

Visualization

Cmpt 767

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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

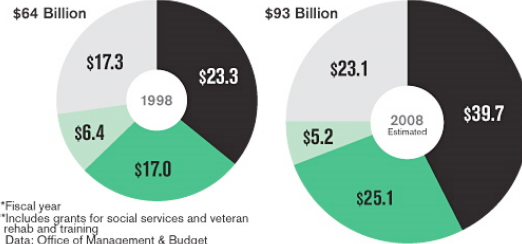
Visualization

To convey information through visual representations

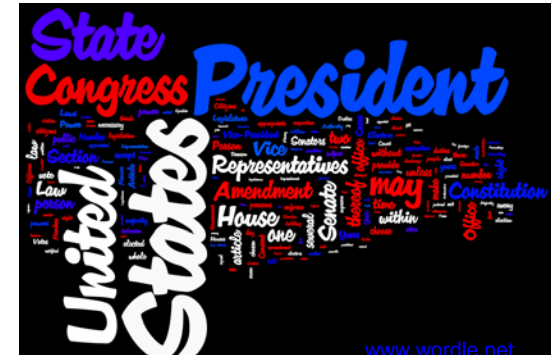
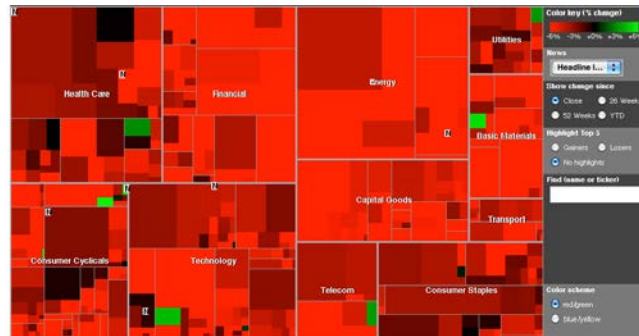


FEDERAL SPENDING ON EDUCATION AND TRAINING, 2008 DOLLARS*

● Elementary, secondary, and vocational education ● Higher education ● Training and employment ● Other**



*Fiscal year
**Includes grants for social services and veteran rehab and training
Data: Office of Management & Budget



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

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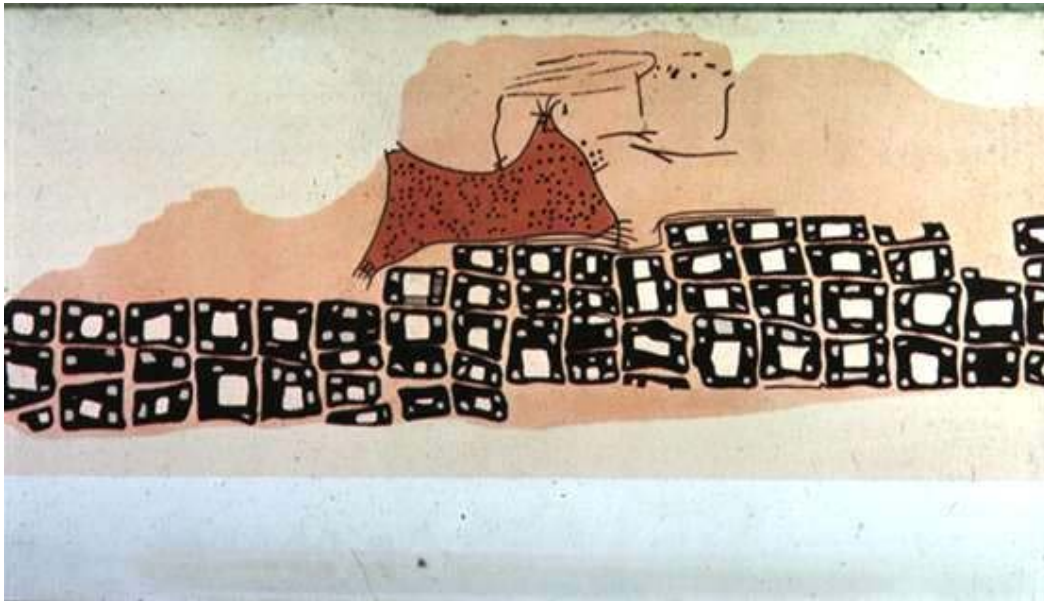
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Visualization Goals

Map



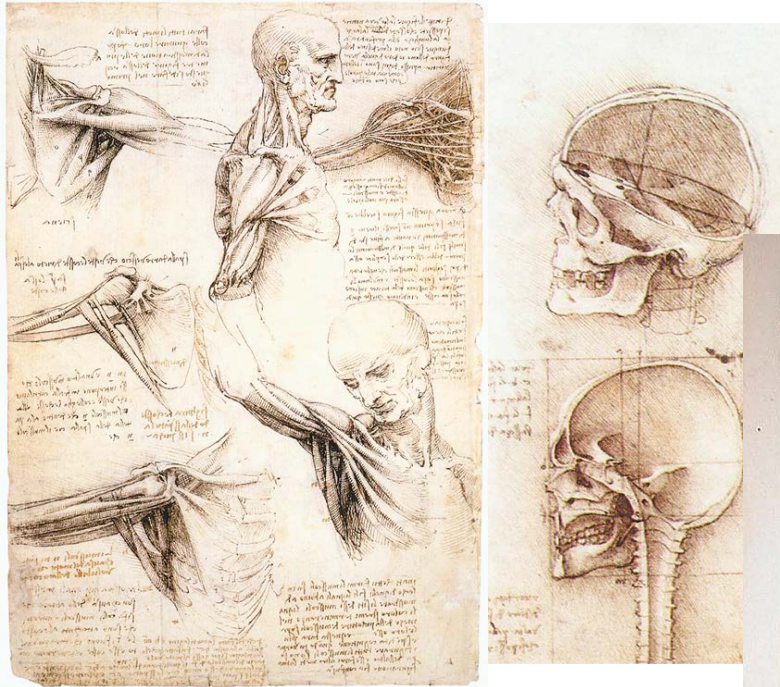
Konya town map, Turkey, c. 6200 BC



Anaximander's Map of the World

Anaximander of Miletus, c. 550 BC

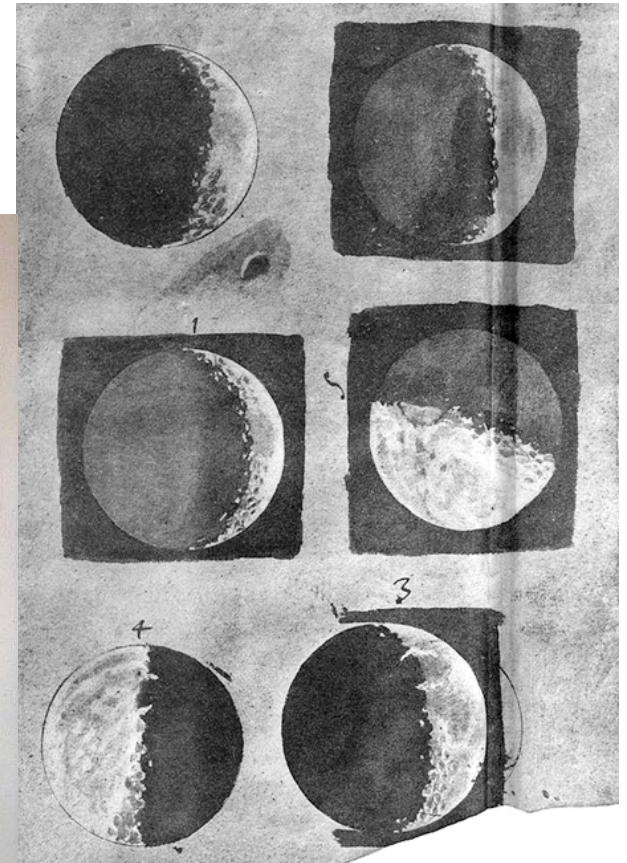
Record



Leonardo Da Vinci, ca. 1500

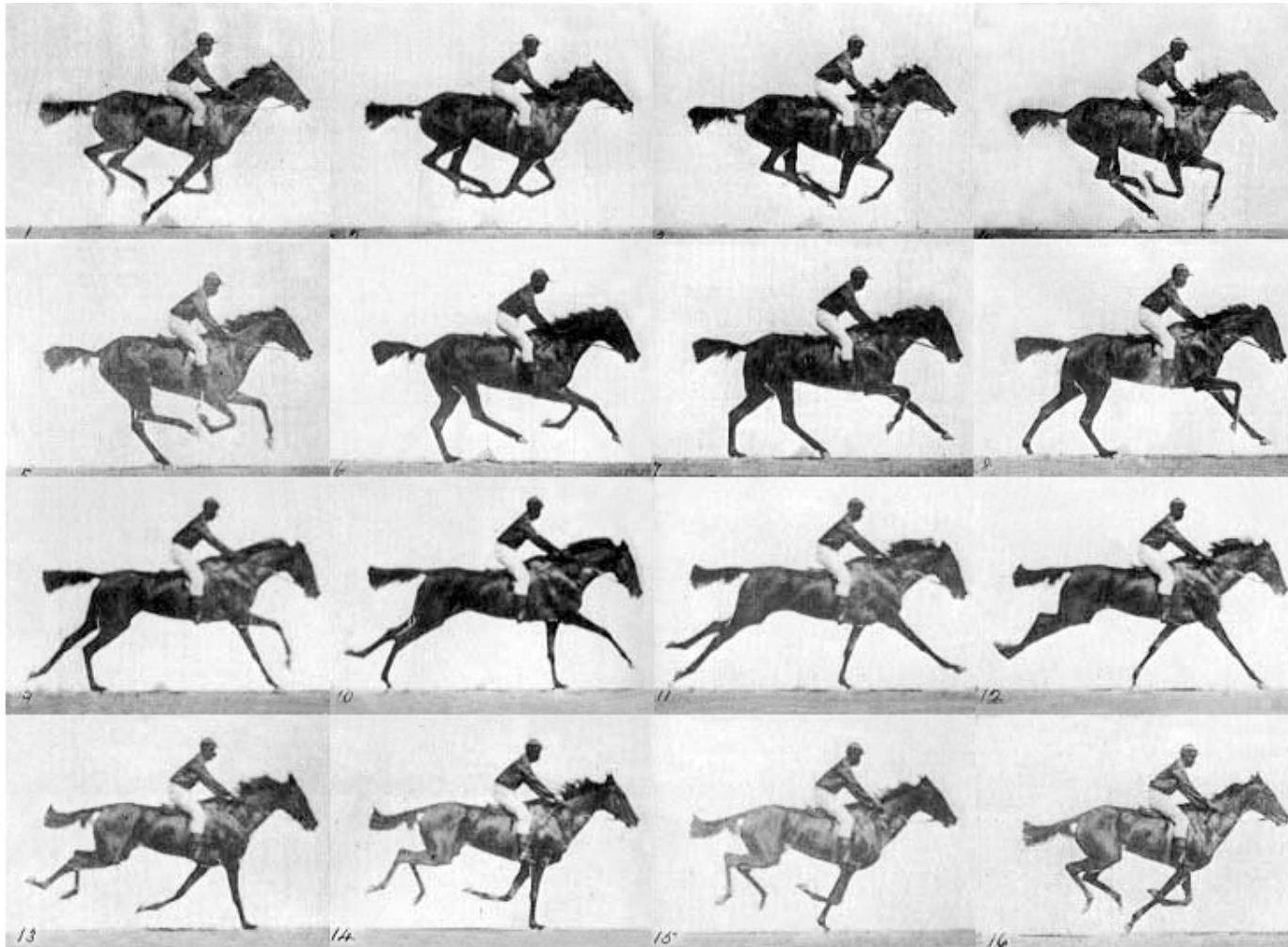


William Curtis (1746-1799)



Galileo Galilei, 1616

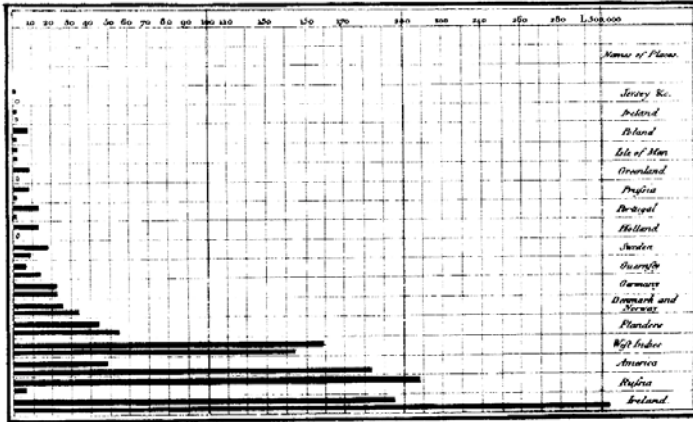
Record



E. J. Muybridge, 1878

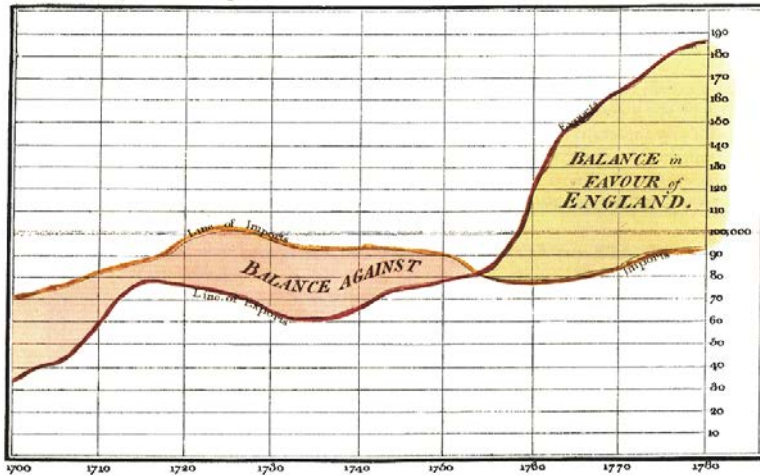
Abstract

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

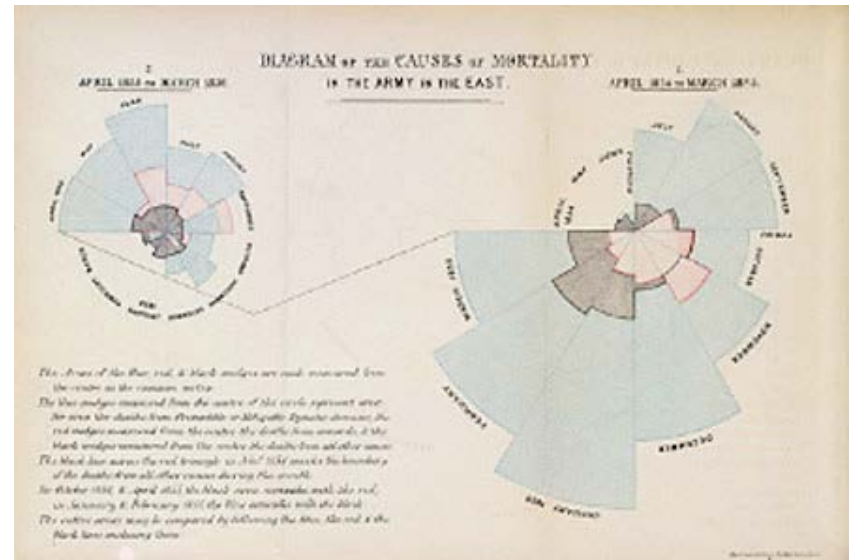


The upright divisions are Ten Thousand Pounds each. The Black Lines are Exports the Reddish Lines Imports.
 Published in the Edinburgh Journal of 1781 by W. Playfair.
 See map 1331 of same. London.

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



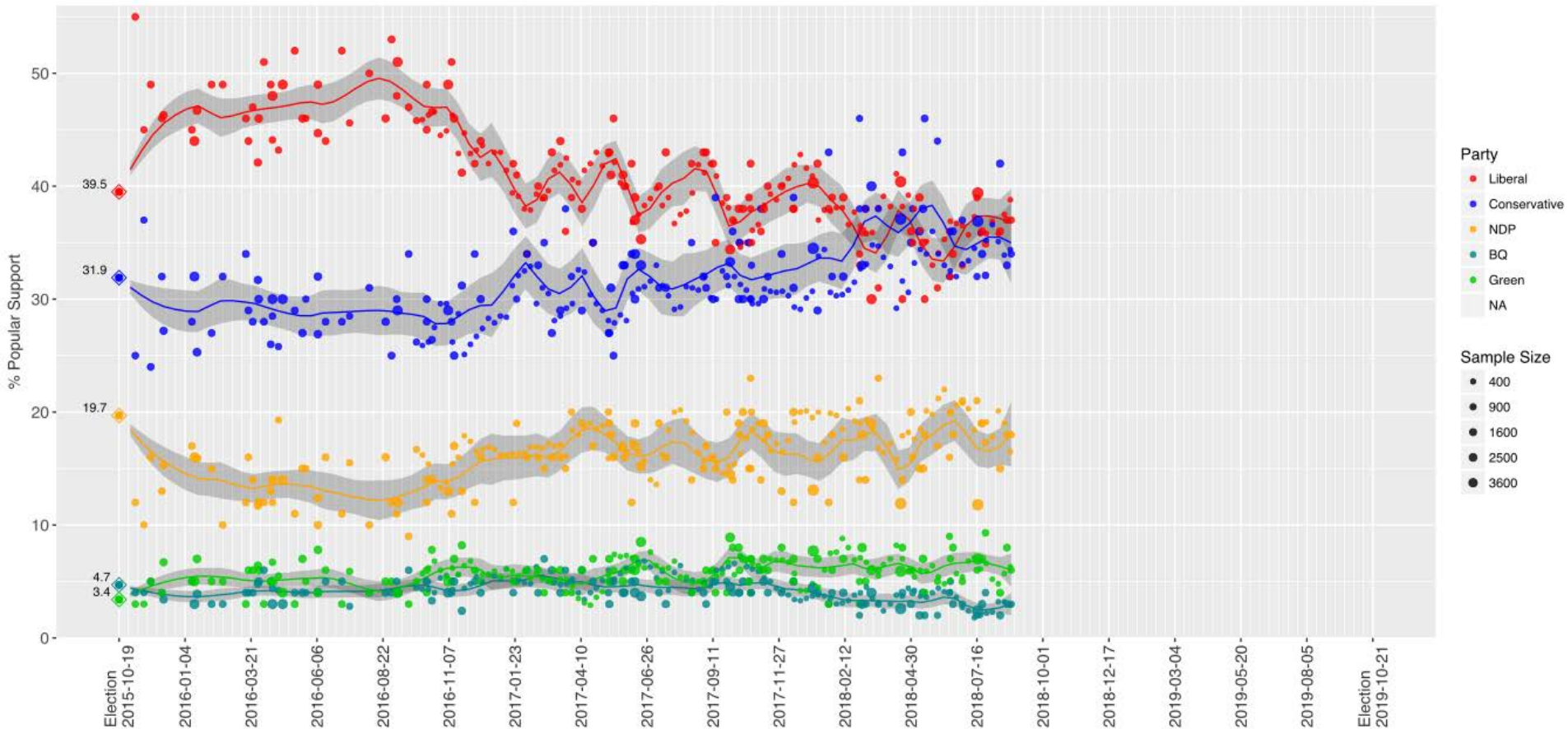
W. Playfair, 1786



F. Nightingale, 1856

Abstract

Canadian pre-campaign voting intentions for the federal election 2019



Discover



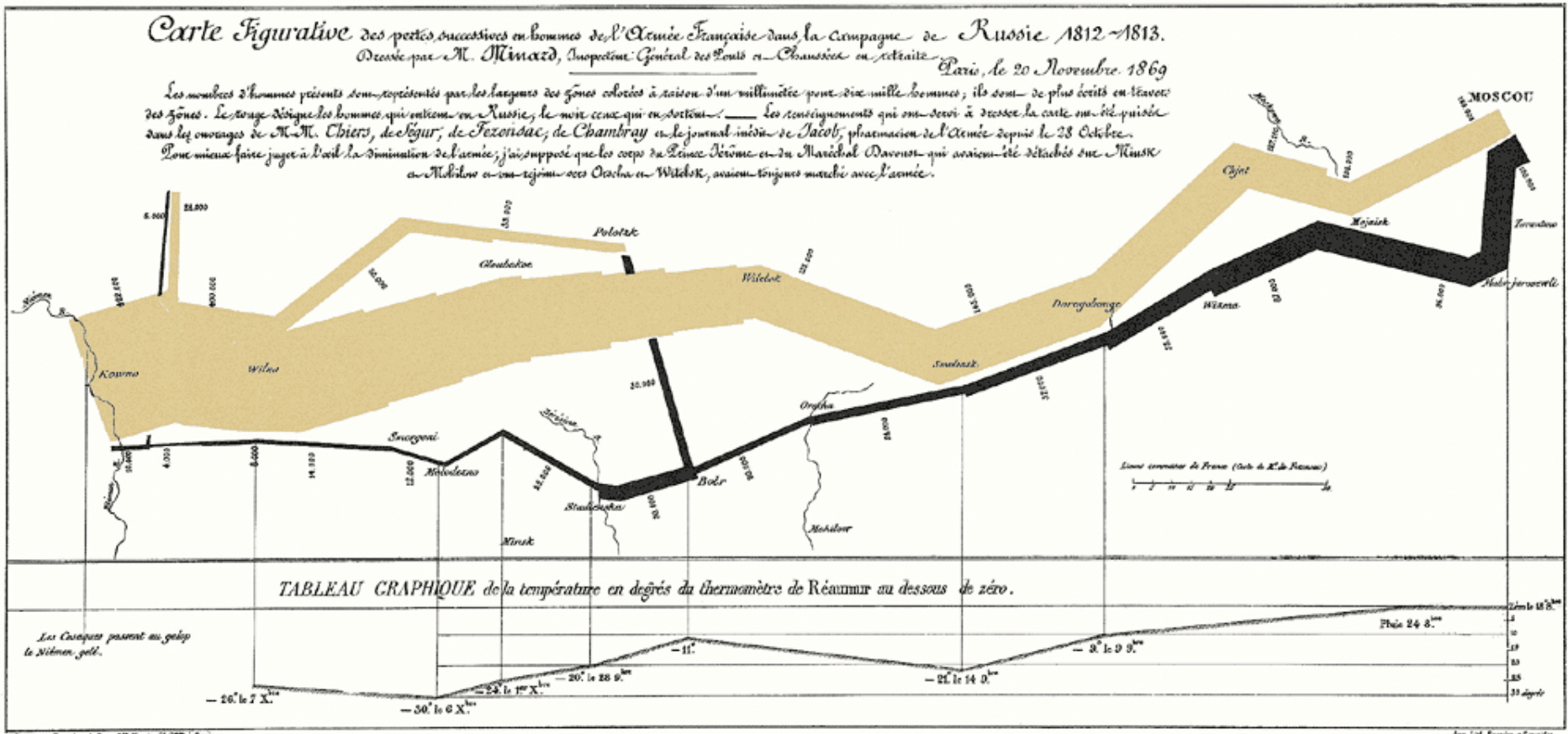
John Snow, 1854

Discover

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

Dessiné par M. Minard, Inspection Générale des Ponts et Chaussées en retraite. Paris, le 20 Novembre 1869

Les nombres d'hommes présents sont représentés par les longueurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en lettres des 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 puisés dans les ouvrages de M. M. Chiers, de Légar, de Fozzardac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre. Pour mieux faire juger à l'œil la diminution de l'armée; j'ai supposé que les corps de Lémar, Jérôme et du Maréchal Davout qui avaient été détachés sur Minsk et Mohilew et qui rejoignirent Orel et Witbek, avaient toujours marché avec l'armée.



C.J. Minard, 1869

Clarify



Harry Beck, 1933

Interact



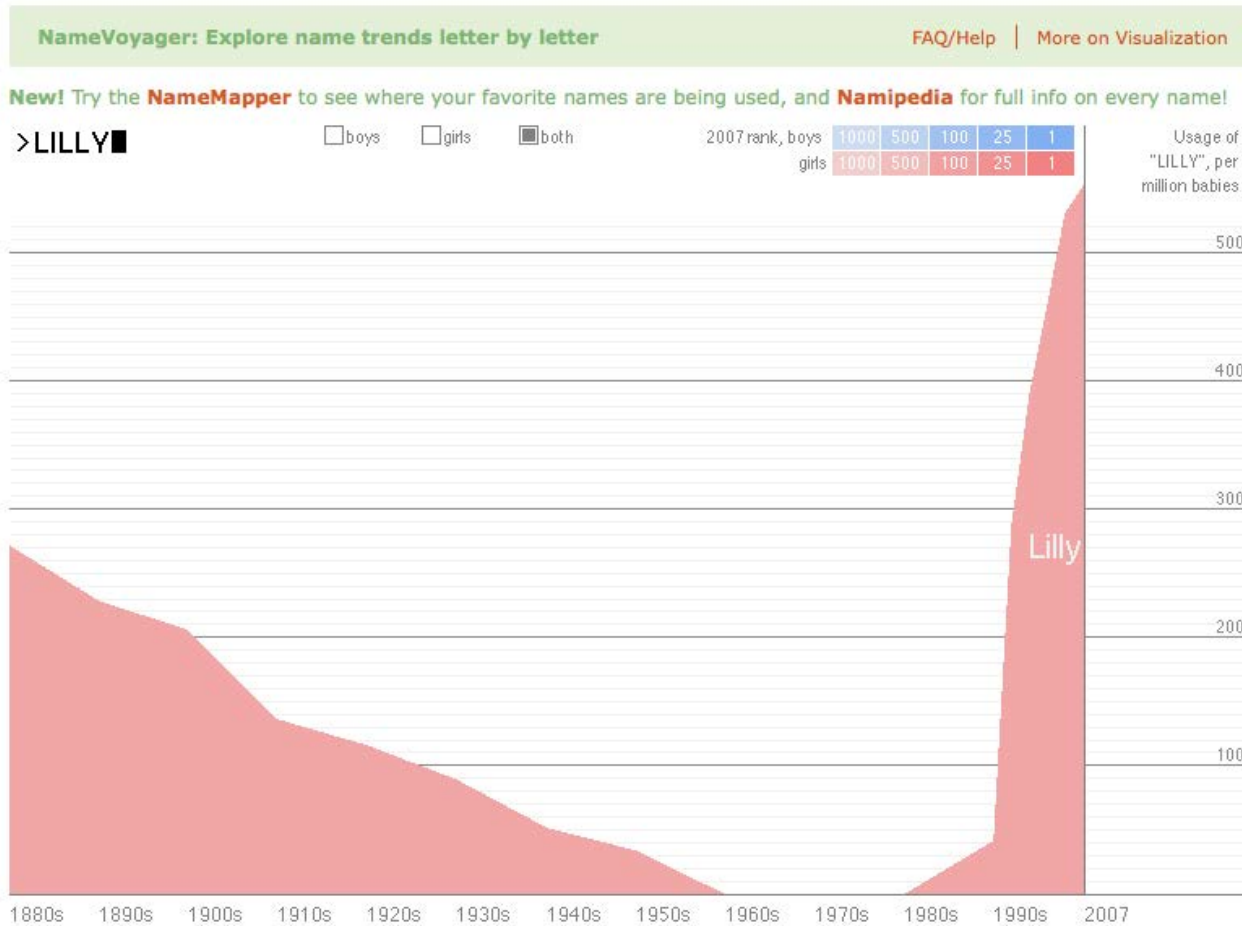
Ivan Sutherland, Sketchpad, 1963

[play Engelbart.mov]



Doug Engelbart, 1968

Interact



M. Wattenberg, 2005

Communicate

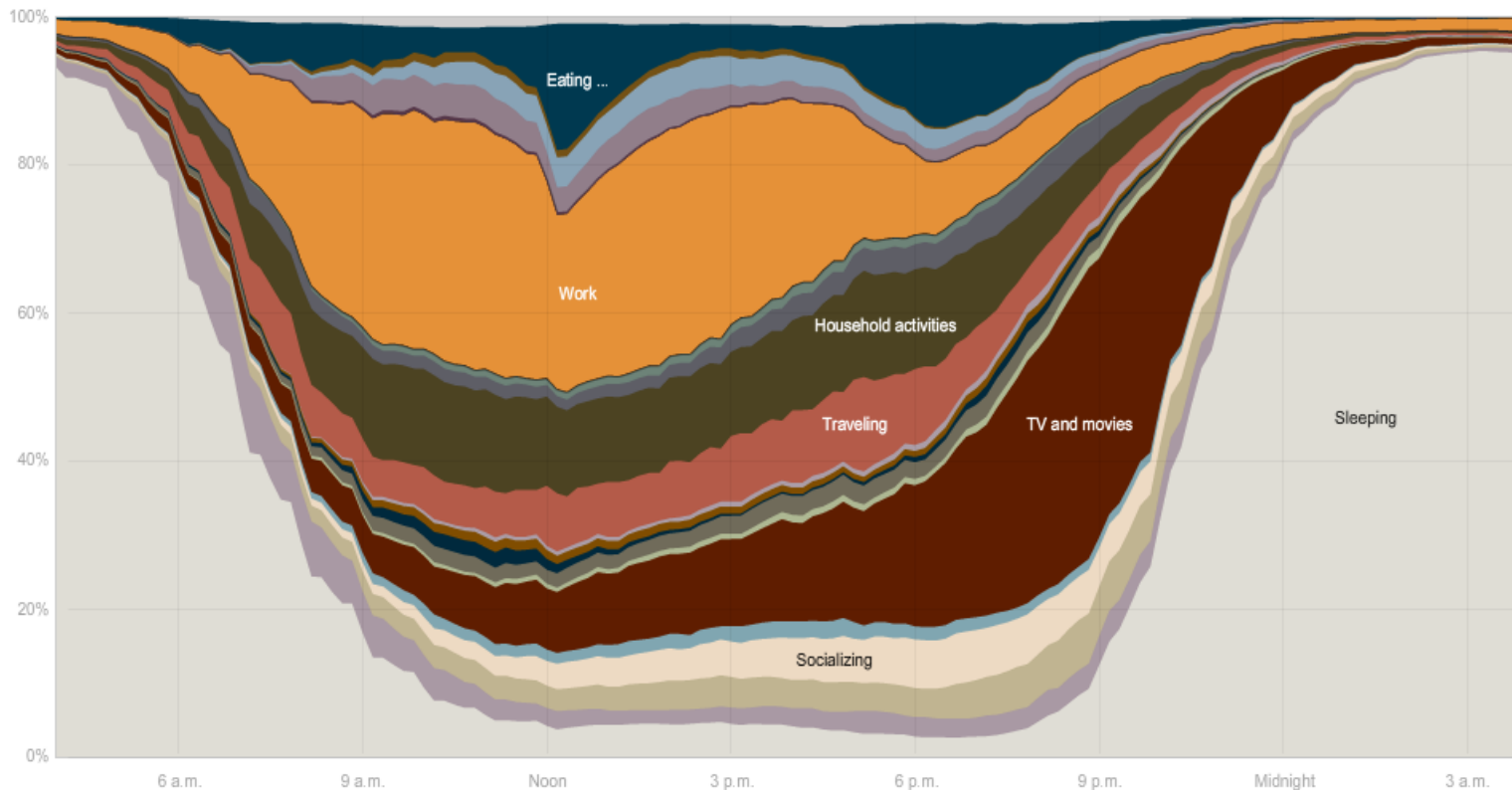
How Different Groups Spend Their Day

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?

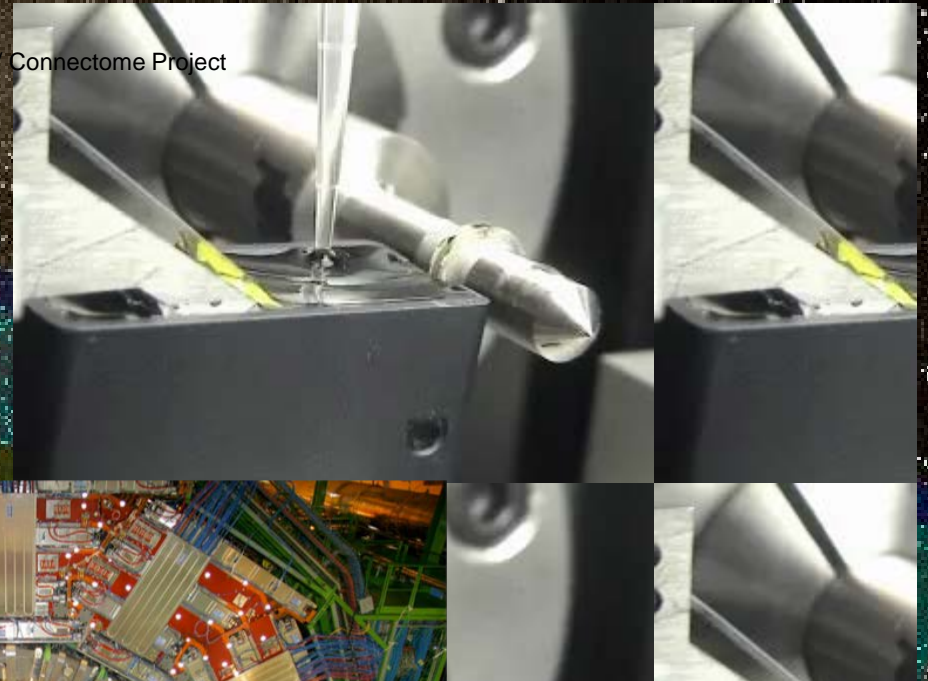
- What?
- Why?
- Who?
- How?

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

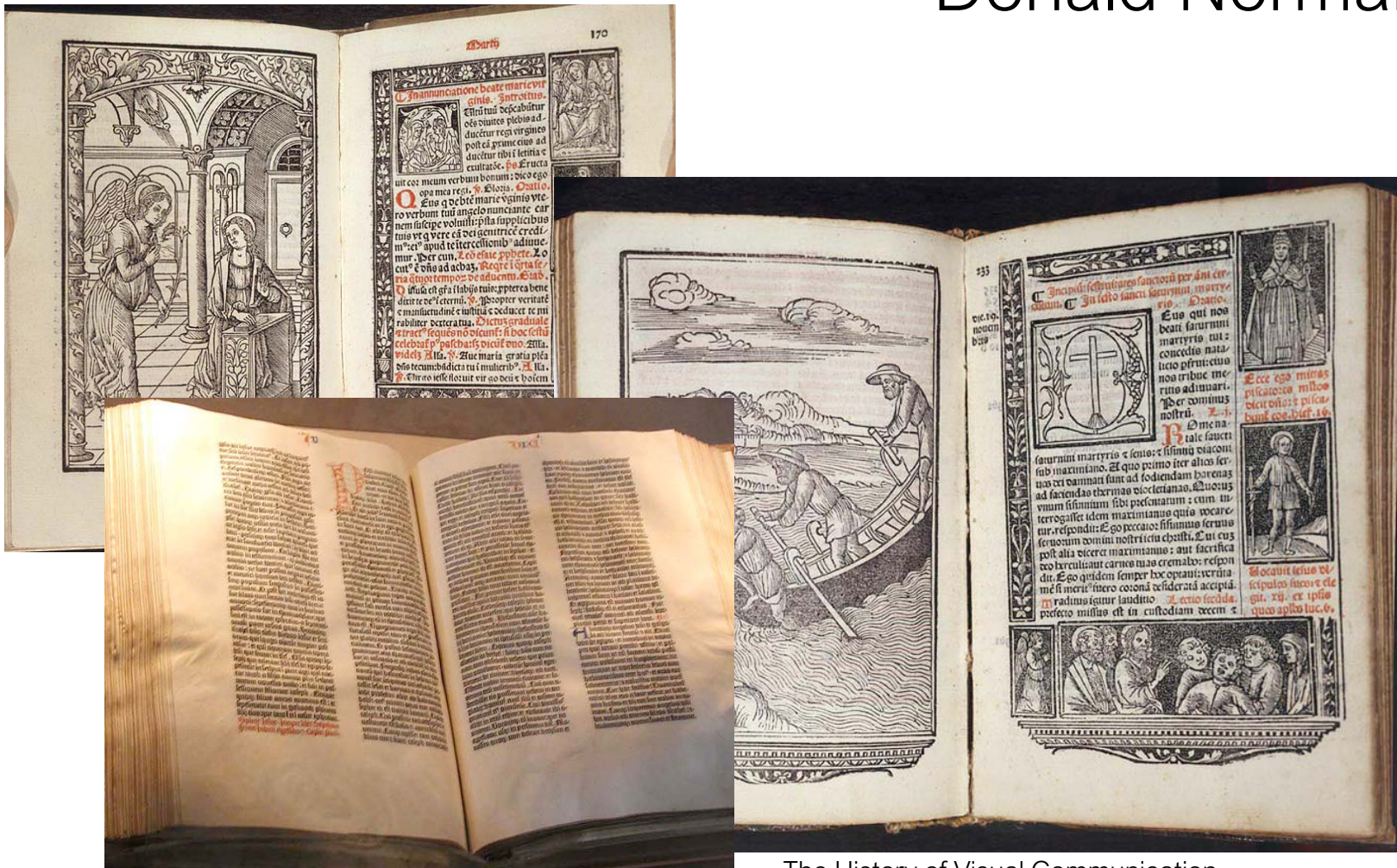
“It is things that make us smart.”

Donald Norman



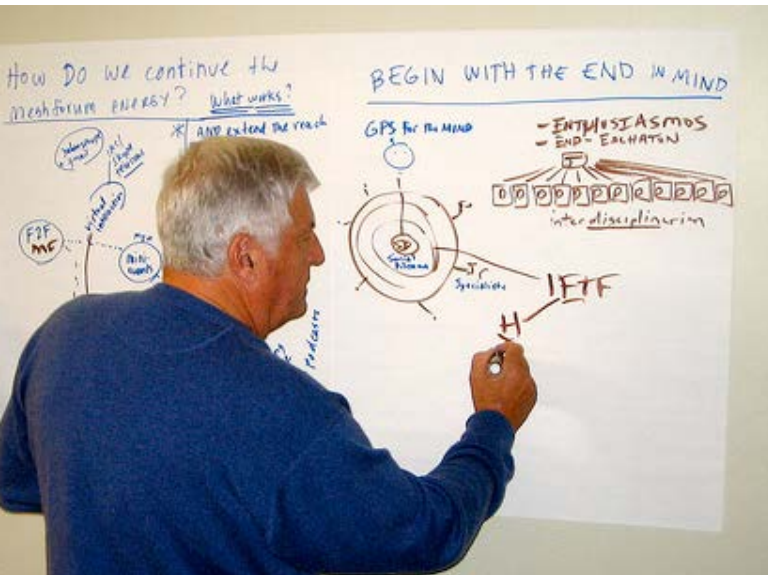
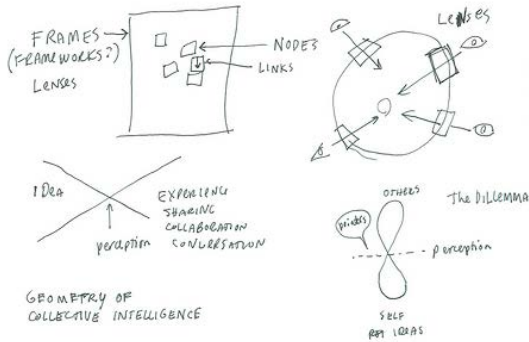
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Visual Thinking Collection, Dave Grey

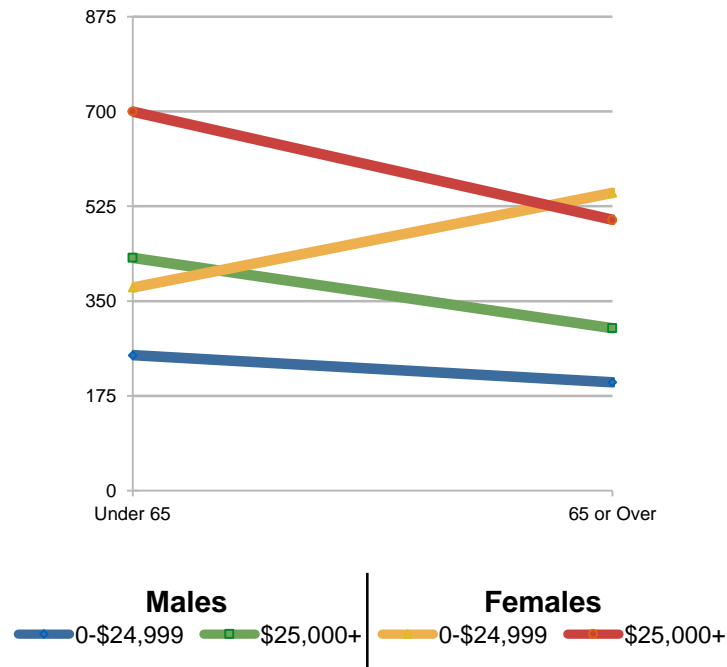
Idea Maps, by Jamie Nast

Mental Queries

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

	Males		Females	
Income Group	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?

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About You

What is Visualization?

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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

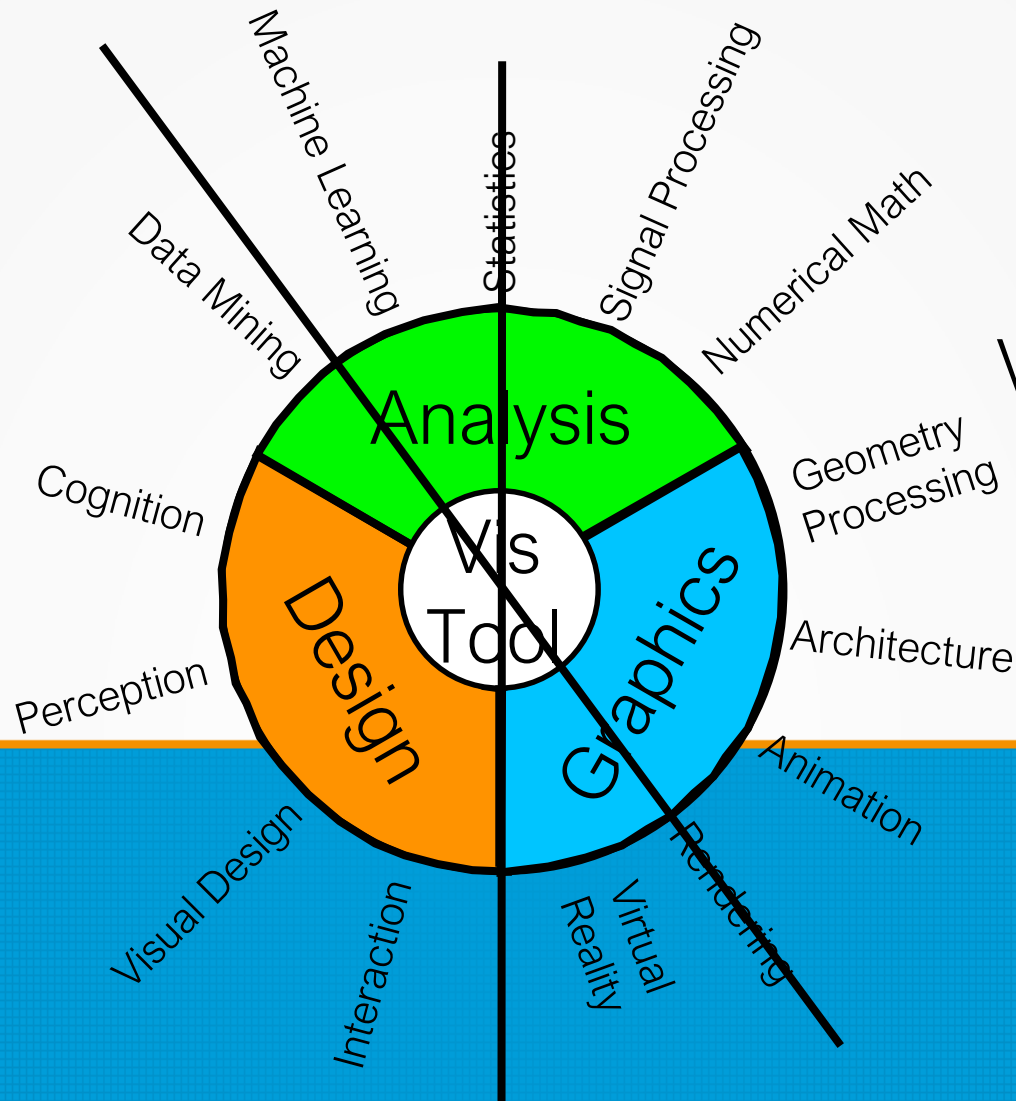
See Web Page

<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/>