

Visualization

Cmpt 767

Steven Bergner
sbergner@sfu.ca

Sources

- Selected contributions from
 - Torsten Möller [This is his slide deck.]
 - Raghu Machiraju
 - Tamara Munzner
 - Hanspeter Pfister
 - Melanie Tory
 - Daniel Weiskopf

What is Visualization?

- What?
- Why?
- Who?
- How?

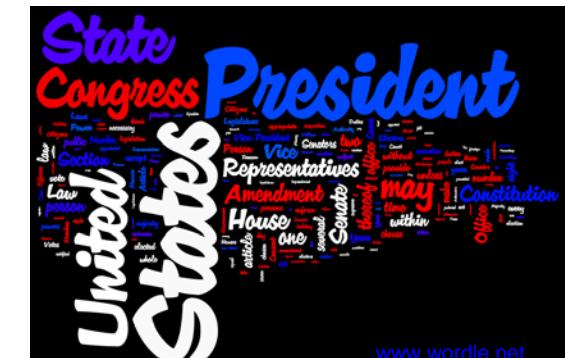
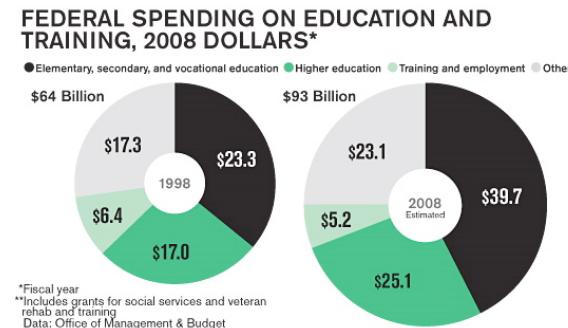


vi·su·al·ize

1. To form a mental image of
2. To make visible

Visualization

To convey information through visual representations



Definitions

- B. McCormick, T. DeFanti, and M. Brown:

Visualization is a method of computing. It transforms [the symbolic into the geometric](#), enabling researchers to observe their simulations and computations. Visualization offers a method for [seeing the unseen](#). It enriches the process of scientific discovery and fosters profound and unexpected insights. In many fields it is already revolutionizing the way scientists do science.

McCormick, B.H., T.A. DeFanti, M.D. Brown, **Visualization in Scientific Computing**, Computer Graphics 21(6), November 1987

Definitions

- Tamara Munzner, 2012:

Computer-based visualization systems provide visual representations of datasets intended to help people carry out some task more effectively.

T. Munzner: **Visualization Design and Analysis: Abstractions, Principles, and Methods**, AK Peters, 2014

Definitions

- Tamara Munzner, 2012:

Computer-based visualization systems provide visual representations of datasets intended to **help people** carry out some task more effectively.

T. Munzner: **Visualization Design and Analysis: Abstractions, Principles, and Methods**, AK Peters, 2014

Definitions

- Tamara Munzner, 2012:

Computer-based visualization systems provide **visual representations** of datasets intended to help people carry out some task more effectively.

T. Munzner: **Visualization Design and Analysis: Abstractions, Principles, and Methods**, AK Peters, 2014

Definitions

- Tamara Munzner, 2012:

Computer-based visualization systems provide visual representations of **datasets** intended to help people carry out some **task** more effectively.

T. Munzner: **Visualization Design and Analysis: Abstractions, Principles, and Methods**, AK Peters, 2014

Definitions

- Tamara Munzner, 2012:

Computer-based visualization systems provide visual representations of datasets intended to help people carry out some task **more effectively**.

T. Munzner: **Visualization Design and Analysis: Abstractions, Principles, and Methods**, AK Peters, 2014

Visualization Goals

Map

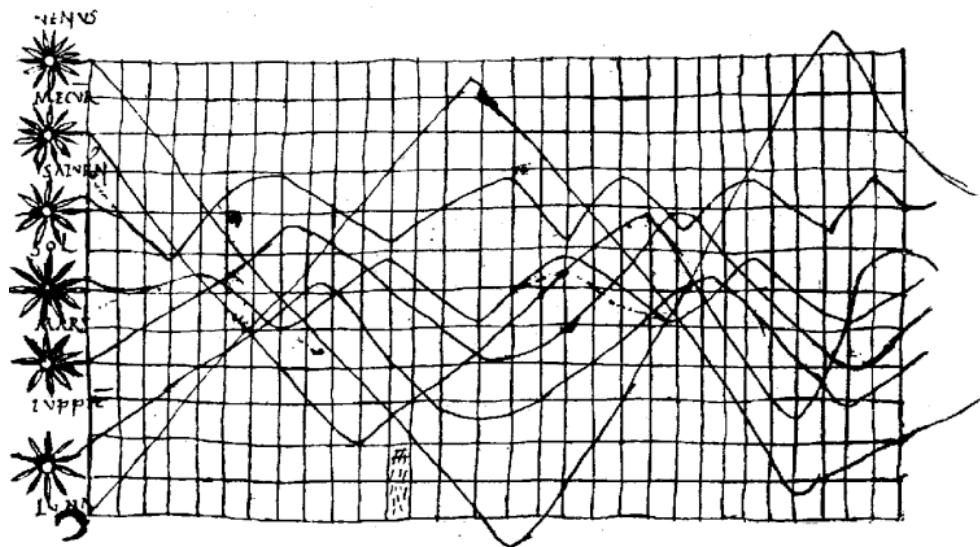


Konya town map, Turkey, c. 6200 BC

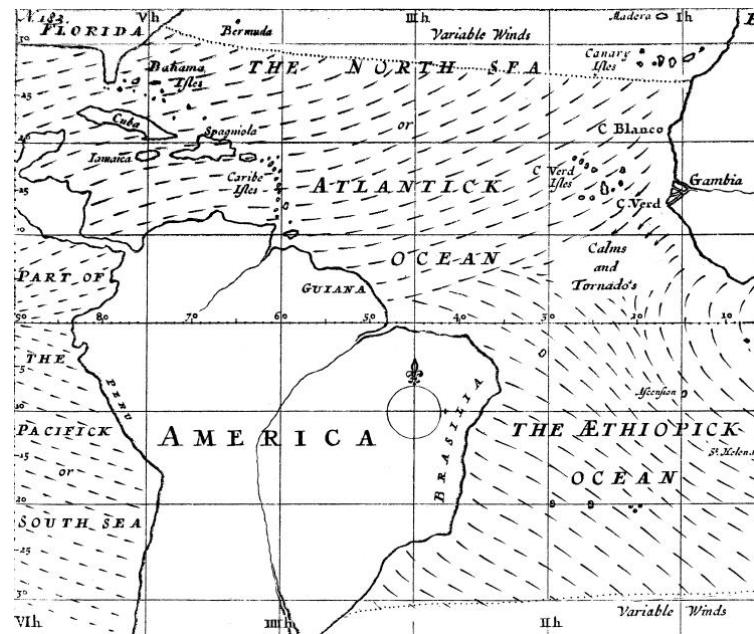


Anaximander's Map of the World
Anaximander of Miletus, c. 550 BC

Map

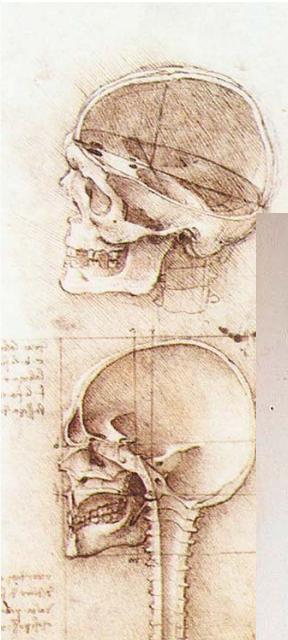


Planetary Movement Diagram, c. 950

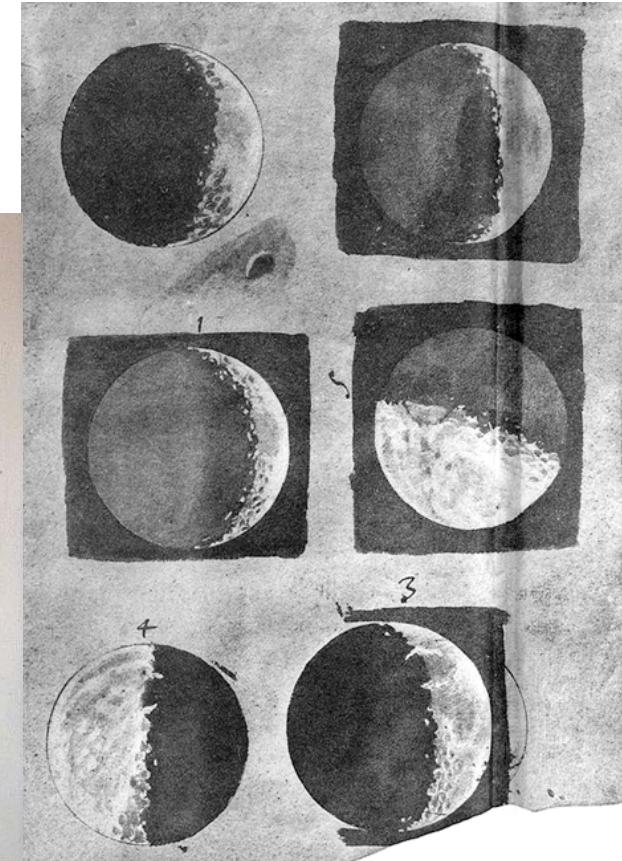


Halley's Wind Map, 1686

Record



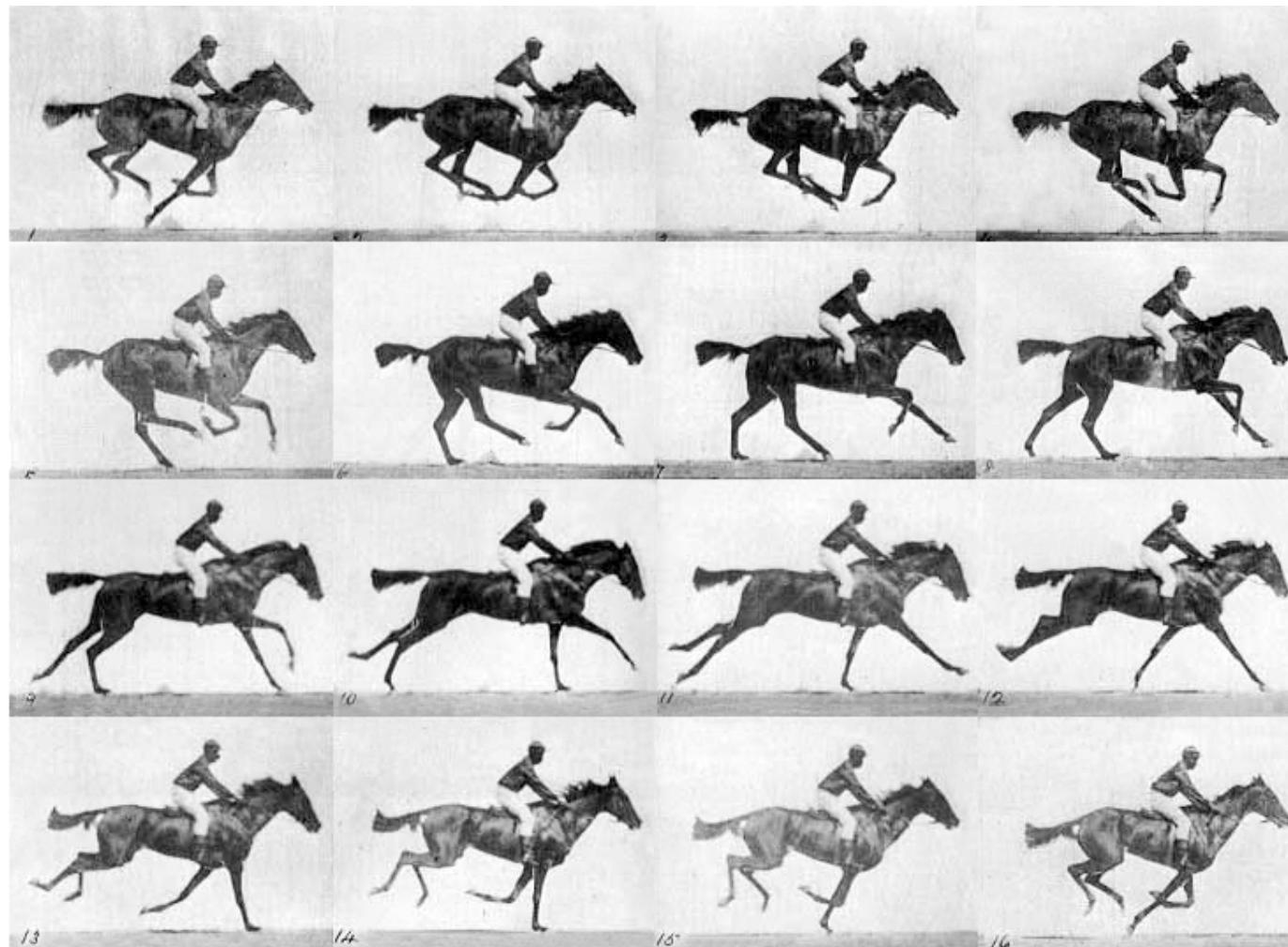
Leonardo Da Vinci, ca. 1500



Galileo Galilei, 1616

William Curtis (1746-1799)

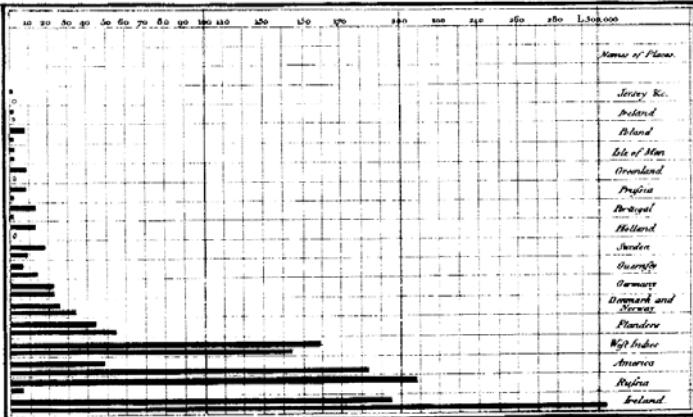
Record



E. J. Muybridge, 1878

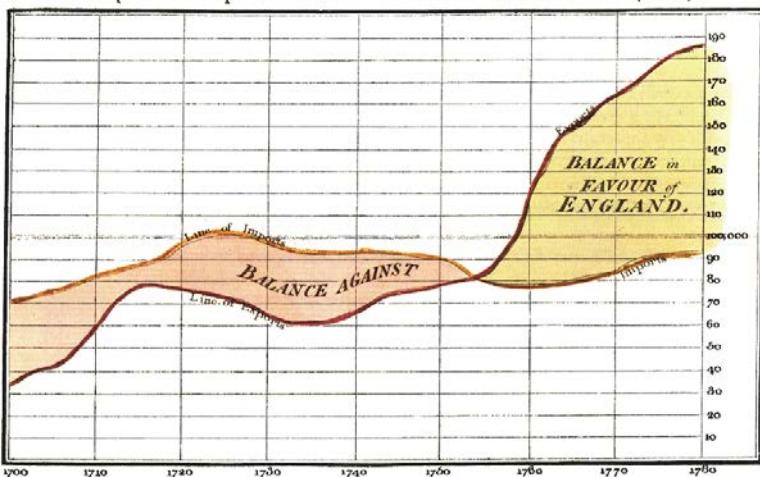
Abstract

Exports and Imports of SCOTLAND to and from different parts for one Year from Christmas 1780 to Christmas 1781.

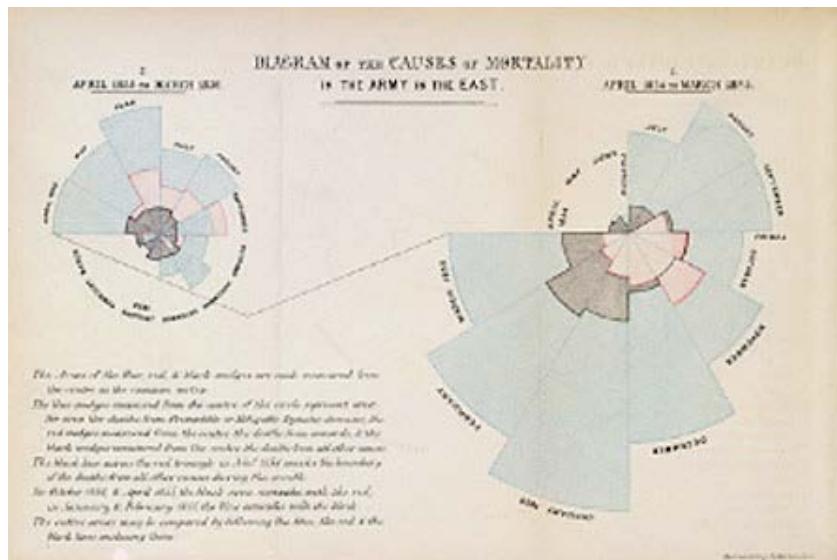


The length of the bars are Ten Thousand Pounds each. The black Lines are Exports the Red Coloured Imports.
Added to the above, see my 8th Chart.

Exports and Imports to and from DENMARK & NORWAY from 1700 to 1780.



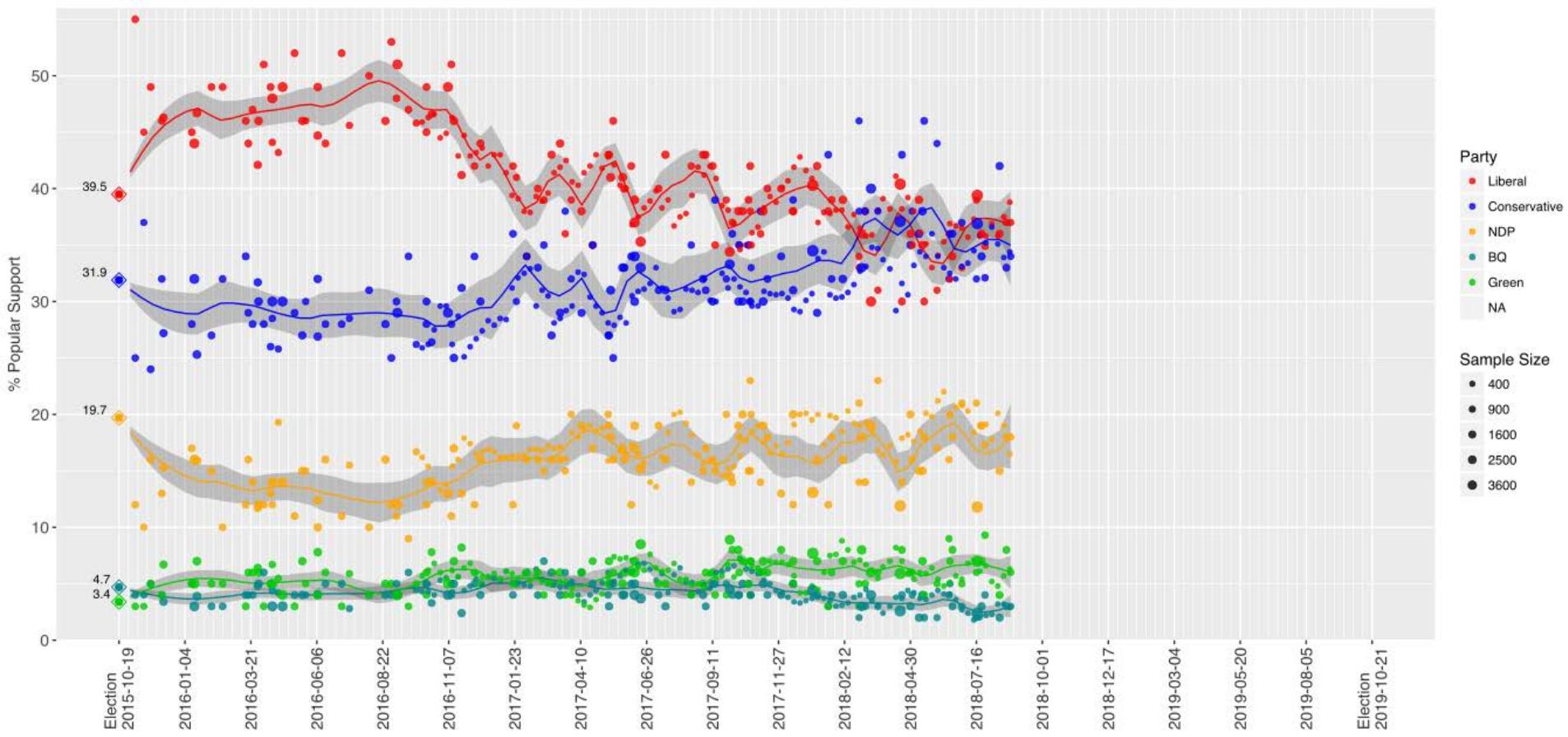
W. Playfair, 1786



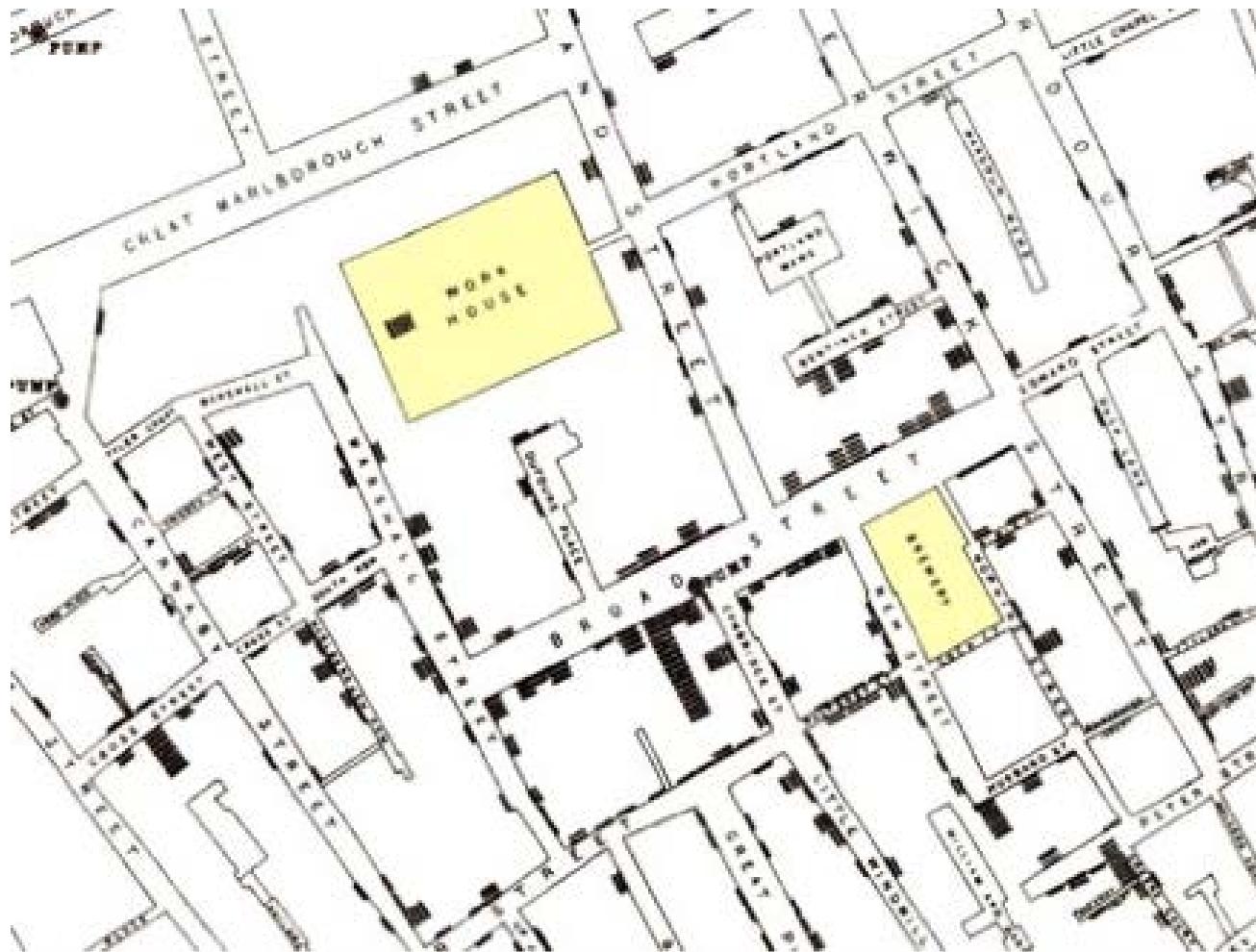
F. Nightingale, 1856

Abstract

Canadian pre-campaign voting intentions for the federal election 2019



Discover



John Snow, 1854

E. Tufte, Visual Explanations, 1997

Discover

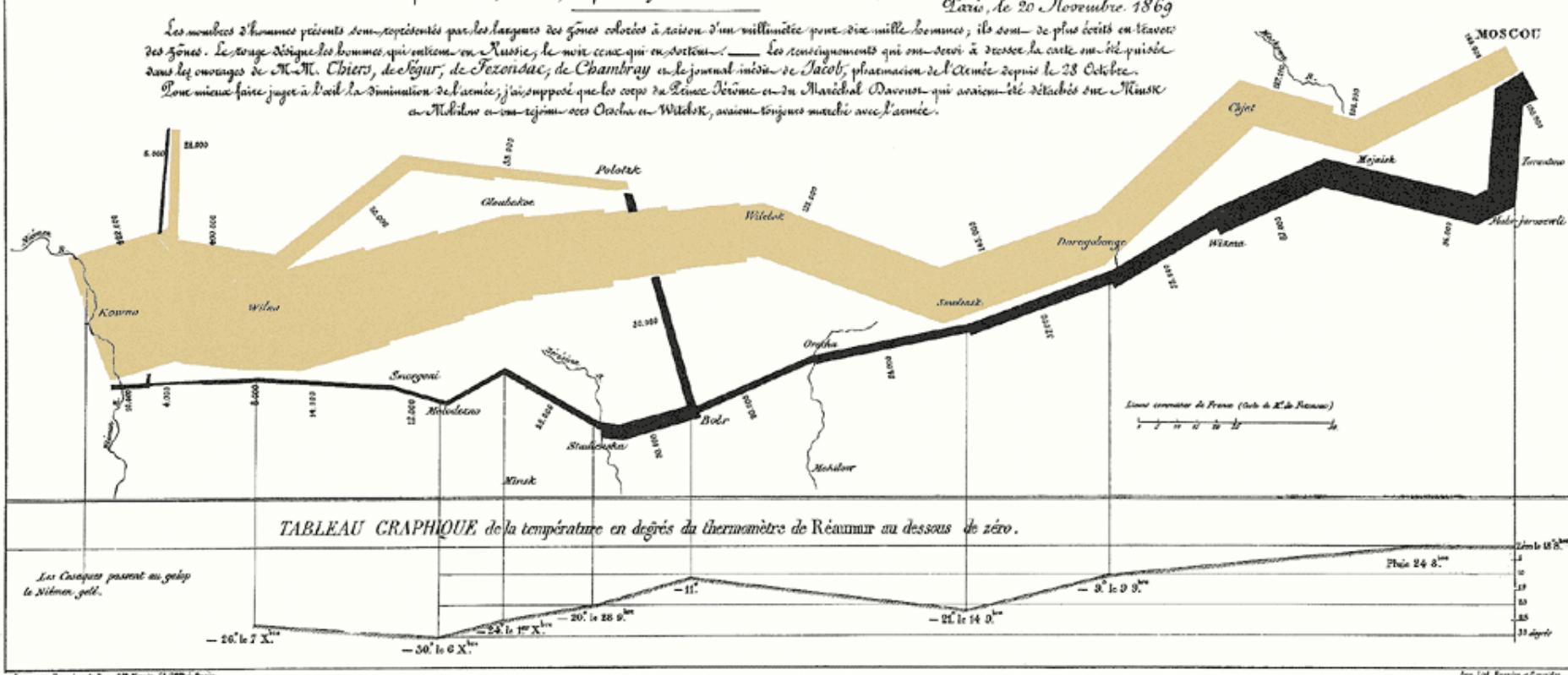
Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.

Créée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite.

Paris, le 20 Novembre 1869

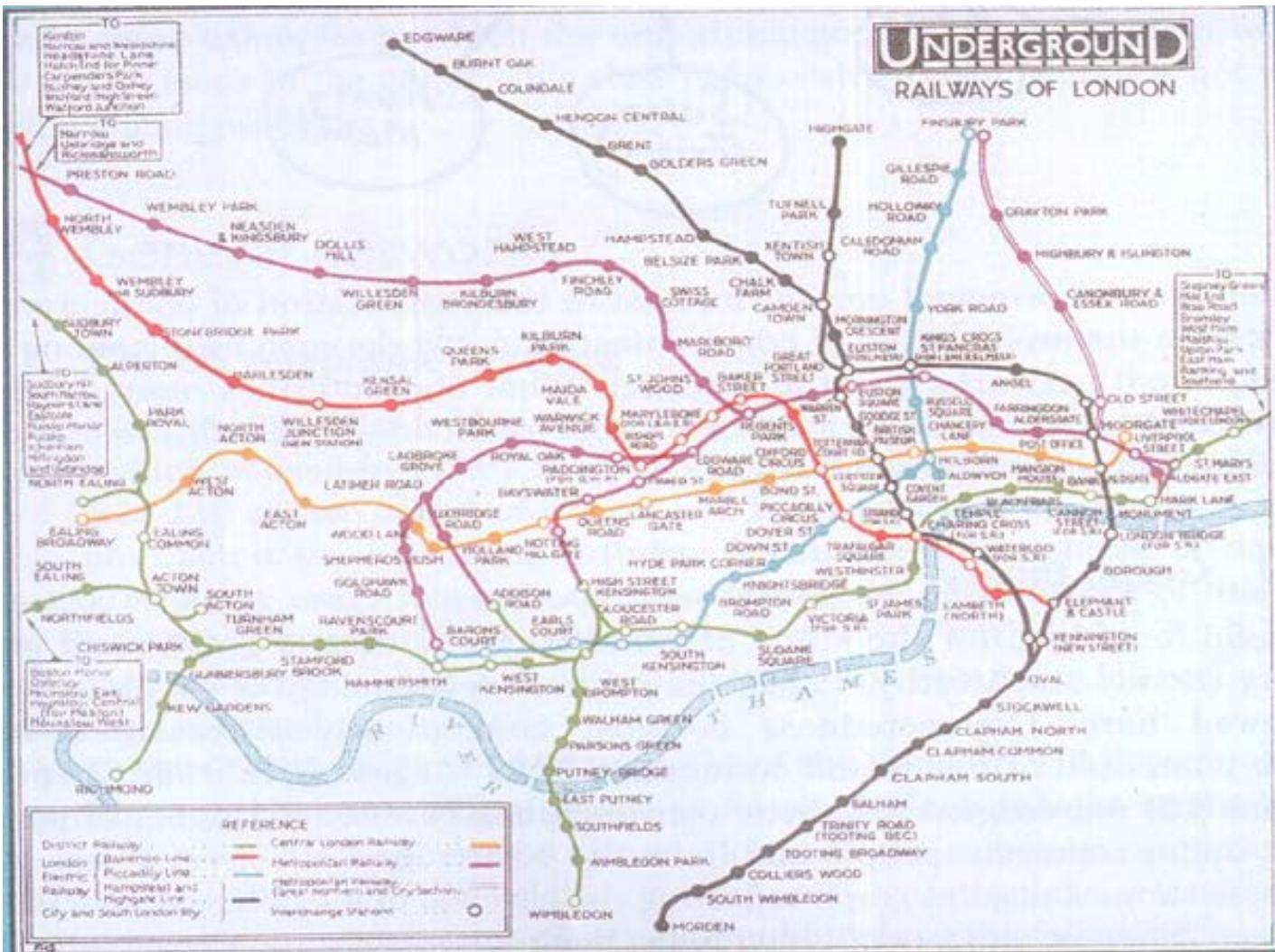
Les nombres d'hommes perdus sont représentés par les larges des zones colorées à raison d'un millimètre pour dix-mille hommes ; ils sont de plus écrits en lettres ces zones. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. — Les renseignements qui ont servi à dresser la carte ont été pris dans les ouvrages de M. Chiers, de Léger, de Tessonac, de Chambray, du journal intime de Jacob, pharmacien de l'Armée depuis le 28 Octobre.

Pour mieux faire juger à l'est la diminution de l'armée, j'ai supposé que les corps de L'armée Iéronine et du Maréchal Davout qui avaient été détachés sur Moscou au début de l'expédition avec Ossatch et Wladiwostok, avaient longé marché avec l'armée.



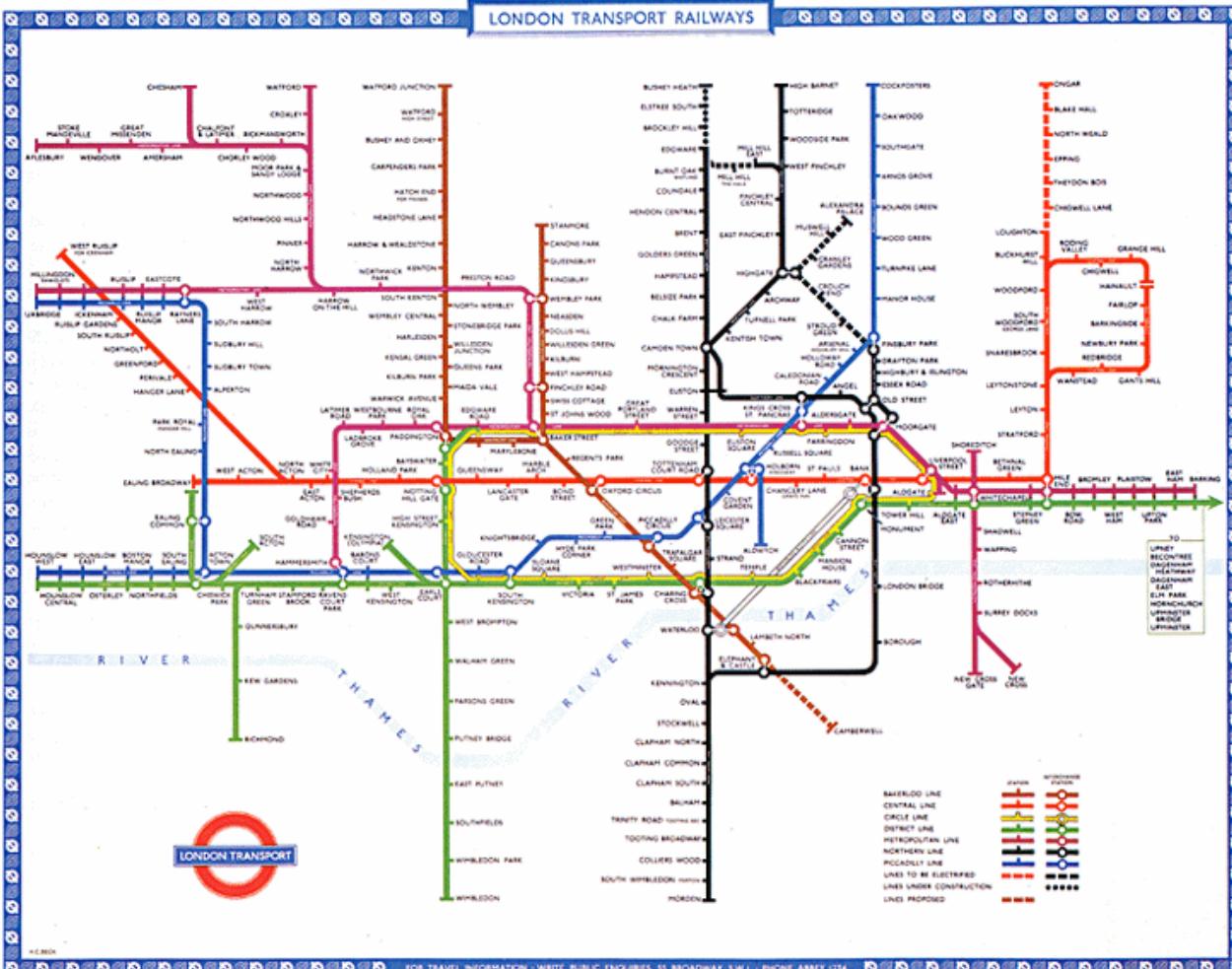
C.J. Minard, 1869

Clarify



London Subway Map, 1927

Clarify



Harry Beck, 1933

Interact



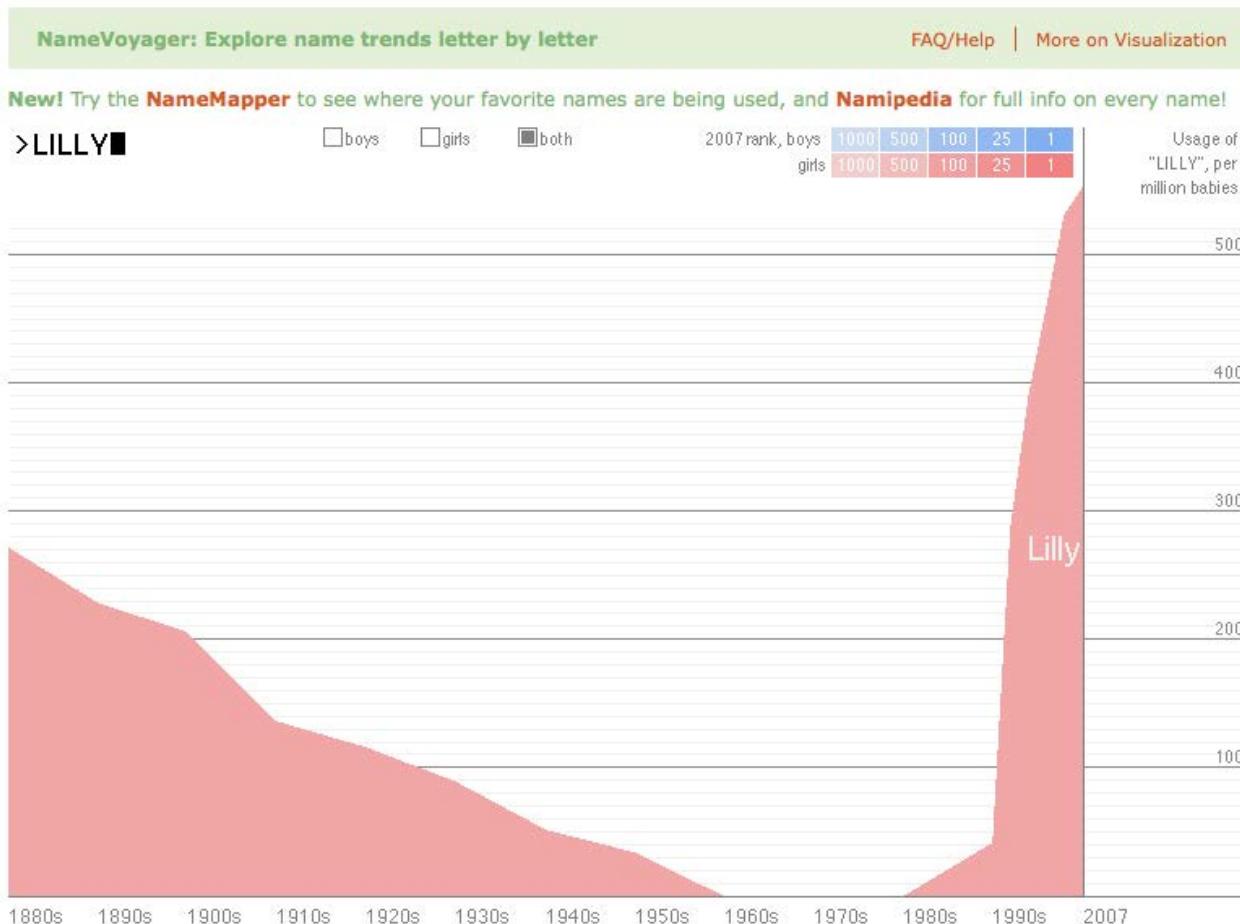
Ivan Sutherland, Sketchpad, 1963

[play Engelbart.mov]



Doug Engelbart, 1968

Interact

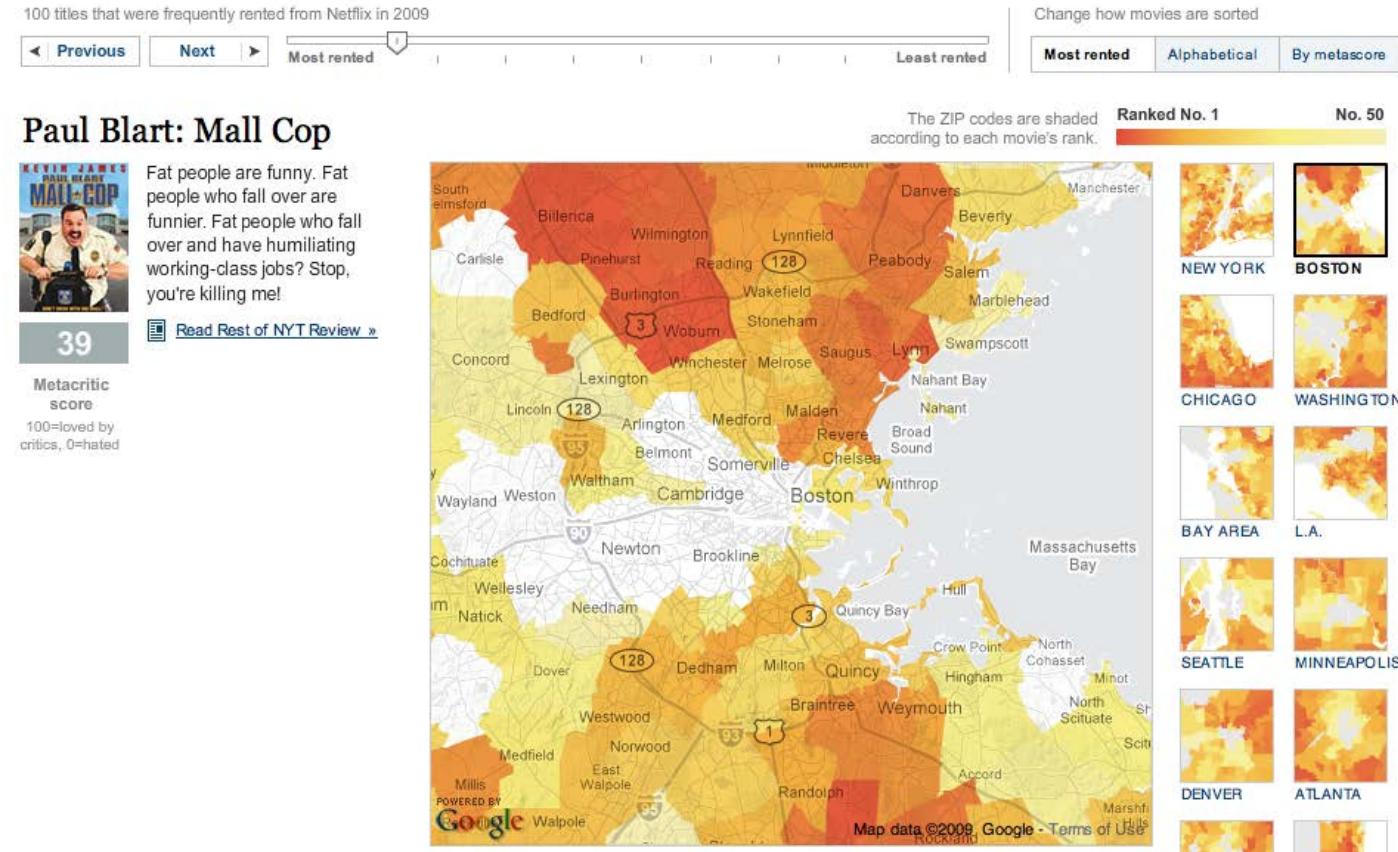


M. Wattenberg, 2005

Interact

A Peek Into Netflix Queues

Examine Netflix rental patterns, neighborhood by neighborhood, in a dozen cities. Some titles with distinct patterns are *Mad Men*, *Obsessed* and *Last Chance Harvey*. [Comments \(131\)](#)



Communicate

118
hits

i don't want to recall



Many Eyes, 2007

Communicate

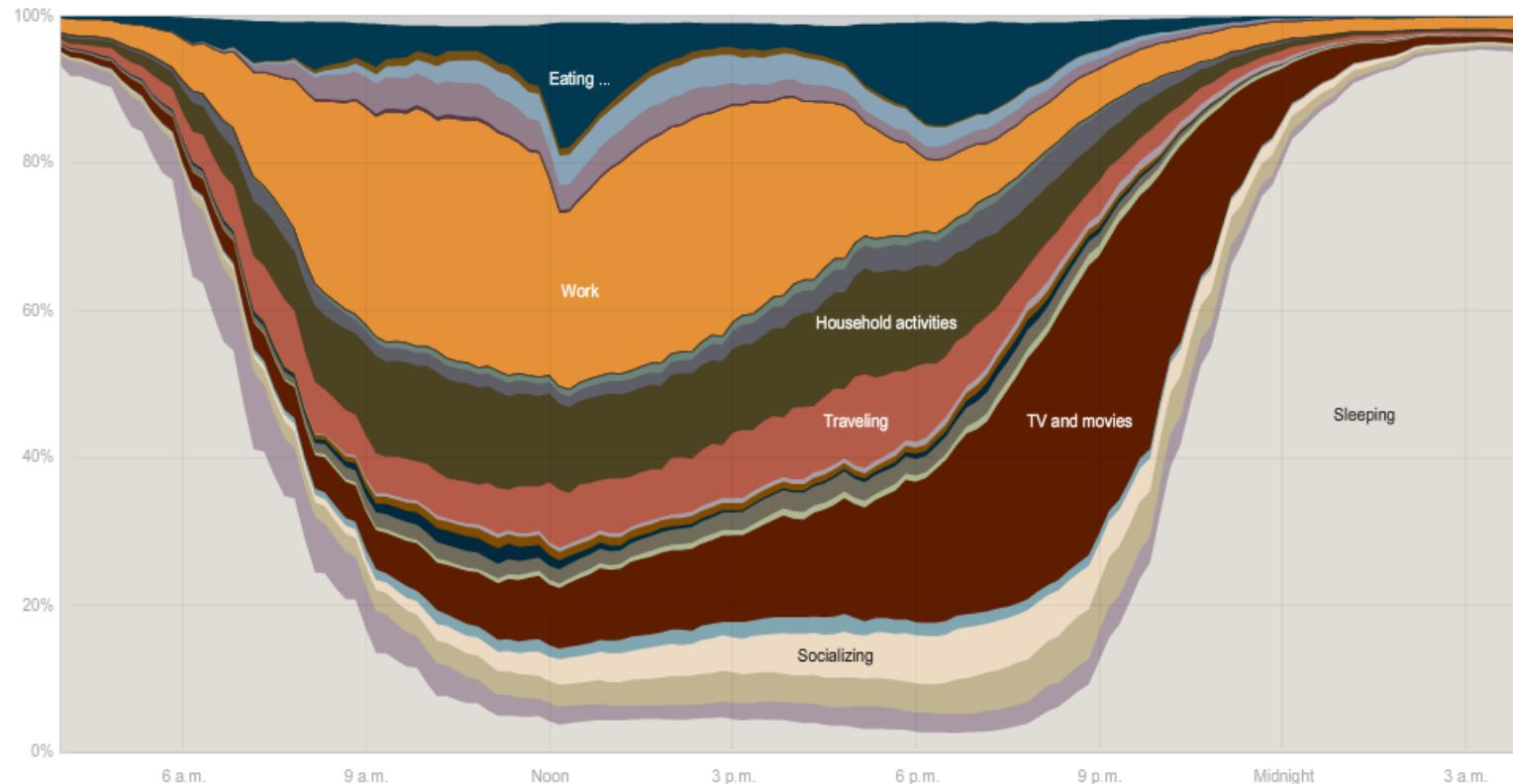
How Different Groups Spend Their Day

The American Time Use Survey asks thousands of American residents to recall every minute of a day. Here is how people over age 15 spent their time in 2008. [Related article](#)

Everyone

Sleeping, eating, working and watching television take up about two-thirds of the average day.

| Everyone | Employed | White | Age 15-24 | H. S. grads | No children |
|----------|---------------|----------|-----------|-------------|---------------|
| Men | Unemployed | Black | Age 25-64 | Bachelor's | One child |
| Women | Not in lab... | Hispanic | Age 65+ | Advanced | Two+ children |



Formation of a Spiral Galaxy

DIRECTOR **Takaaki Takeda**

AFFILIATION **4D2U Project**

Inspire / Tell a Story



Hans Rosling, TED 2006

Visualization

- To convey information through visual representations

Map

Record

Abstract

Discover

Clarify

Goals

- Insight and analysis
 - Extract the information content
 - Make things/coherences visible that are not apparent
 - Analyze the data by means of the visual representation
- Communication
 - Allow the non-expert to understand
 - Present specific information in a way that all of us understand
 - Guide the expert into the right direction
- Exploration
 - Interactively control and drive your application
 - Use the visual representation to understand the phenomena as soon as possible
- “The purpose of computing is insight not numbers”
(Hamming 1962)

What is Visualization?

- What?
- Why?
- Who?
- How?

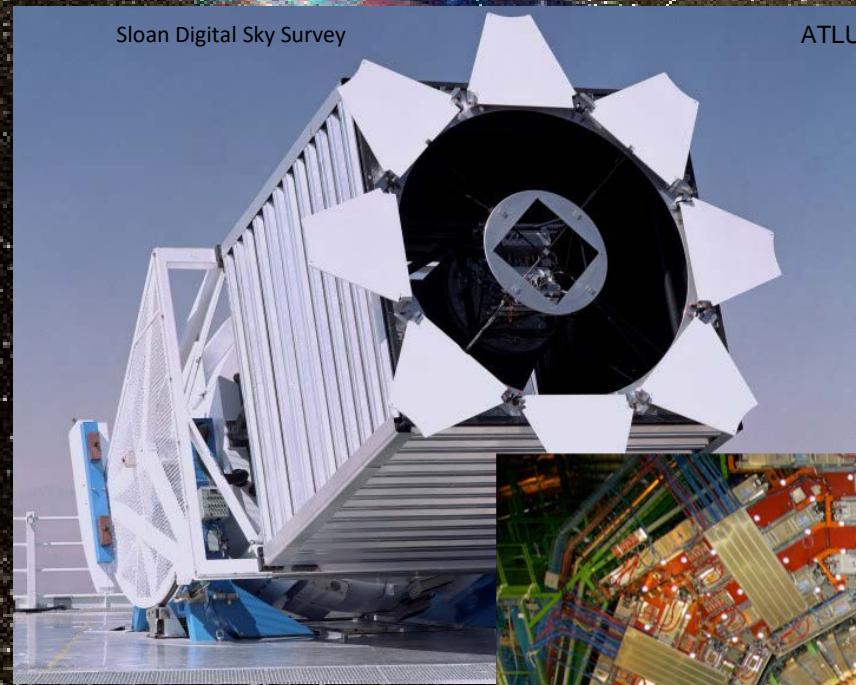
Information Explosion

The collage illustrates the "Information Explosion" through several web 2.0 interfaces:

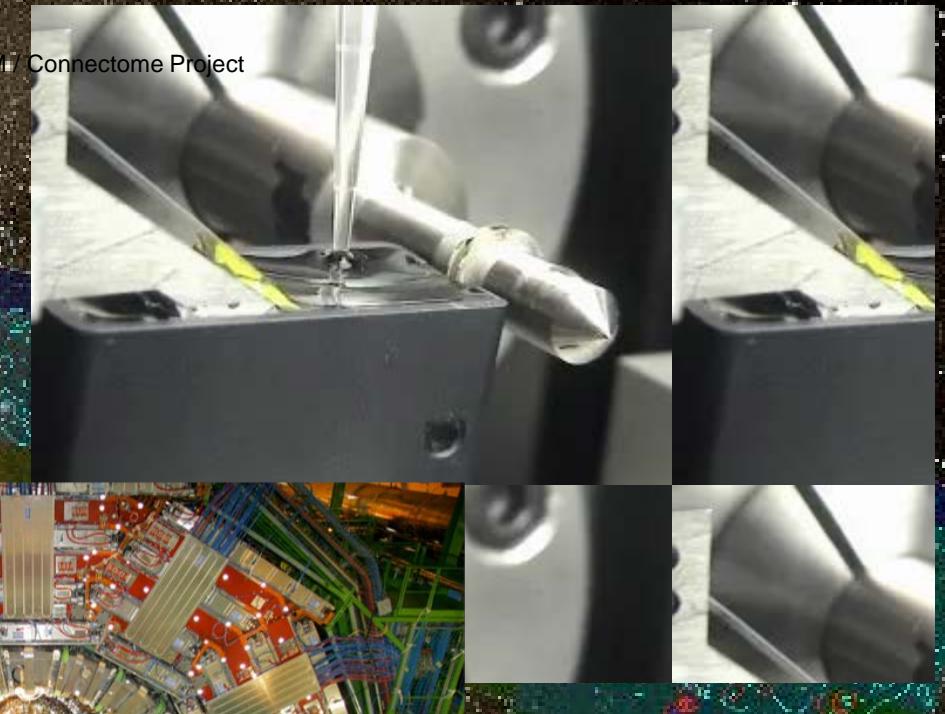
- Google Reader (1000+)**: Shows a feed with items from "Data Mining: Text Mining, Visualization and Social Media" and "Subtraction".
- Twitter**: Shows a timeline with tweets from users like **guykawasaki** and **timoreilly**.
- Wikipedia**: Displays the main page with sections for English, Deutsch, Polski, Nederlands, and Português.
- Digg**: Shows a news feed with stories like "Barack Obama wins South Carolina Democratic primary" and "Driver Who Killed Teen Sues for Damaged Vehicle".
- Facebook**: Shows a group page for "Barack Obama for President in 2008" with 100,000+ members and posts from "Students for Barack Obama".

Instrument Data Explosion

Sloan Digital Sky Survey



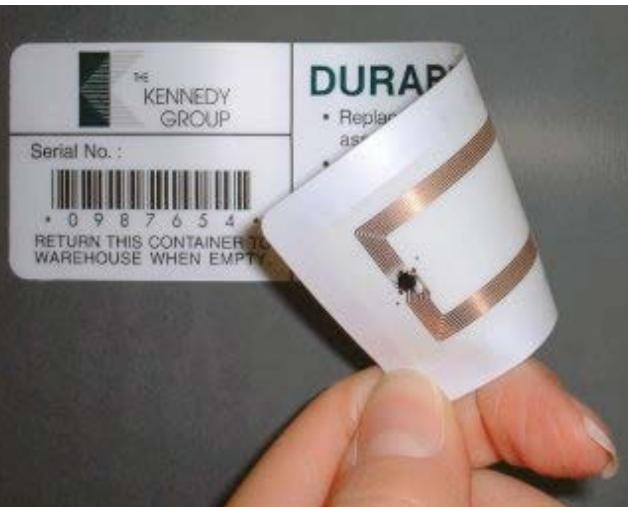
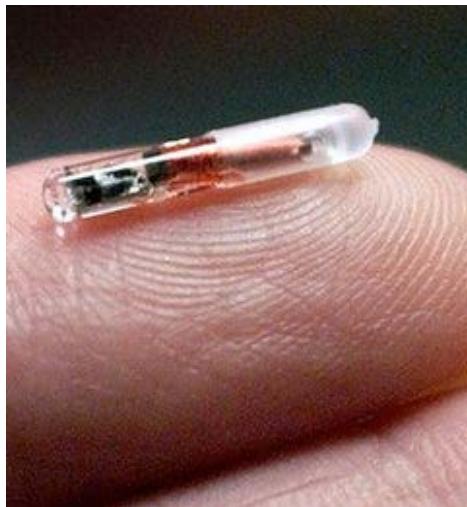
ATLUM Connectome Project



Maximilien Brice, © CERN

“The Industrial Revolution of Data”

Joe Hellerstein, UC Berkeley



Limits of Cognition



Daniel J. Simons and Daniel T. Levin, Failure to detect changes to people during a real world interaction, 1998

“It is things that make us smart.”

Donald Norman



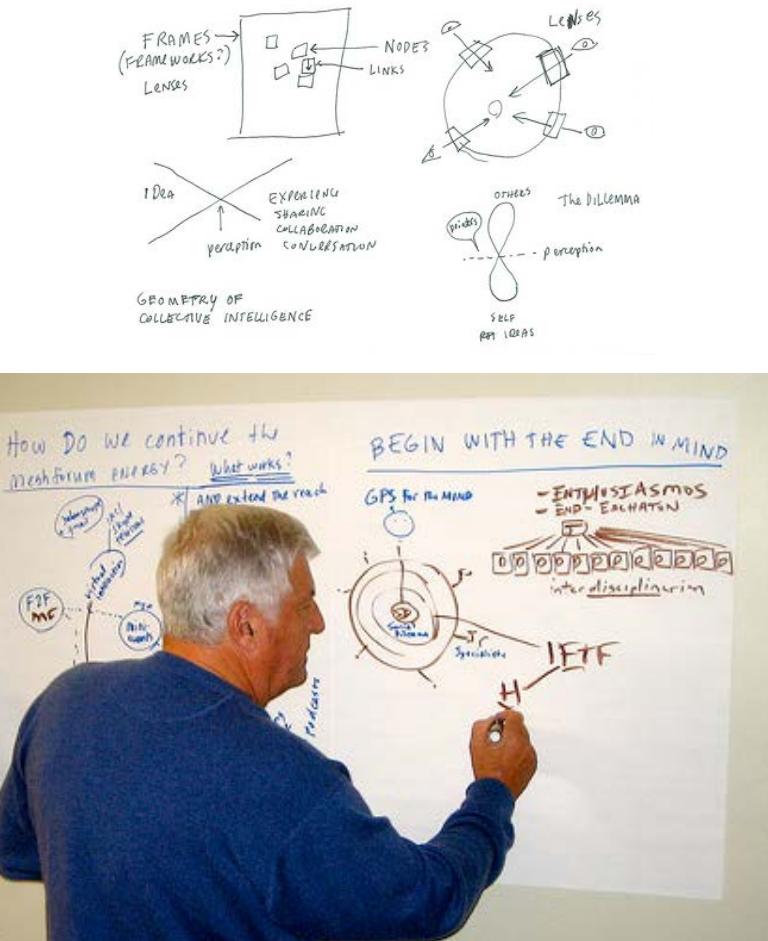
“It is things that make us smart.”

Donald Norman



“It is things that make us smart.”

Donald Norman



Visual Thinking Collection, Dave Grey



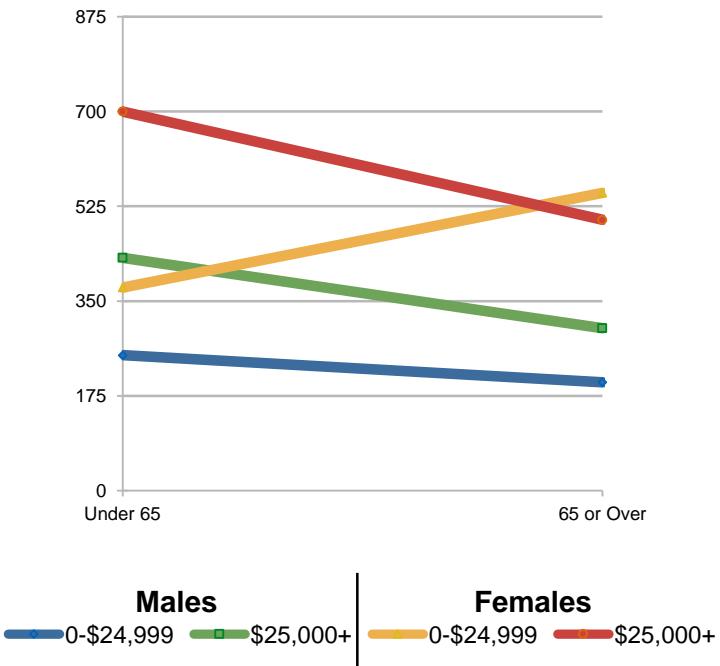
Idea Maps, by Jamie Nast

Mental Queries

Which gender or income level group shows different effects of age on triglyceride levels?

| Income Group | Males | | Females | |
|--------------|----------|------------|----------|------------|
| | Under 65 | 65 or Over | Under 65 | 65 or Over |
| 0-\$24,999 | 250 | 200 | 375 | 550 |
| \$25,000+ | 430 | 300 | 700 | 500 |

Visual Queries



Visualization

- Helps us think
- Reduces load on working memory
- Offloads cognition
- Uses the power of human perception

What is Visualization?

- What?
- Why?
- Who?
- How?

About You

What is Visualization?

- What?
- Why?
- Who?
- How?

Goals of this course

- Learn basic design and perceptual principles
- Explore different visualization methods
- Implement an interactive visualization

Educational Goals

- Visualization specialist ... practitioner ... novice++
- Theory
 - Classification
 - Algorithms
 - Visual design
- Application
 - Methods
 - Visualization packages
- Experience
 - How to visualize something in the best way

Outline

- Fundamentals
 - What is vis?
 - Design principles
 - The visualization process
 - Data abstractions + Task abstractions
 - Design studies
- Visual Encodings + Algorithms
 - Basic visual encoding principles
 - Tables (Dimension reduction)
 - Spatial data (Interpolation)
 - Networks / trees (Embedding)
 - Time-varying data
 - 3D scalar fields (isosurfaces + volume rendering)
- Perception + Cognition
 - Color
 - Aggregation: Items + Attributes
 - Space / Order; Multiple views
 - Depth / Occlusion; Focus + Context
- Special topics
 - Machine learning models
 - Big Data
- Applications
 - Science (Climate data)
 - Medical Imaging
 - Business

Syllabus

See Web Page

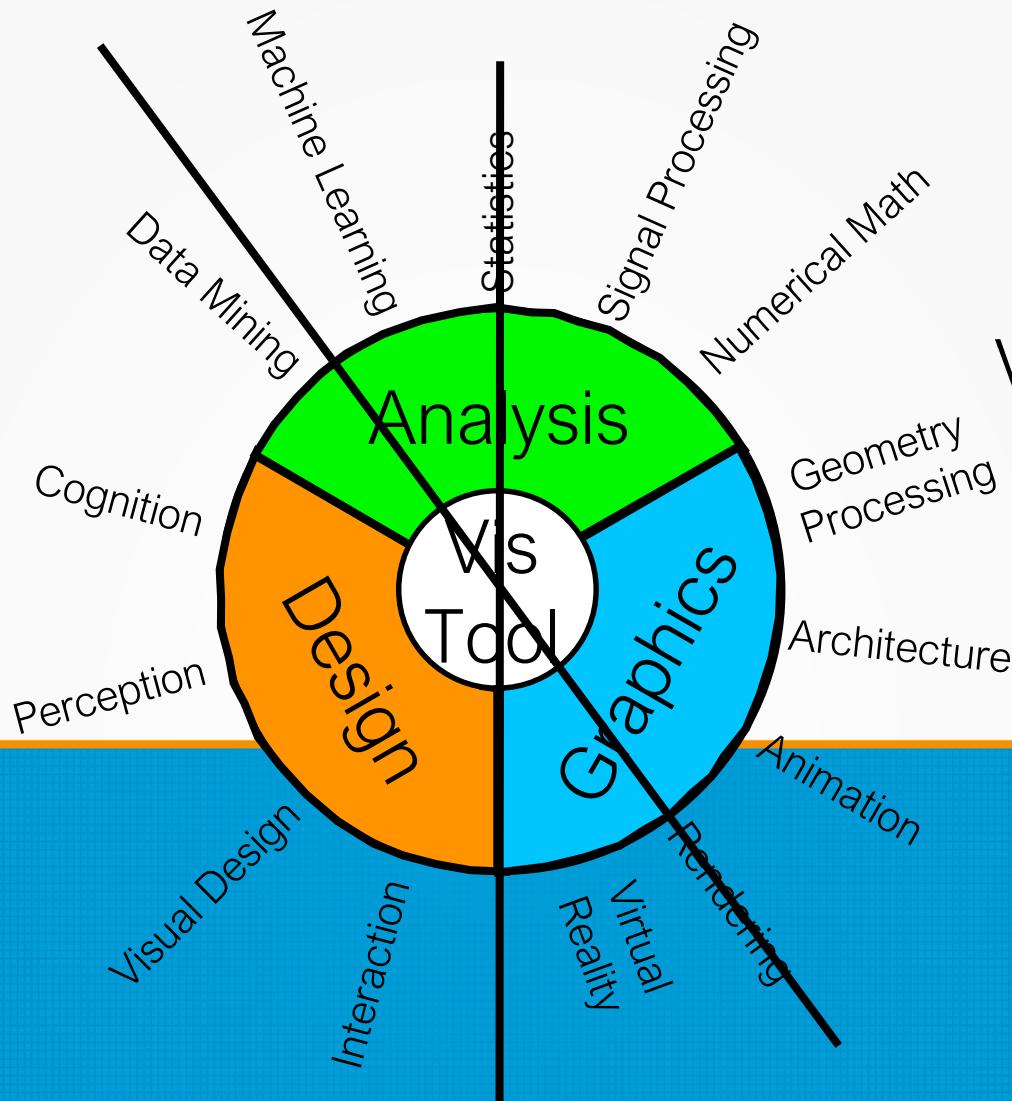
<https://stevenbergner.github.io/Teaching/cmpt767/>

Related Fields

“Visual
Analytics”

“Scientific
Visualization”

“Information
Visualization”



Visualization Flavors

- Spatial Data Vis (aka: Scientific visualization)
 - User Interfaces
 - Data representation/processing
 - Algorithms
 - Visual representations
 - Mainly: *Continuous* models + Mathematical approach
- Non-Spatial Data Vis (aka: Information visualization)
 - Abstract data
 - WWW documents
 - File structures
 - Arbitrary relationships
 - ...
 - Mainly: *Discrete* models + Human-Centered Design

Textbook

- Tamara Munzner, Visualization Analysis & Design: Abstractions, Principles, and Methods, CRC Press, 2014

(Spatial) Visualization Tools

- Great / free:
 - VTK (The Visualization Toolkit) <http://www.vtk.org>
 - ParaView
- Commercial tools:
 - Amira <http://www.amiravis.com>
 - AVS/Express <http://www.avs.com>
 - IDL
<http://www.exelisvis.com/IntelliEarthSolutions/GeospatialProducts/IDL.aspx>
 - IRIS Explorer http://www.nag.co.uk/WELCOME_IEC.asp
 - OpenDX (now open software): <http://www.opendx.org>

(Non-Spatial) Vis. Tools

- Tamara's resources page!

<http://www.cs.ubc.ca/~tmm/courses/533-11/resources.html>

- Free:

- Processing

<http://www.processing.org/>

- Prefuse (java)

<http://prefuse.sourceforge.net/>

- D3

<http://alignedleft.com/work/d3-book>

- Xgobi

<http://www.research.att.com/areas/stat/xgobi/>

- Commercial tools:

- Tableau

<http://www.tableausoftware.com/>