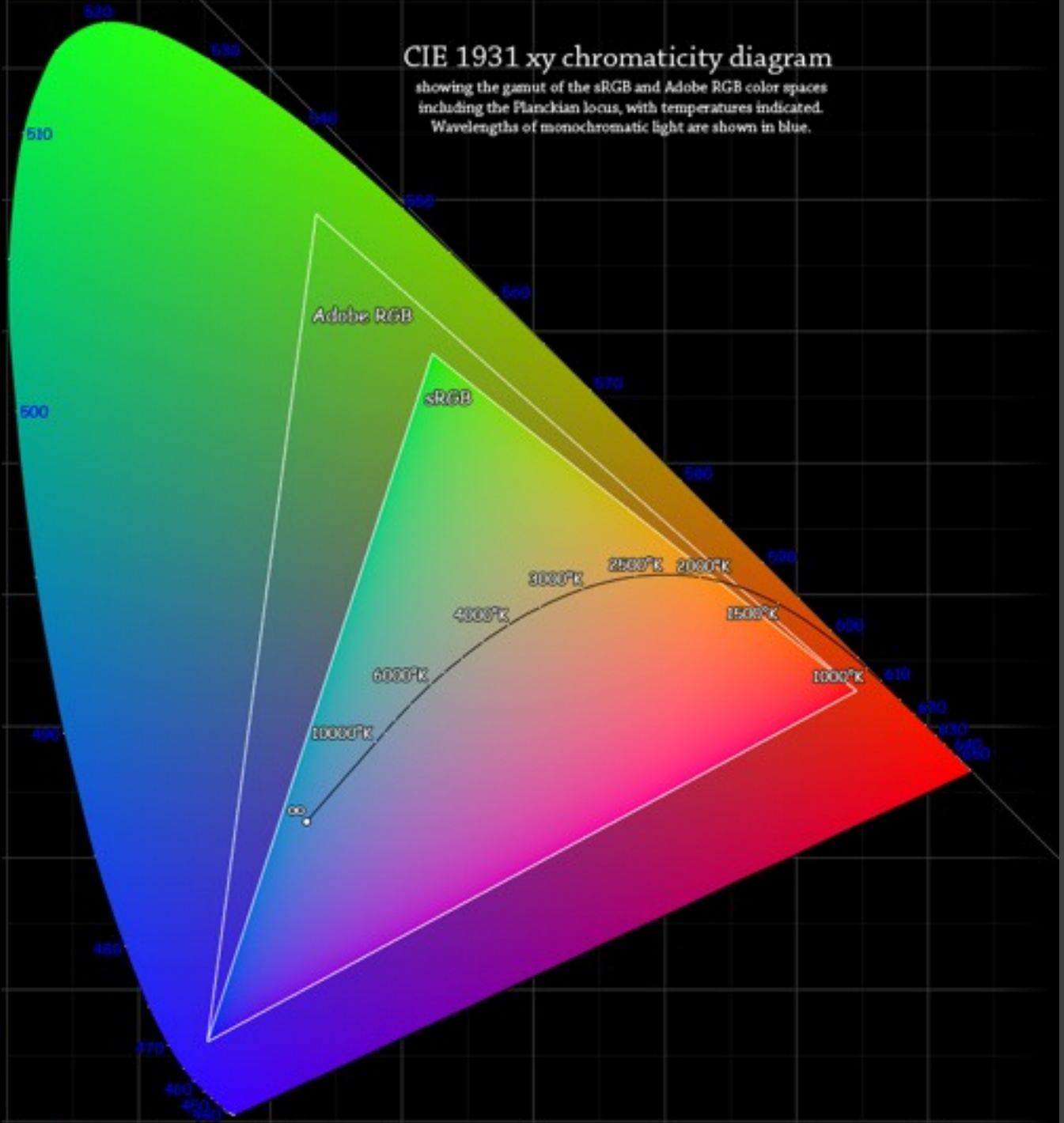


The psychophysics of sensory function [Stevens 61]

Color

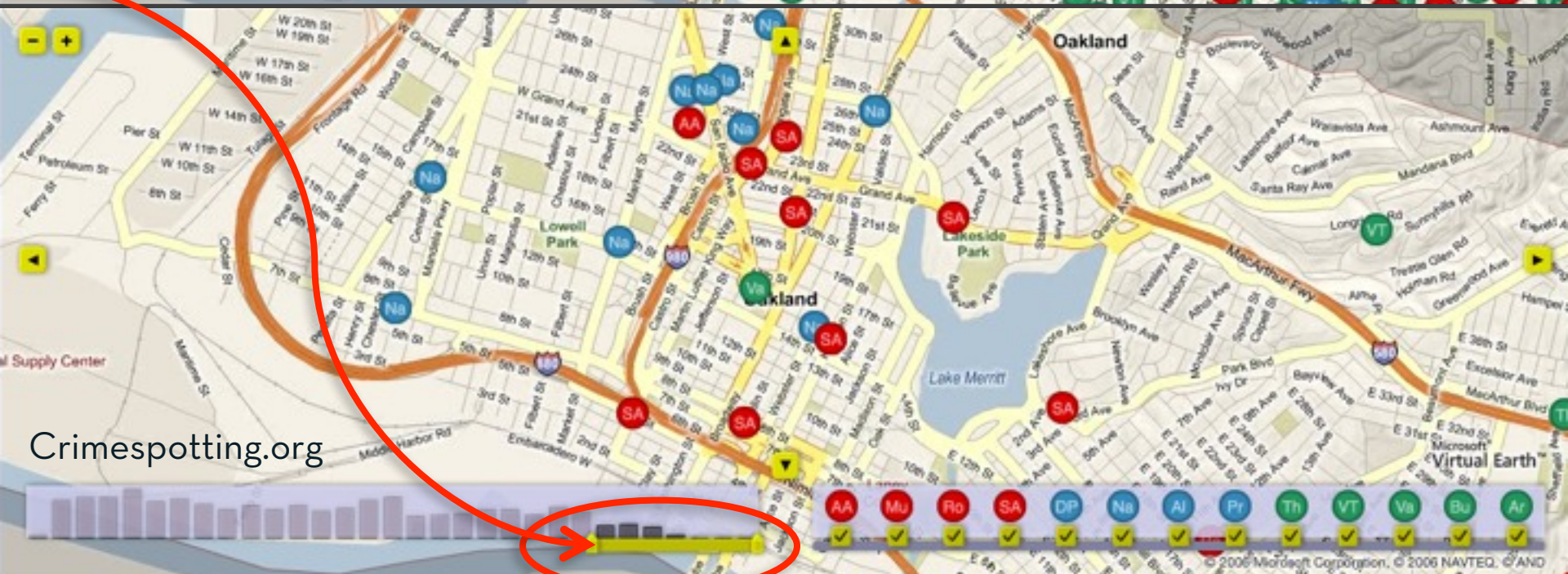
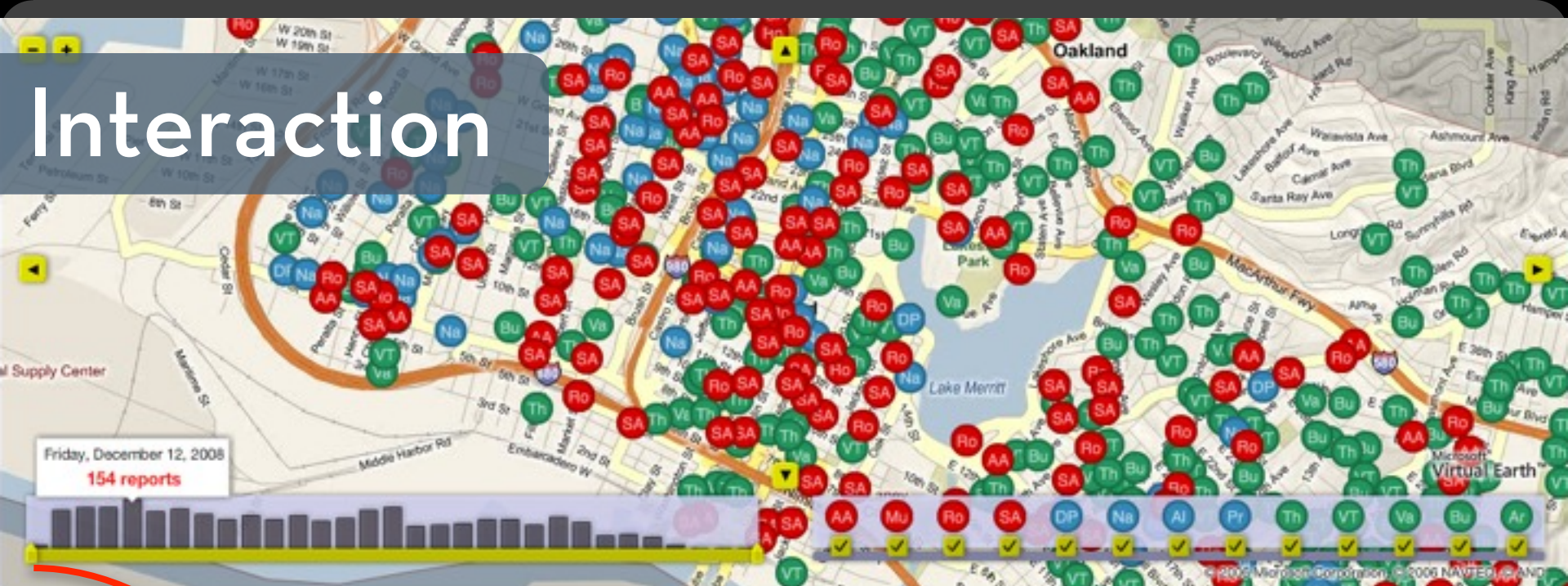
CIE 1931 xy chromaticity diagram

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.

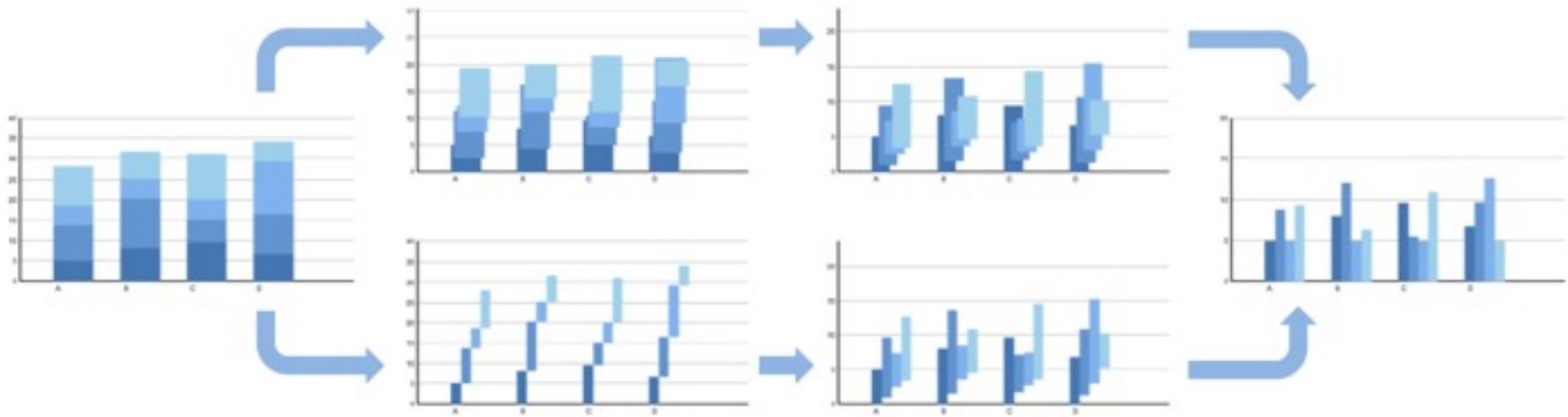


Color Brewer

Interaction

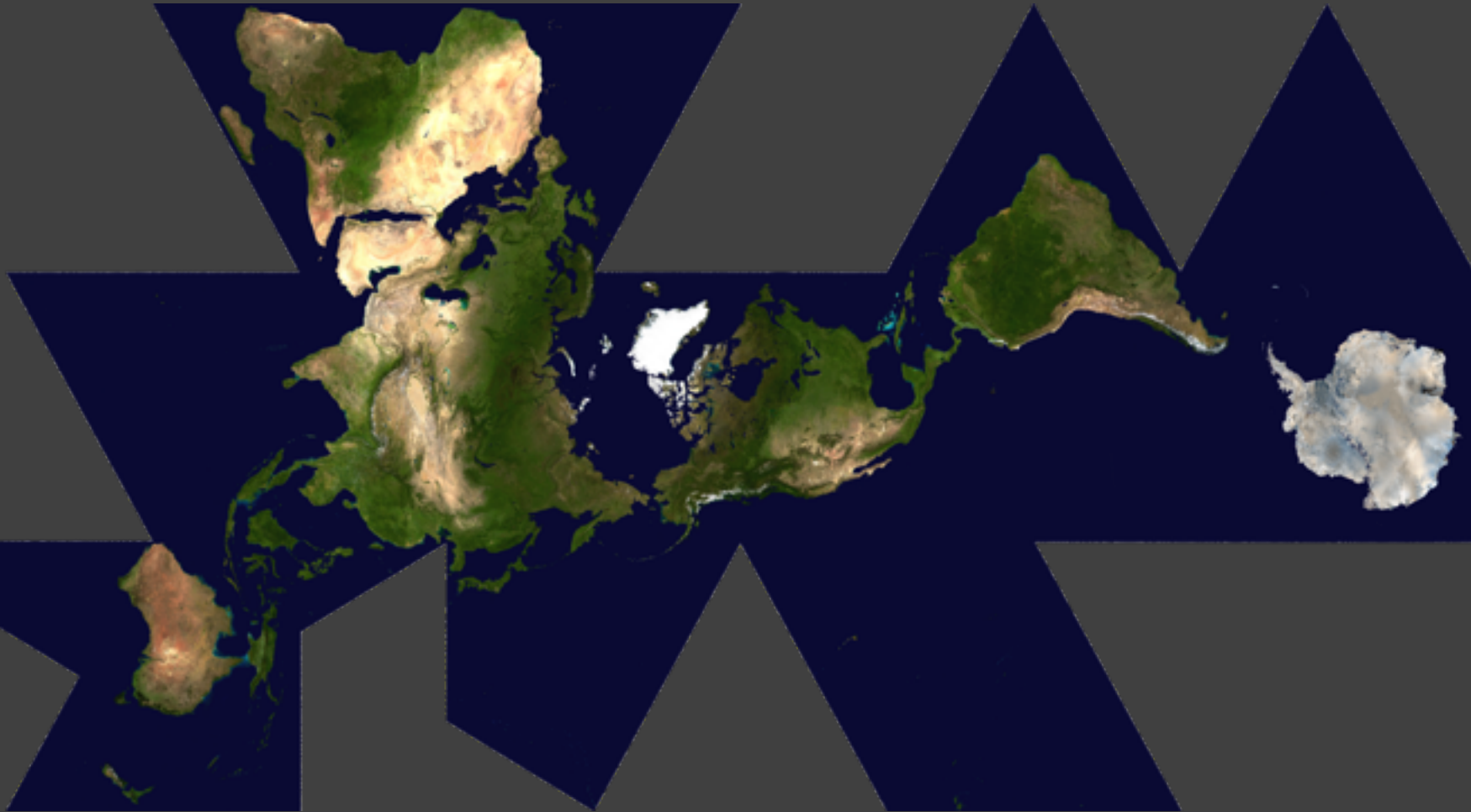


Animation



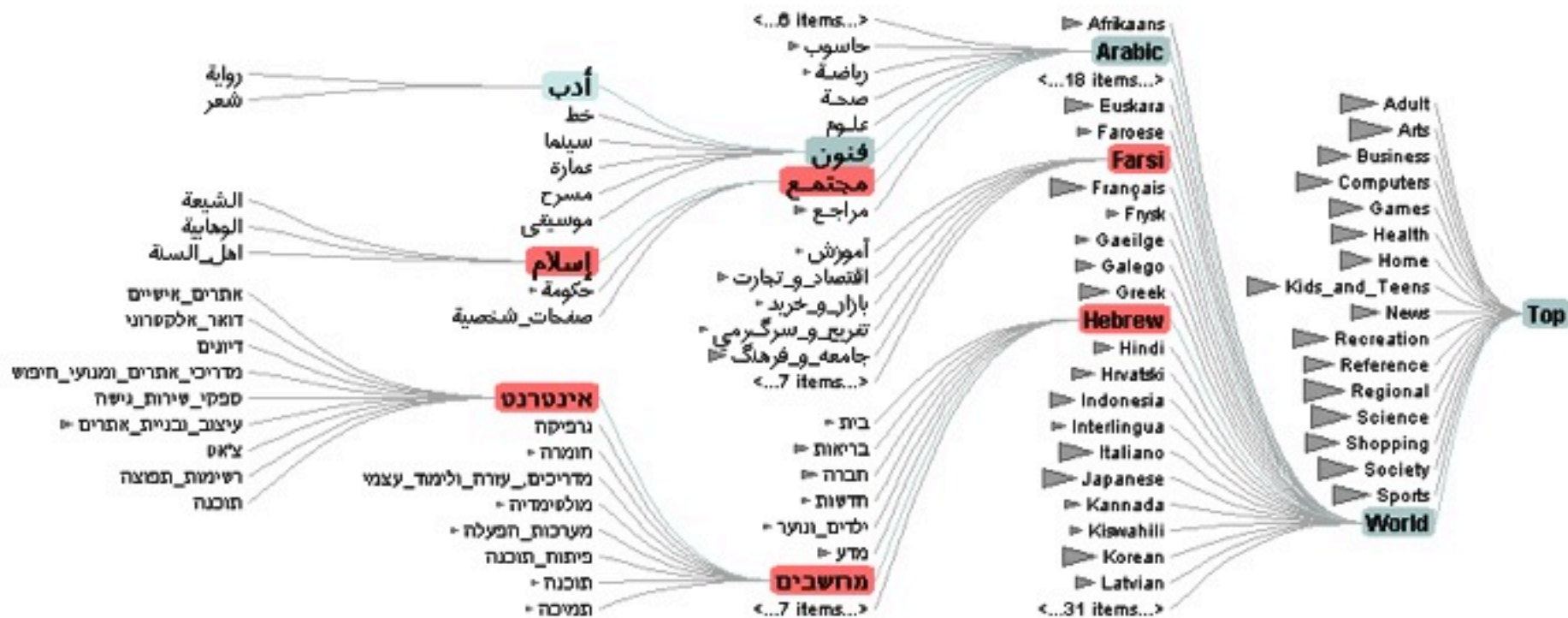
Animated transitions in statistical data graphics [Heer & Robertson 07]

Mapping / Cartography



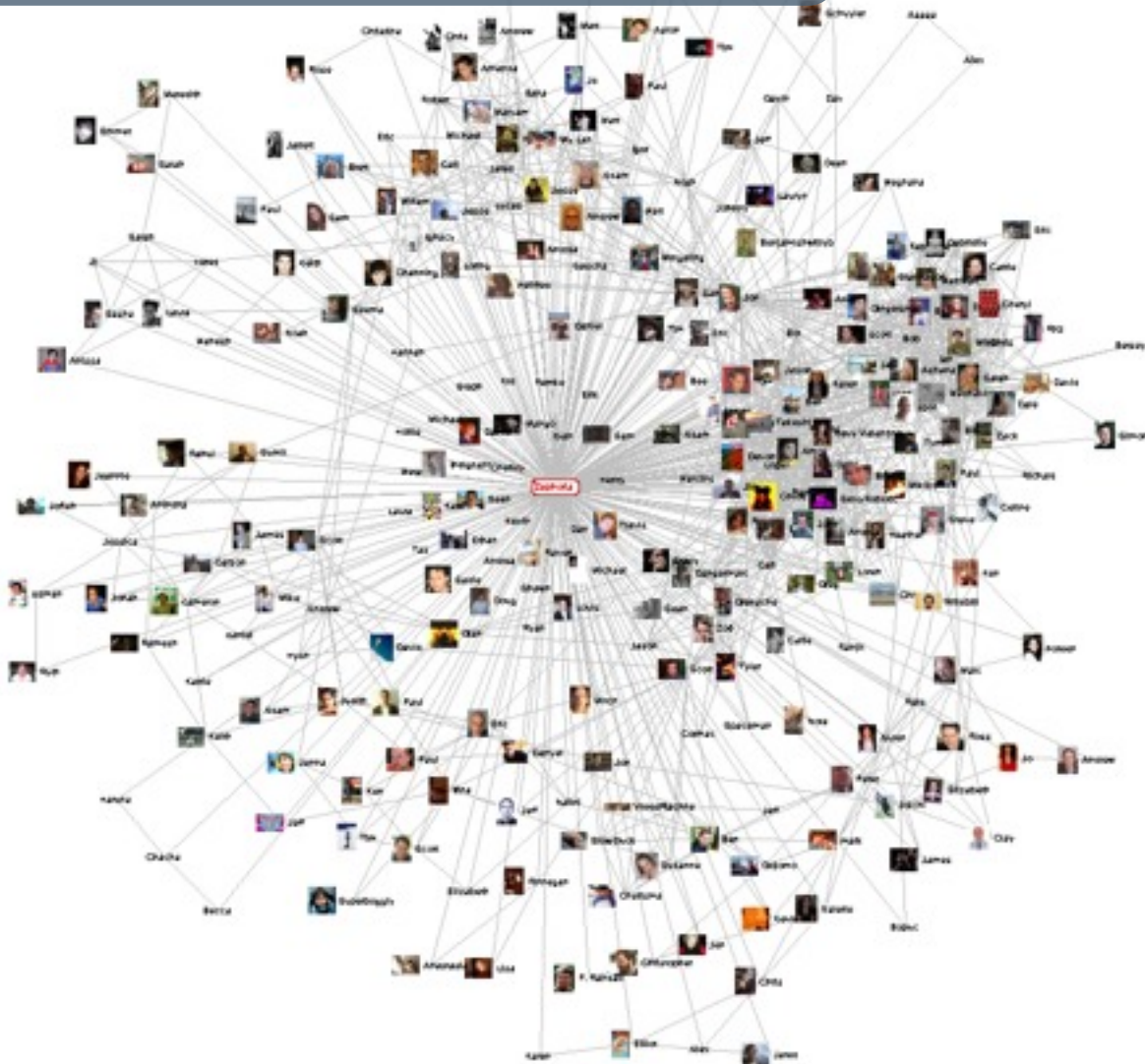
Dymaxion Maps [Fuller 46]

Graphs and Trees



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

Graphs and Trees



community >>

Enable

search >>

Zephoria

User ID 21721
Friends 288
Age ??
Gender Female
Status 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, stamping
Music psytrance/goatrance [Infected Mushroom, Son K9e... 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.

Text Visualization

Visualization of Text / Alberto Gonzales

Creator: Martin Wattenberg
Tags:

explore

- visualizations
- data sets
- comments
- topic hubs

participate

- create visualization
- upload data set
- create topic hub
- register

learn more

- quick start
- visualization types
- data format & style
- about Many Eyes
- FAQ
- blog

contact Us

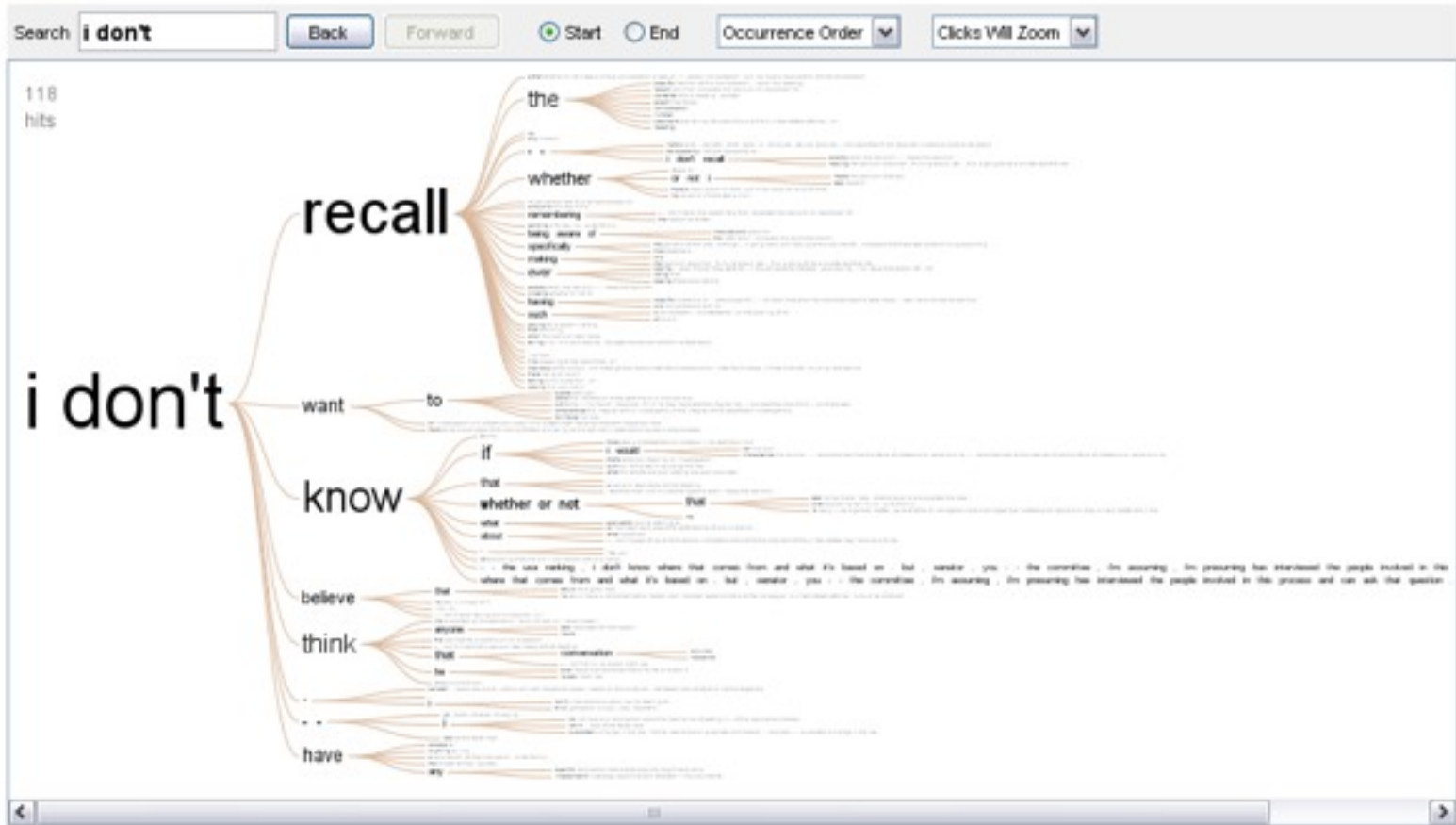
- contact
- report a bug

legal

- terms of use

Popular Dataset Tags

- 2007 2008 bible blog
- books census crime
- education eharmony
- election energy food
- health inauguration
- internet ireland literature
- lyrics media music
- network obama
- people politics
- population
- president prices religion



Data file: [Word in testimony from Gonzales, 4/19/2007](#) Data source: CQ Transcript Wire via the Washington Post

This data set has not yet been rated

- Full image
- share this
- watch this
- add to topic hub
- rate this

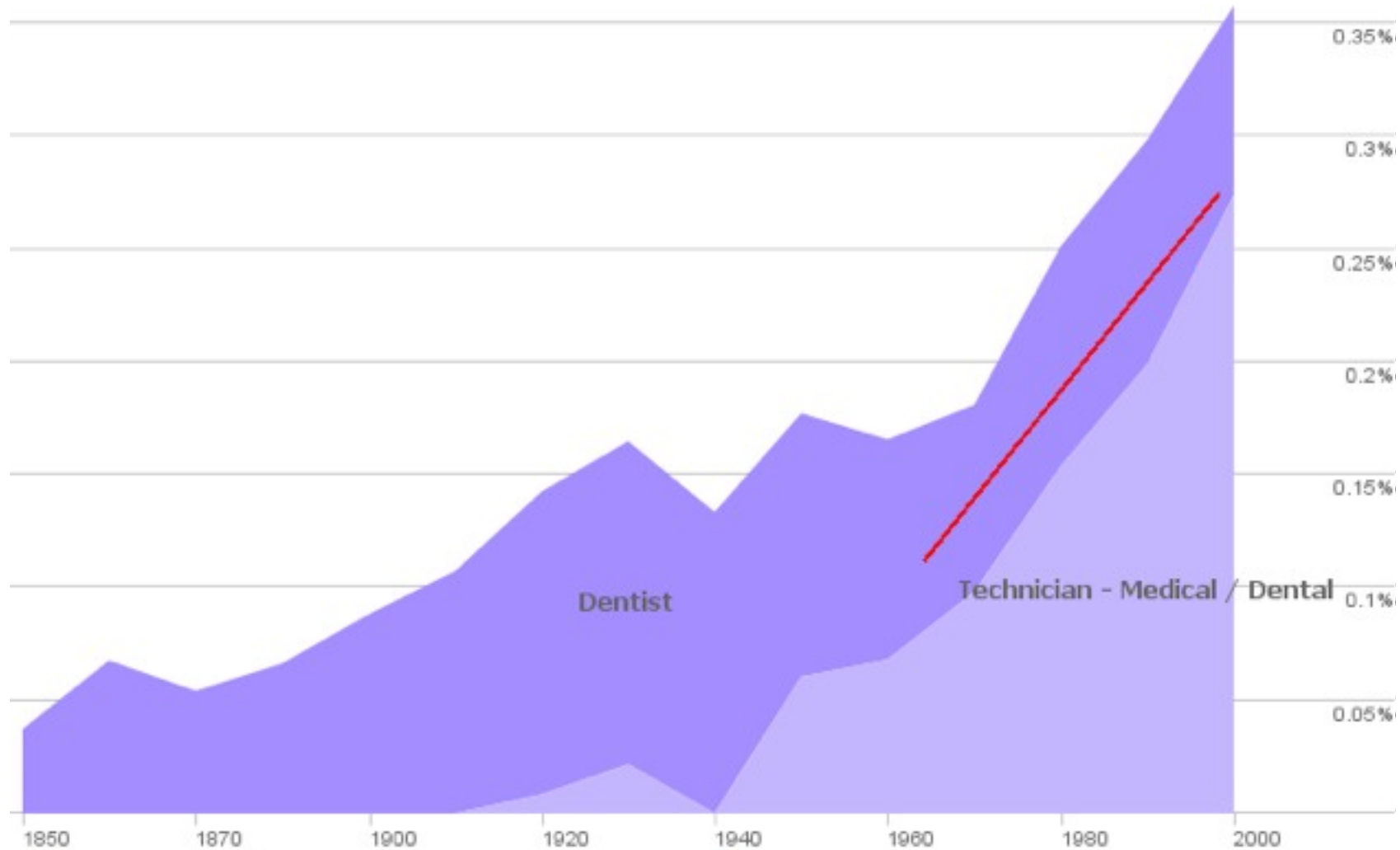
Comments (4)

currently showing

This visualization has 4 positive and 0 negative

Collaboration and History

Where have all the dentists gone?



Course Mechanics

You should expect to:

- 1** *Evaluate and critique* visualization designs
- 2** *Implement* interactive data visualizations
- 3** *Gain* an overview of research & techniques
- 4** *Develop* a substantial visualization project

Instructors

cse512@cs

Instructor

Jeffrey Heer

Assoc Prof, CSE

OH: *Tue 9:30-10:30, 642 CSE*

<http://jheer.org>

Teaching Assistant

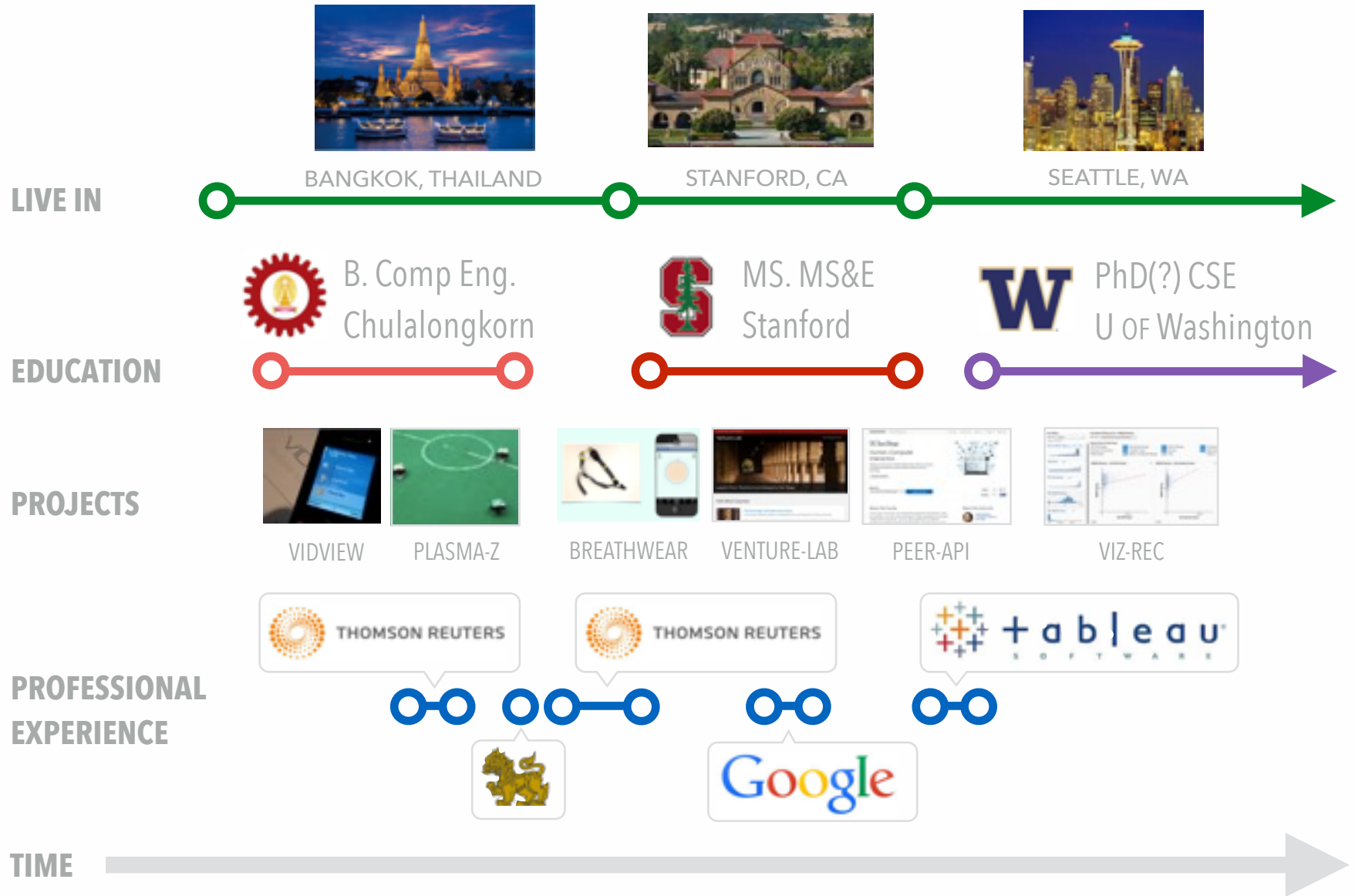
Kanit “Ham”

Wongsuphasawat

OH: *Thu 9:45-10:45, 218 CSE*

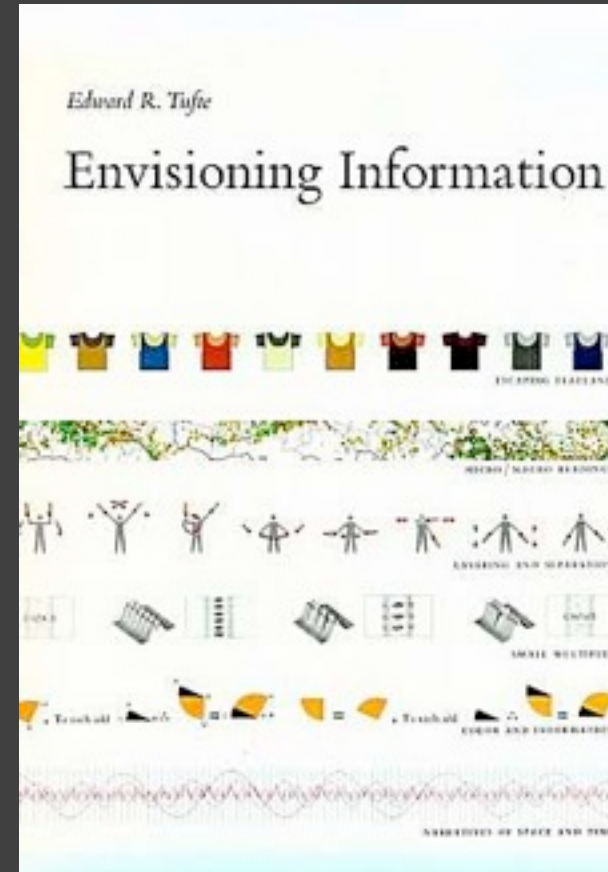
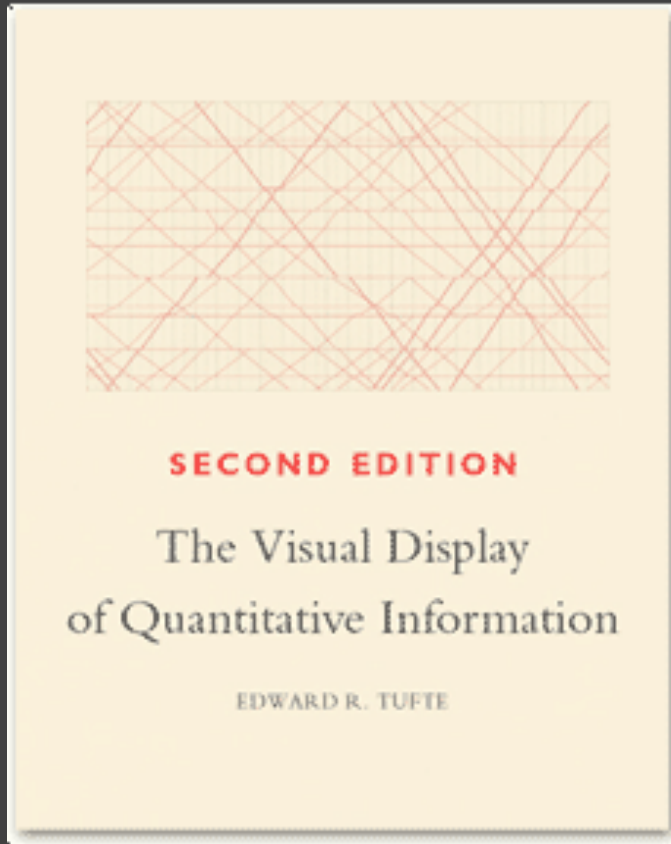
<http://kanitw.yellowpigz.com>

Kanit "Ham" Wongsuphasawat @kanitw



See my portfolio at kanitw.yellowpigz.com or bit.ly/knowham

Textbooks



See also: www.edwardtufte.com

Readings

Some from textbooks, also many papers

Material in class will loosely follow readings

Readings should be read by start of class

Post discussion comments on class Piazza forum

Comments must be posted within **1 day** of lecture

You have 2 “passes” for the quarter

Complete enrollment form on the website!

We will then invite you to the Piazza forum.

Requirements

Class participation (10%)

A1: Visualization Design (10%)

A2: Exploratory Data Analysis (15%)

A3: Interactive Visualization Software (25%)

FP: Final Project (40%)

Final Project

Visualization research project on topic of your choice

Project write-up in form of a short research paper

Two project presentations

1. Initial in-class status report (2/27)
2. Final poster presentation (tentatively 3/13)

Projects from previous classes have been:

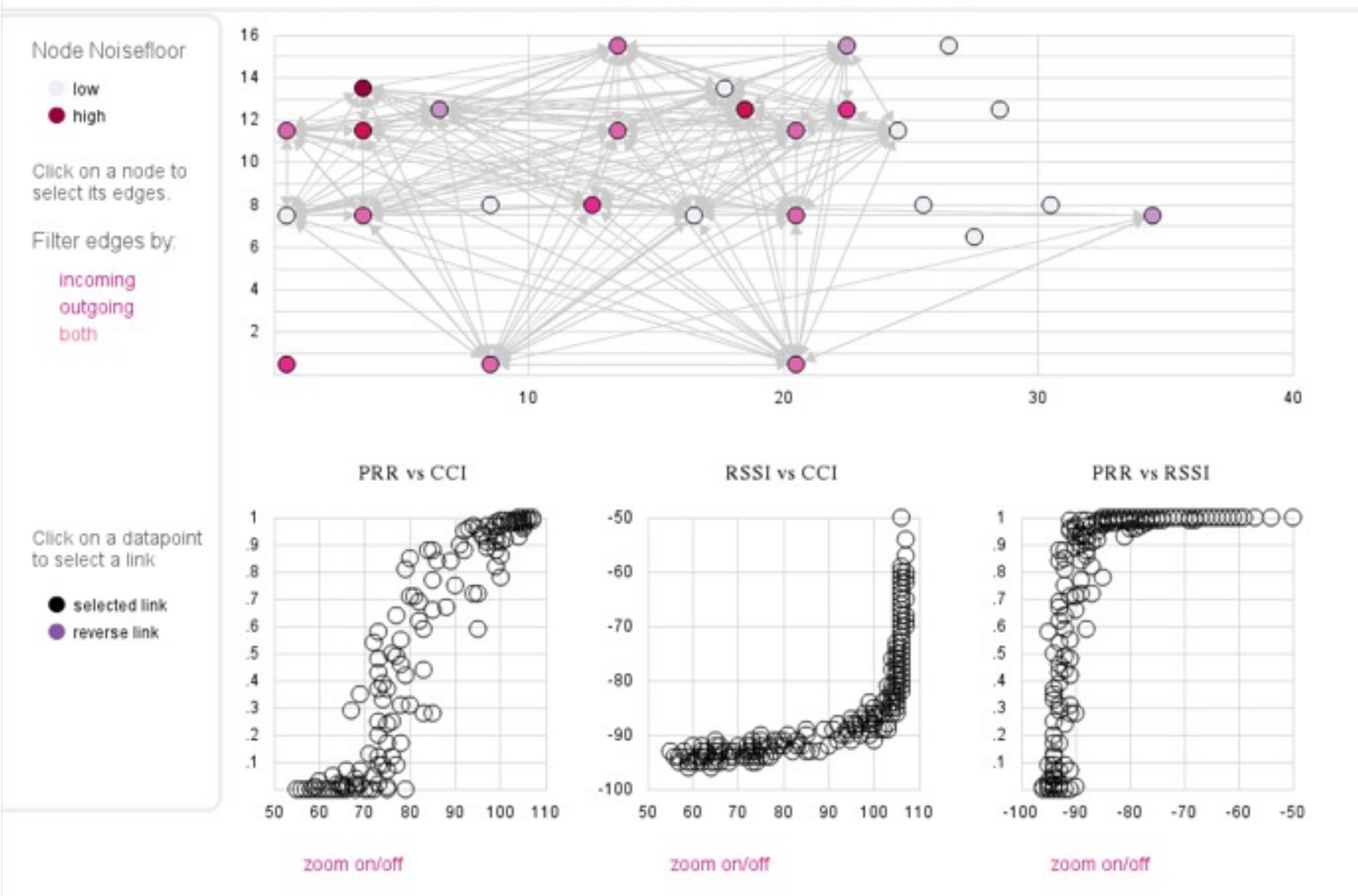
- Published (e.g., at the IEEE InfoVis conference)
- Featured in the New York Times
- Released as successful open source projects



RunMonster

Troy Brant & Steve Marmon

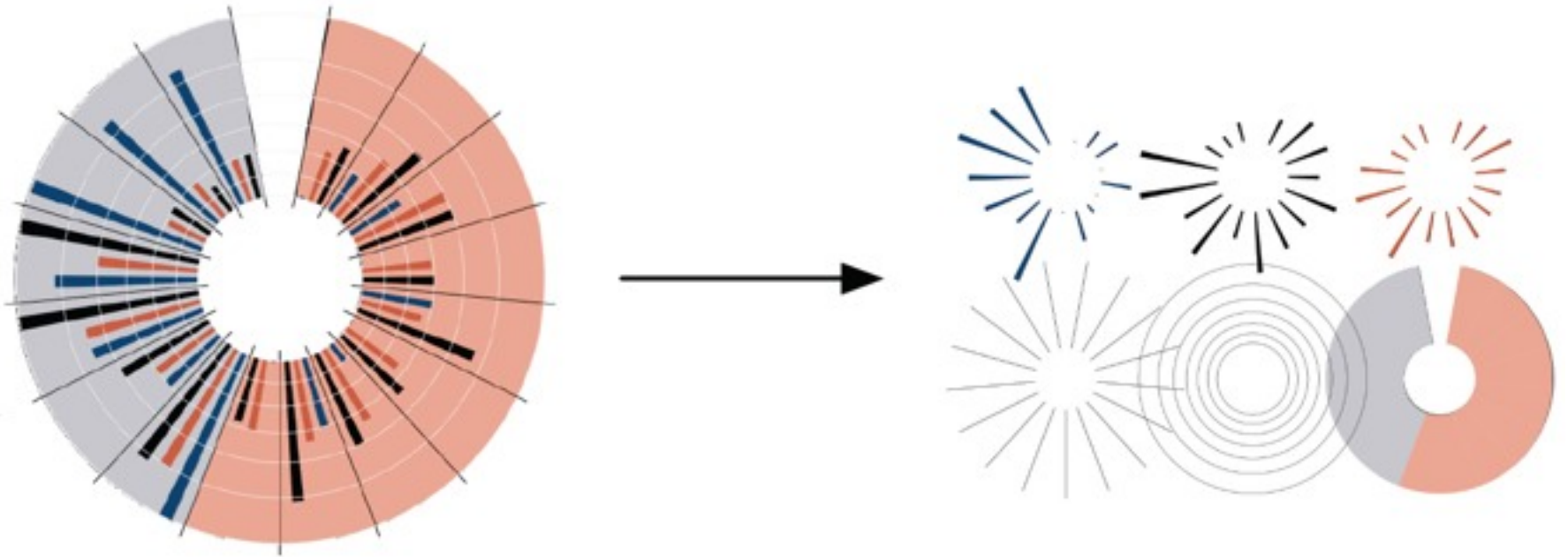


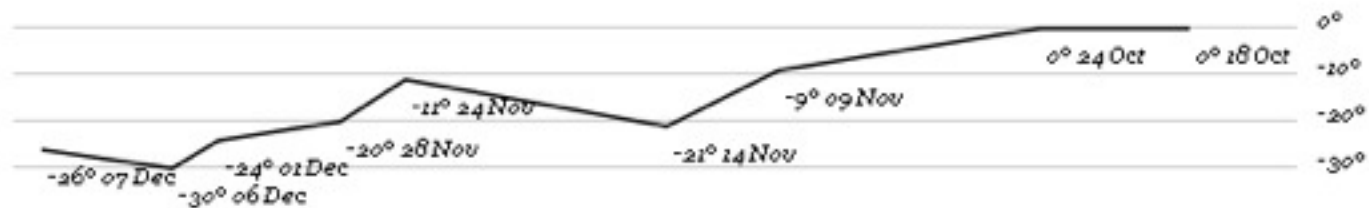
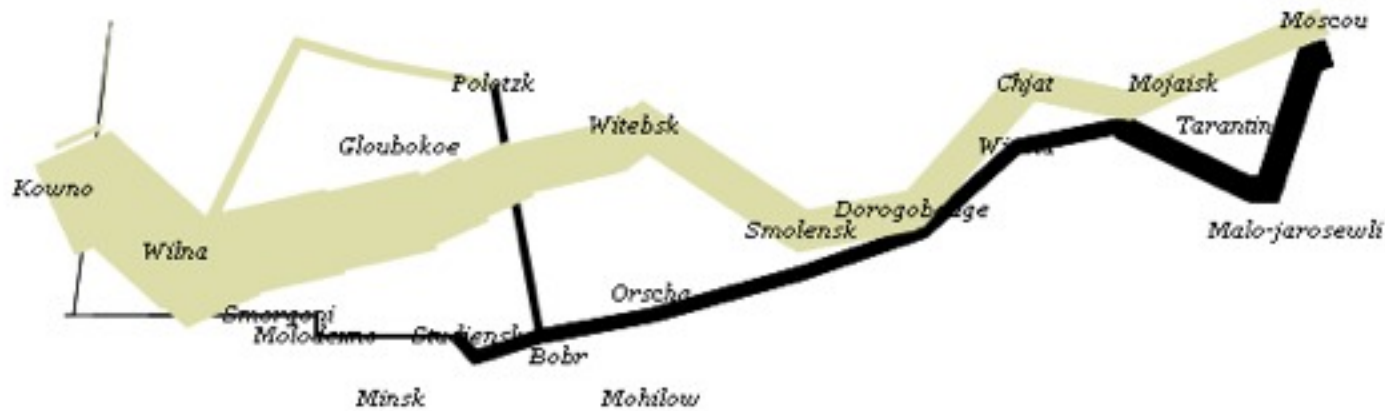


Stanford Network Analysis Tool – Nick Briggs & Maria Kazandjieva

Protovis: A Graphical Toolkit for Visualization

Mike Bostock





```

var army = pd.nest(napoleon.army, "dir", "group");
var vis = new pv.Panel();

var lines = vis.add(pv.Panel).data(army);
lines.add(pv.Line)
  .data(function() army[this.idx])
  .left(lon).top(lat).size(function(d) d.size/8000)
  .strokeStyle(function() color[army[panelIndex][0].dir]);

```

```

vis.add(pv.Label).data(napoleon.cities)
  .left(lon).top(lat)
  .text(function(d) d.city).font("italic 10px Georgia")
  .textAlign("center").textBaseline("middle");

```

```

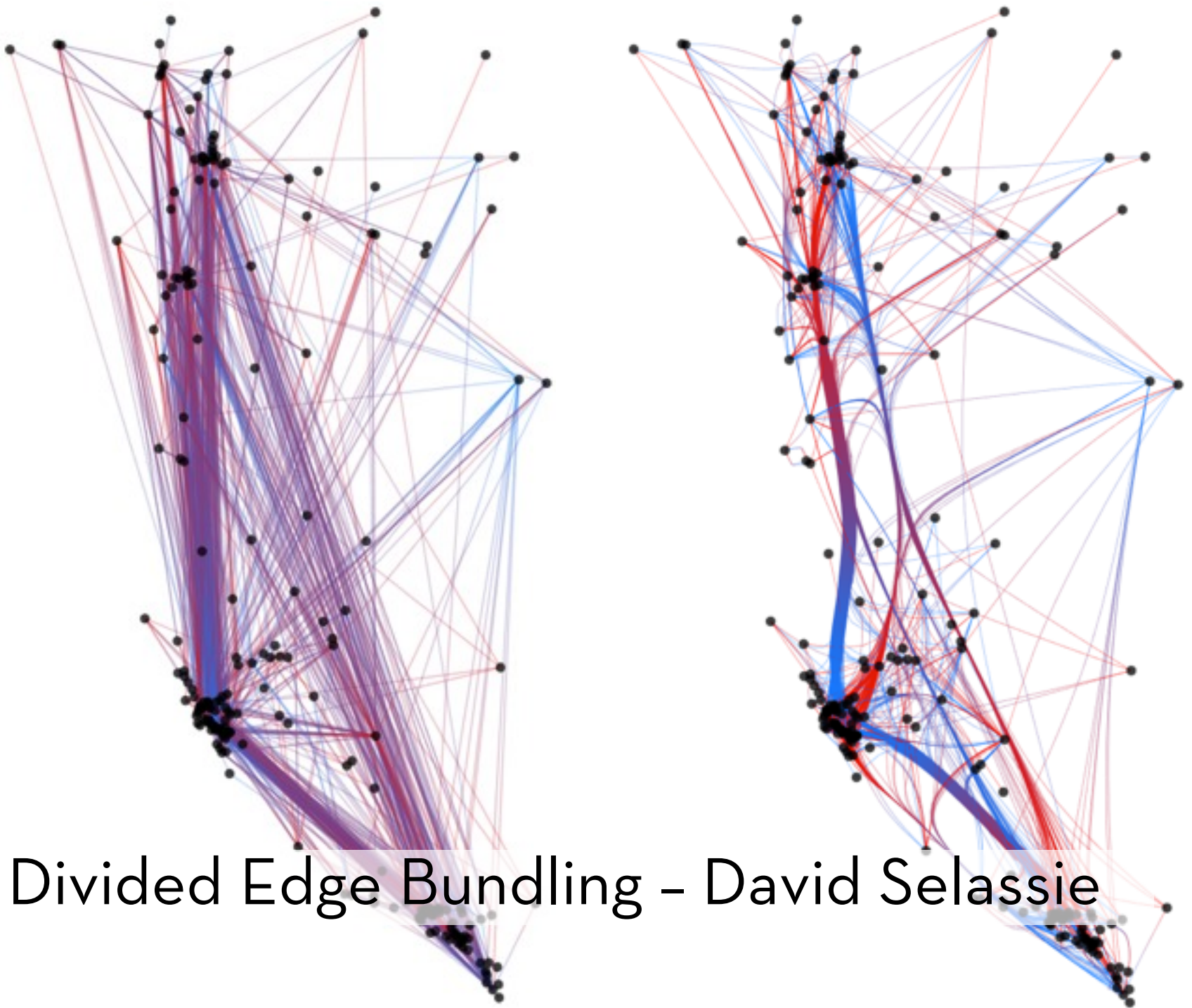
vis.add(pv.Rule).data([0,-10,-20,-30])
  .top(function(d) 300 - 2*d - 0.5).left(200).right(150)
  .lineWidth(1).strokeStyle("#ccc")
  .anchor("right").add(pv.Label)
  .font("italic 10px Georgia")
  .text(function(d) d+"°").textBaseline("center");

```

```

vis.add(pv.Line).data(napoleon.temp)
  .left(lon).top(tmp) .strokeStyle("#0")
  .add(pv.Label)
  .top(function(d) 5 + tmp(d))
  .text(function(d) d.temp+"° "+d.date.substr(0,6))
  .textBaseline("top").font("italic 10px Georgia");

```



Divided Edge Bundling - David Selassie

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



Questions?

Assignment 1: Visualization Design

Design a static visualization for a data set.

After the World War II, antibiotics were considered “wonder drugs.” To learn which drug is most effective for which bacterial infection, performance of the three most popular antibiotics were gathered.

You must choose the message you want to convey. What task do you want to support? What insight do you want to communicate?

Assignment 1: Visualization Design

Design a *static* visualization for the data set.
You are free to use any tools (inc. pen & paper).

Deliverables (upload via Catalyst; see A1 webpage)

- Image of your visualization (e.g., PNG, GIF, JPG)
- Short description and design rationale (≤ 4 paragraphs)

Due by 5:00 pm, **Monday Jan 13.**