The Purpose of Visualization

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CS 294-10: Visualization
Fall 2007

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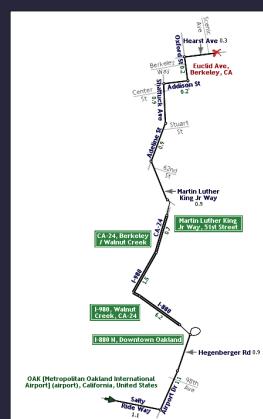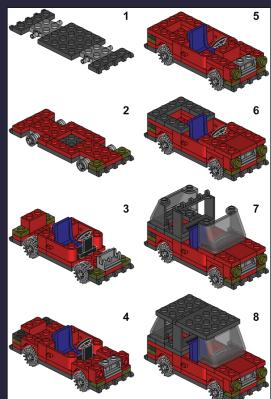
# What is visualization?

# What is visualization?

Definition [www.oed.com]

1. The action or fact of visualizing; the power or process of forming a mental picture or vision of something not actually present to the sight; a picture thus formed.

2. The action or process of rendering visible.

# Why do we create visualizations?

Examples

Examples

Observation: A large number of auto thefts occur in the University district, even though the area ranks relatively low in total crime.

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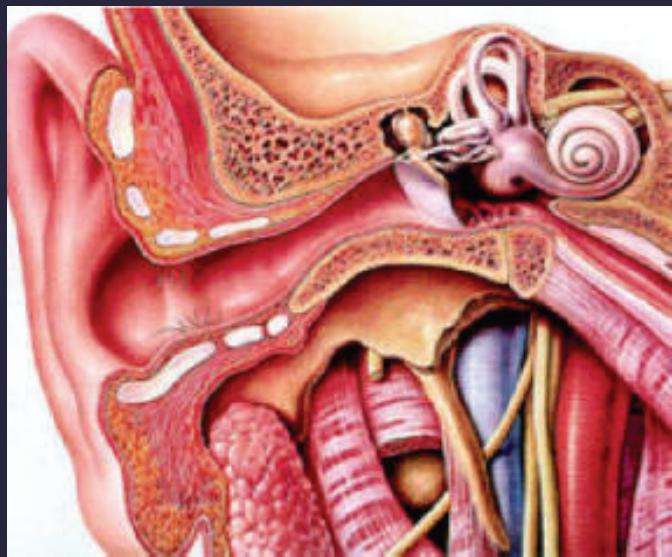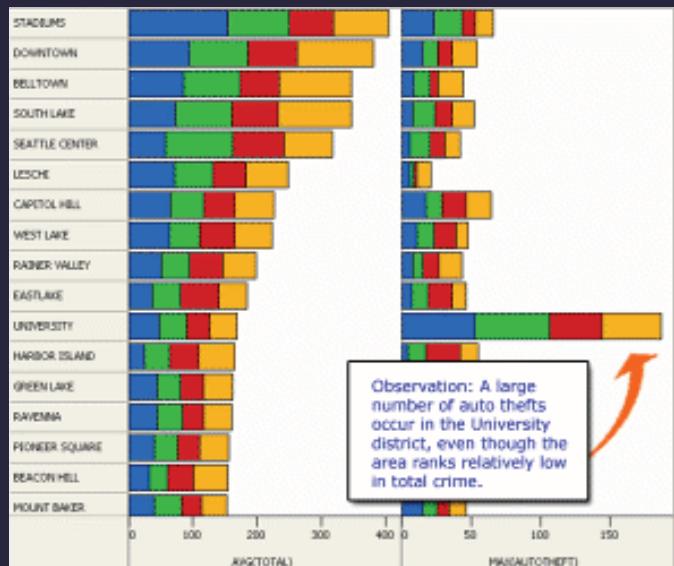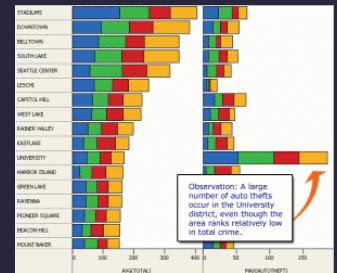
Other examples?

Why do we create visualizations?

Easier Interpretability

Emotional impact

Simplify data

Communication

Reveal/conceal trends

Visual bandwidth

Use Human Perception/Cognition

Crystallization of abstract ideas

Articulates relationships

Focuses on relevant data

Why do we create visualizations?

- **Answer questions**
- **Make decisions**
- **See data in context**
- **Expand memory**
- **Support graphical calculation**
- **Find patterns**
- **Present argument**
- **Tell a story**
- **Inspire**

Three functions of visualizations

Record information
- Photographs, blueprints, …

Support reasoning about information (analyze)
- Process and calculate
- Reason about data
- Feedback and interaction

Convey information to others (present)
- Share and persuade
- Collaborate and revise
- Emphasize important aspects of data

Record Information

Drawing: Phases of the moon
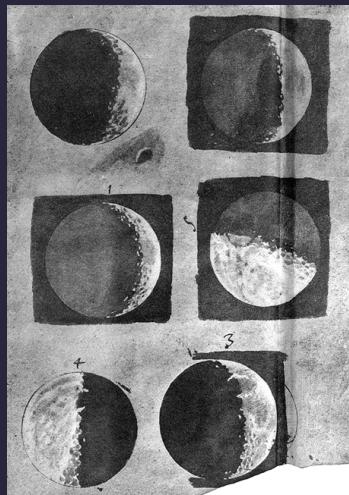
Galileo's drawings of the phases of the moon from 1616
http://galileo.rice.edu/sci/observations/moon.html

Photographs: Phases of the moon

Answer question

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

Other recording instruments
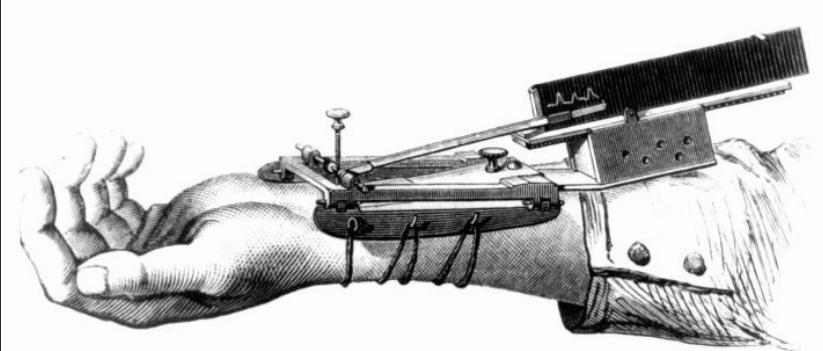
Marey's sphygmograph [from Braun 83]

Support Reasoning

Make a decision: Challenger

2 of 13 pages of material faxed to NASA by Morton Thiokol [from Tufte 1997]

Make a decision: Challenger
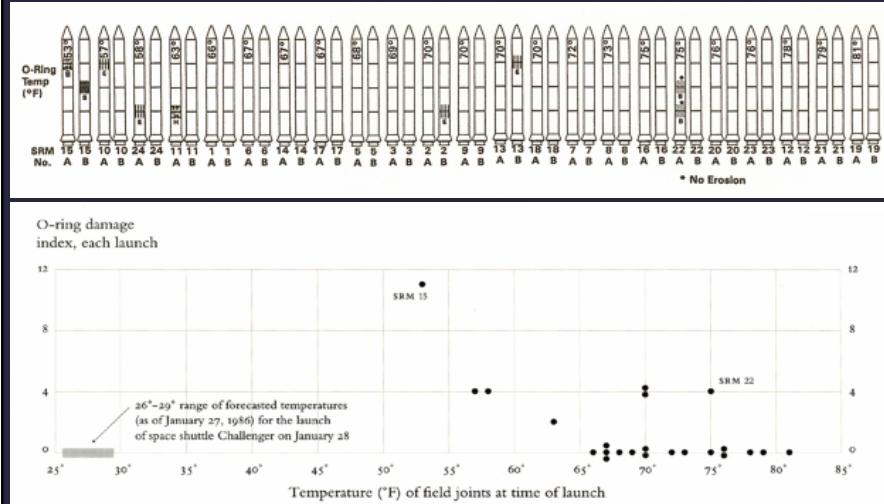
Visualizations drawn by Tufte show how low temperatures damage O-rings [Tufte 97]

See data in context: Cholera outbreak

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

See data in context: Cholera outbreak

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

Expand memory: Multiplication

```
   34
 x 72
```

Expand memory: Multiplication

```
   34
 x 72
   68
 2380
 2448
```


Bar chart titled with y-axis "Time (Sec.)" ranging 0 to 120, x-axis categories "Mental" and "Paper & Pencil"
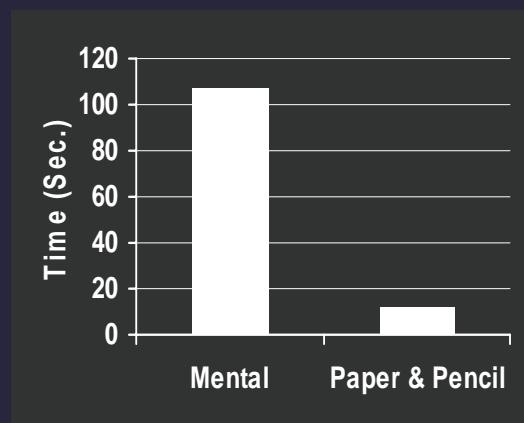
Graphical calculation: Evaporation
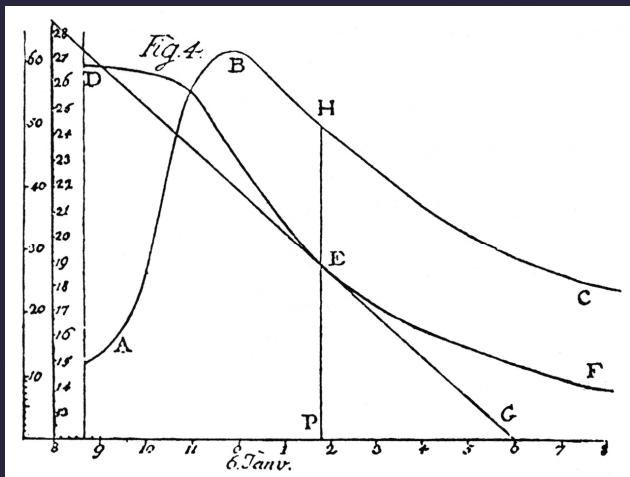
Johannes Lambert used graphs to study the rate of water evaporation as function of temperature [from Tufte 83]

# Graphical calculation: Evaporation
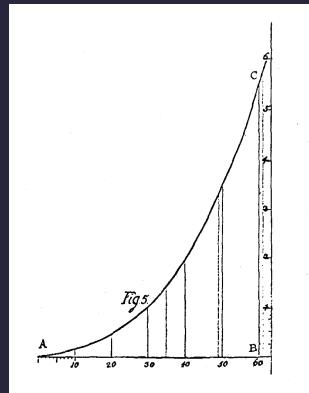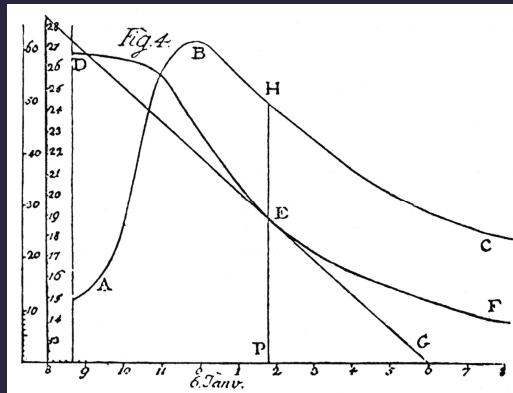
Johannes Lambert used graphs to study the rate of water evaporation as function of temperature [from Tufte 83]

Graphical calculation: Visual proofs
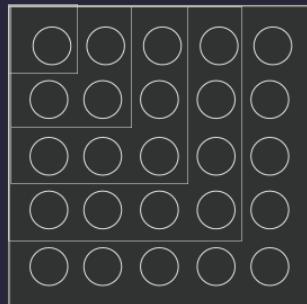
Sum of odd numbers:

$1 + 3 + 5 + 7 + 9 = 5^2$

Pythagorean theorem:
Chinese proof by dissection
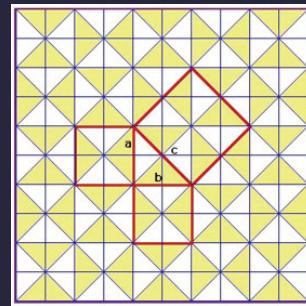
Find patterns: New York weather
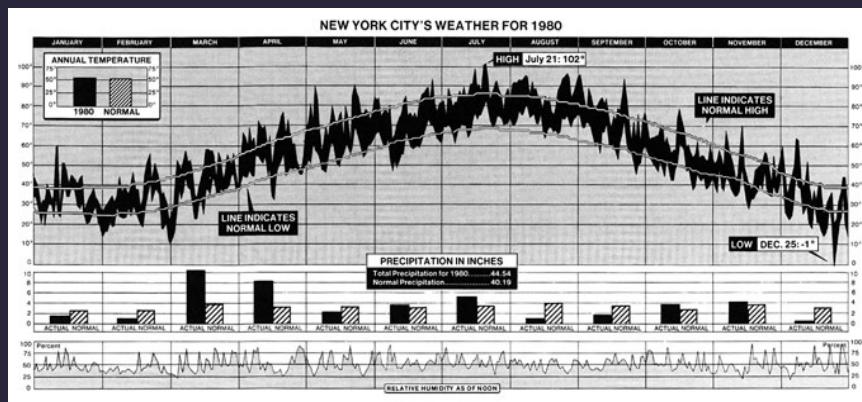
From the New York Times 1981

# Convey Information to Others

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Present argument: Exports and Imports

Exports and Imports to and from DENMARK & NORWAY from 1700 to 1780.
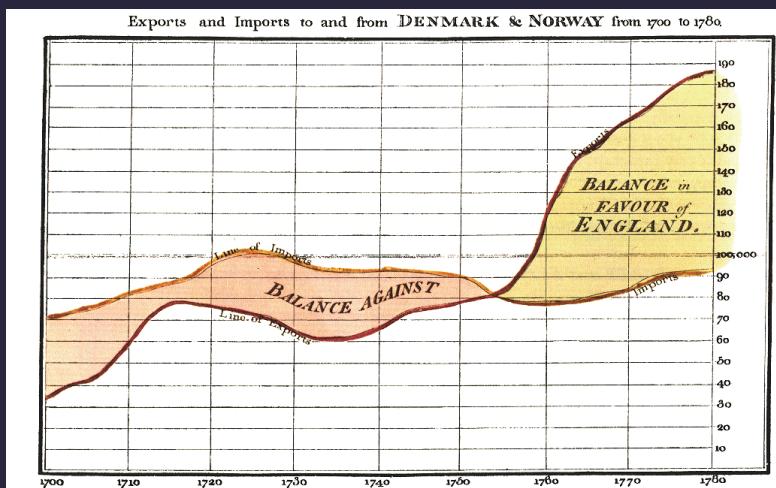
[Playfair 1786]

Tell a story: Most powerful brain?


Tell a story: Most powerful brain?

The Dragons of Eden [Carl Sagan]

Inspire
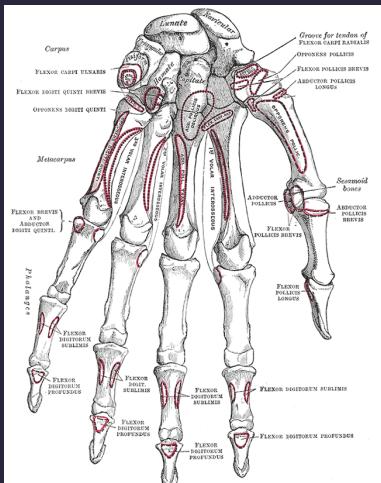
Bones in hand [from 1918 edition]
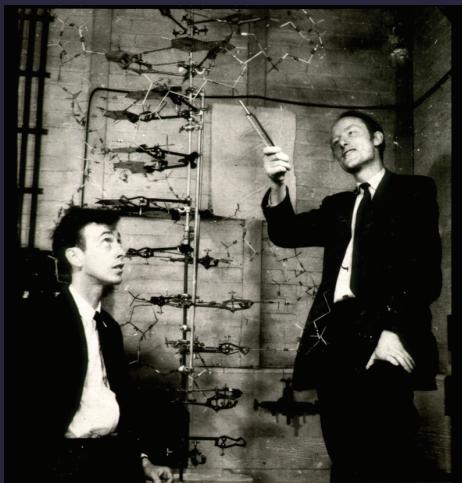
Double helix model [Watson and Crick 53]

Visualization Research

Challenge

**More and more unseen data**

- Faster creation and collection

Challenge

More and more unseen data

- Faster creation and collection
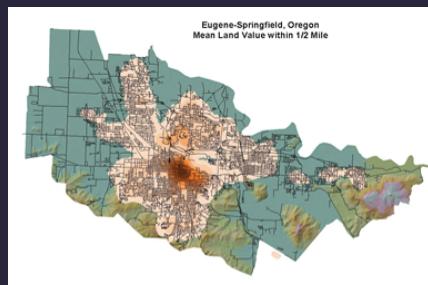
Urban development planning
www.urbansim.org
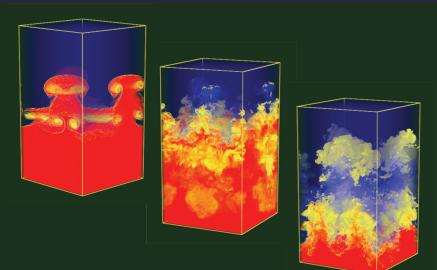
Fluid flow
ctr.stanford.edu

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
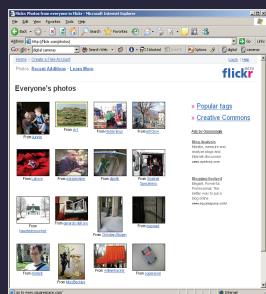
Photo sharing/annotation
flickr.com

Group Authored Encyclopedia
wikipedia.org
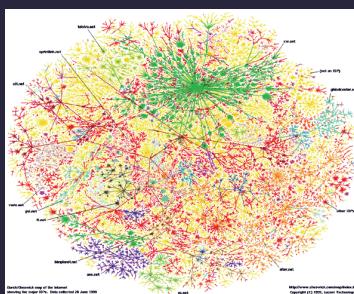
Map of the Internet [Cheswick 99]
research.lumeta.com

Internet

Challenge

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

**5 exabytes of new information in 2002** [Lyman 03]
- 37,000 Libraries of Congress

161 exabytes in 2006 [Gantz 07]

Need 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."
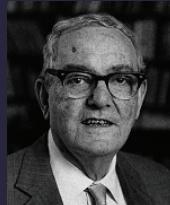
~Herb Simon
as quoted by Hal Varian
Scientific American
September 1995

[slide from PARC UIR group]

Goals of visualization research

**1. Understand how visualizations convey information to people**

- What do people perceive/comprehend ?
- How do visualizations correspond with mental models of data?

2. Develop principles and techniques for creating effective visualizations

- Amplify perception and cognition
- Strengthen connection between visualization and mental models of data

Topics

# 1. Data and image models
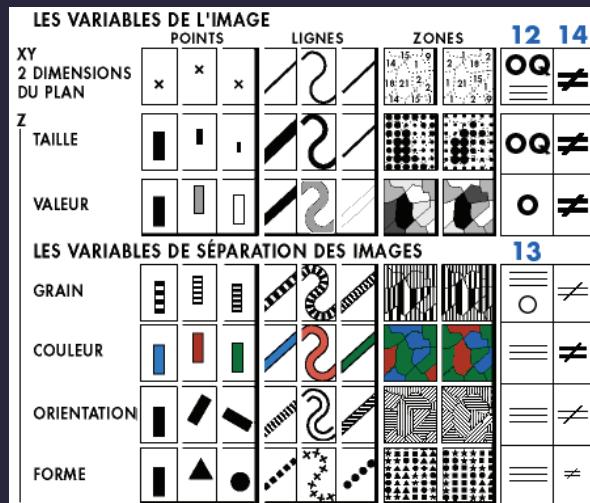
[Bertin, Graphics and Graphic Information Processing 1981]

2. Good and bad visualizations

Problematic design

Redesign
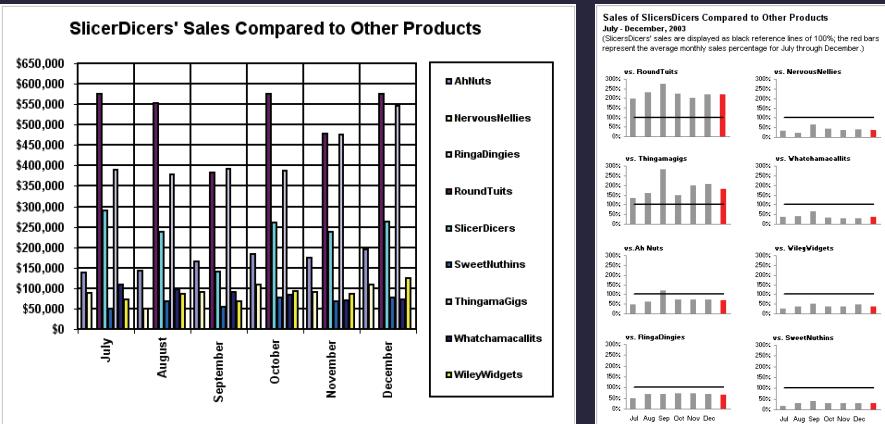
3. Perception
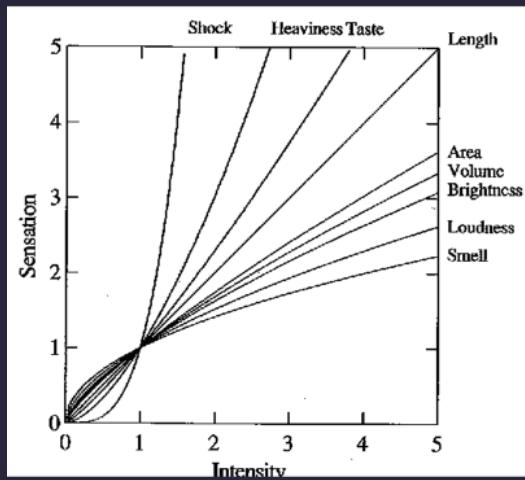


The psychophysics of sensory function [Stevens 61]

4. Interaction
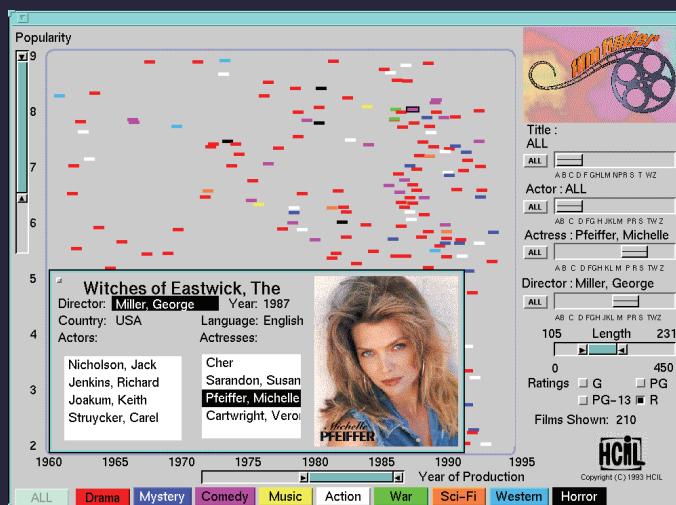
FilmFinder [Ahlberg 94]

5. Spatial Layout
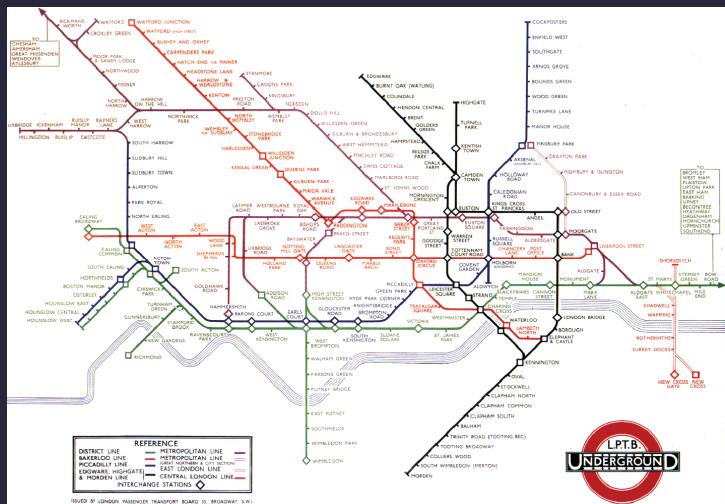
London underground [Beck 33]

6. Trees and graphs
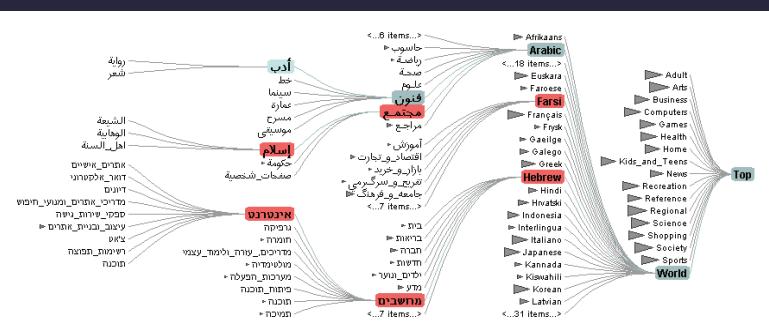
Degree-of-Interest Trees [Heer & Card, 2004]

7. Color


[from Cynthia Brewer http://www.personal.psu.edu/faculty/c/a/cab38/]
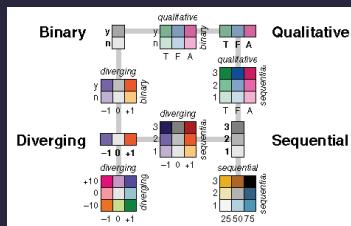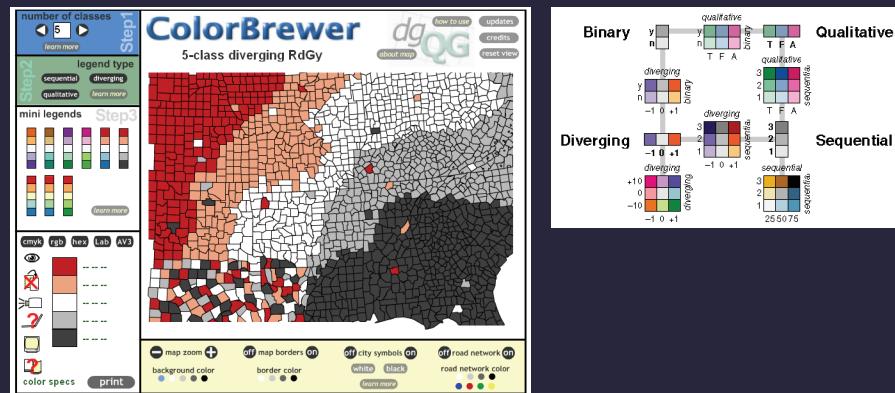
# 8. Collaborative visualization
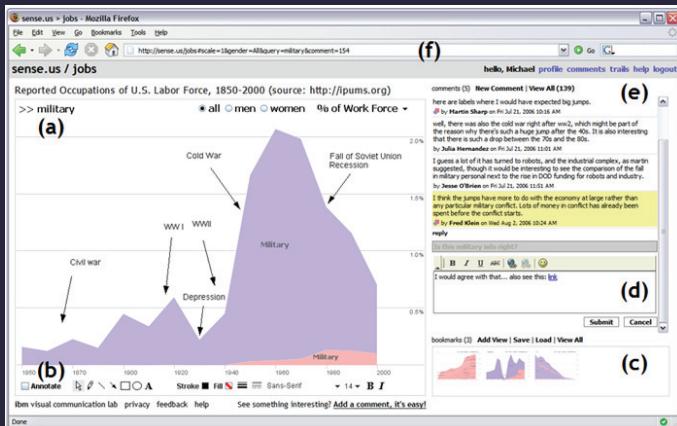
sense.us [Heer 07]

# 9. Identifying design principles
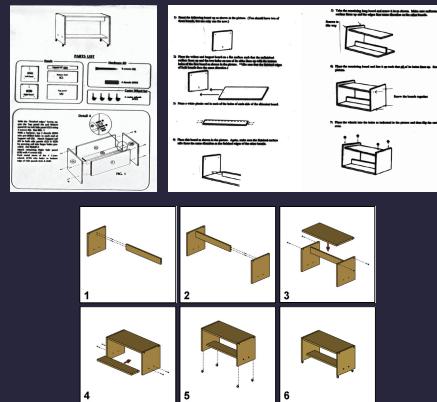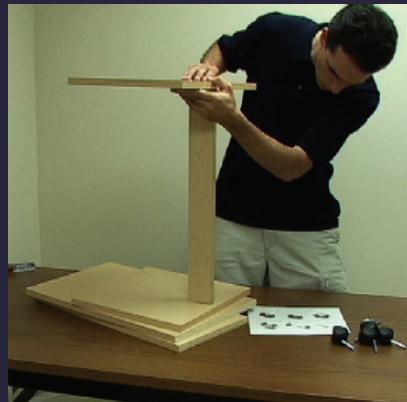
Testing effectiveness of 3 types of assembly instructions [Heiser 04]

10. Conveying shape
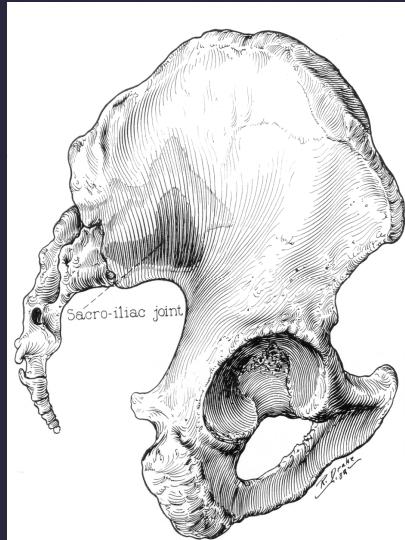
Lumbosacral and Sacro-iliac fusion
Russell Drake, medical illustrator,
Mayo Foundation, 1932.

11. Conveying structure
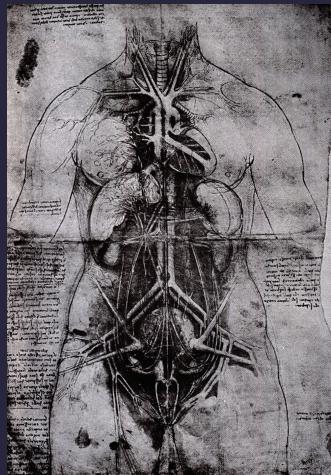
Principal Organs & Vascular System
[Leonardo da Vinci ca. 1490]
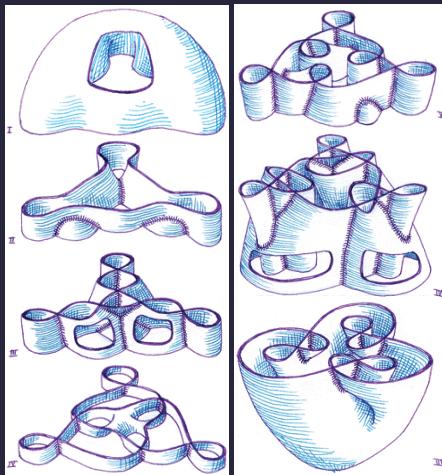
Strange Immersion of Torus in
3-Space [Curtis 92]

12. Photography
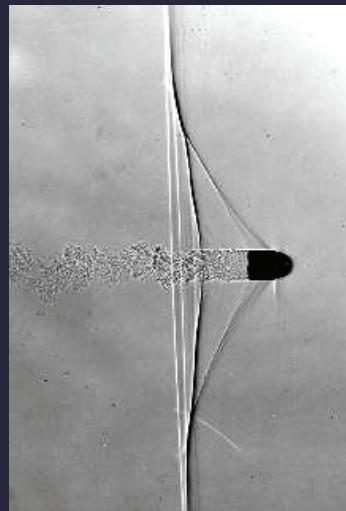
Shadowgraph of a .22-caliber bullet in flight
Taken by an MIT freshman in 1962, in Edgerton's
lab. The flash was triggered by the shock wave
(shown) hitting a microphone (out of frame). The
picture shows no solid object except the bullet
http://en.wikipedia.org/wiki/Doc_Edgerton

13. Depicting processes & actions
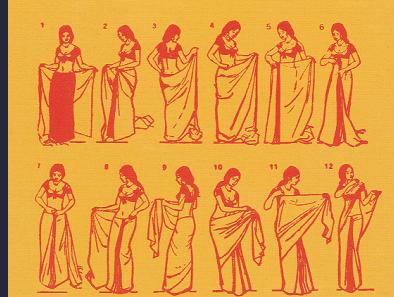
Wearing a sari [from Mijksenaar 99]

Visualizing dance steps [from Tufte 90]

14. Animation

Outside-In, Geometry Computing Center

Course Mechanics

Textbooks
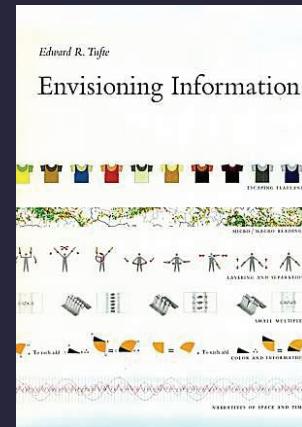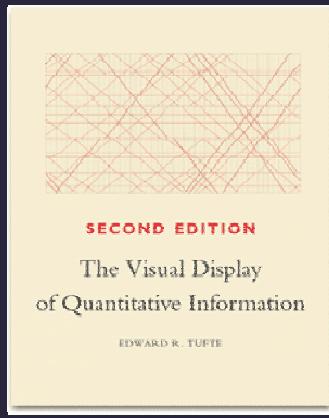
See also: www.edwardtufte.com

Readings

- **Some from textbooks, also many papers**
  Username/Password: vis/visISfun
- **Material in class will be loosely based on readings**
- **Readings should be read by start of class**
- **Post discussion comments on class wiki**
  Important: Create a wiki account

Class home page
http://vis.berkeley.edu/courses/cs294-10-fa07/wiki

Requirements

Class participation (10%)

Assignment 1a: Good and Bad Visualizations **(5%)**

Assignment 1b: Visualization Deconstruction and Redesign **(5%)**

Assignment 2: Creating Visualizations with Existing Software **(10%)**

Assignment 3: Creating Interactive Visualization Software **(25%)**

Final Project (45%)

Final project

- **Visualization research project on topic of your choice**
- **2nd half of class**
- **Project write-up in form of a research paper**
- **Project presentations**
  1. Background research on project area
  2. Midway presentation on prototype solutions
  3. Final presentation – exact time to be determined

Projects from previous classes have been published
- IEEE Visualization
- IEEE Information Visualization
- SIGGRAPH

Final presentations to outside experts on visualization