Introduction to Human-Computer Interaction

Information Visualization

Lecture 7

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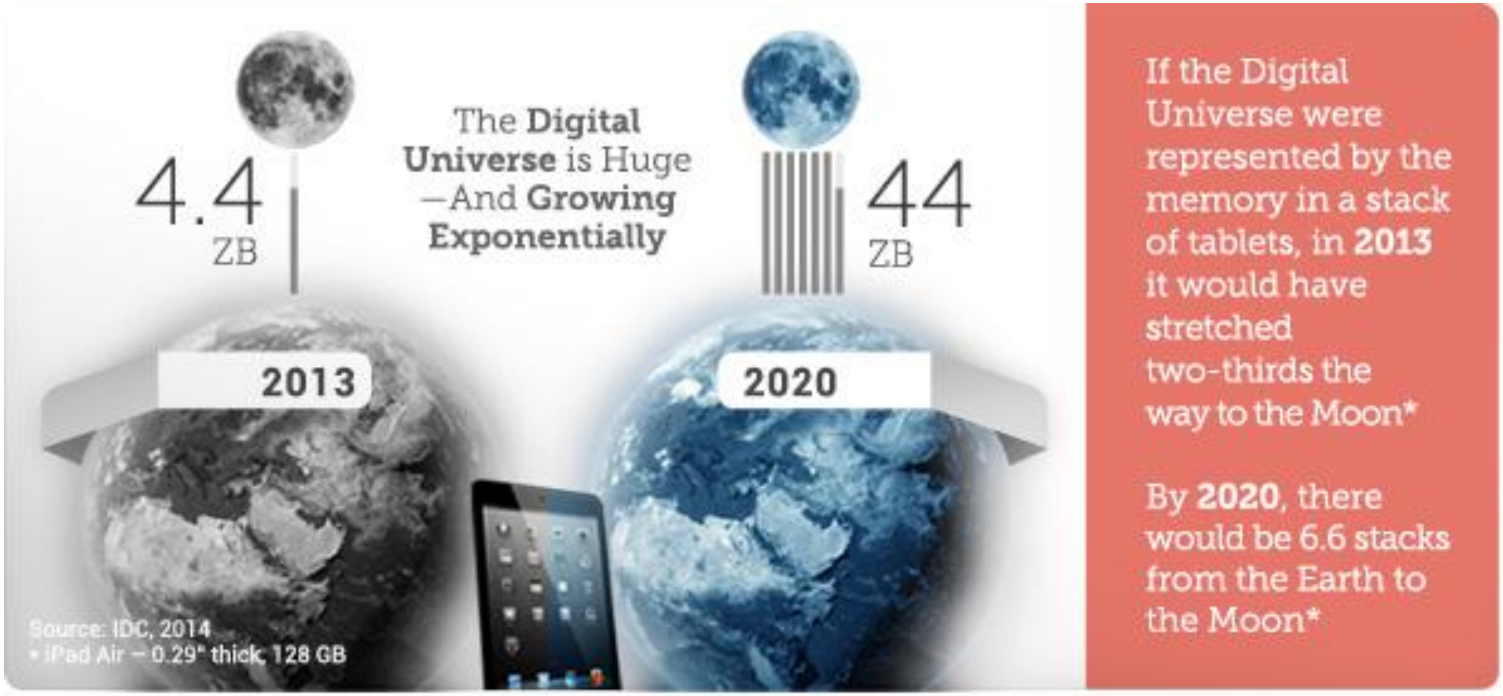
with acknowledgements to:
Petra Isenberg

After today you will…

- have gained an overview of the research area
- learned basic principles of data representation and interaction

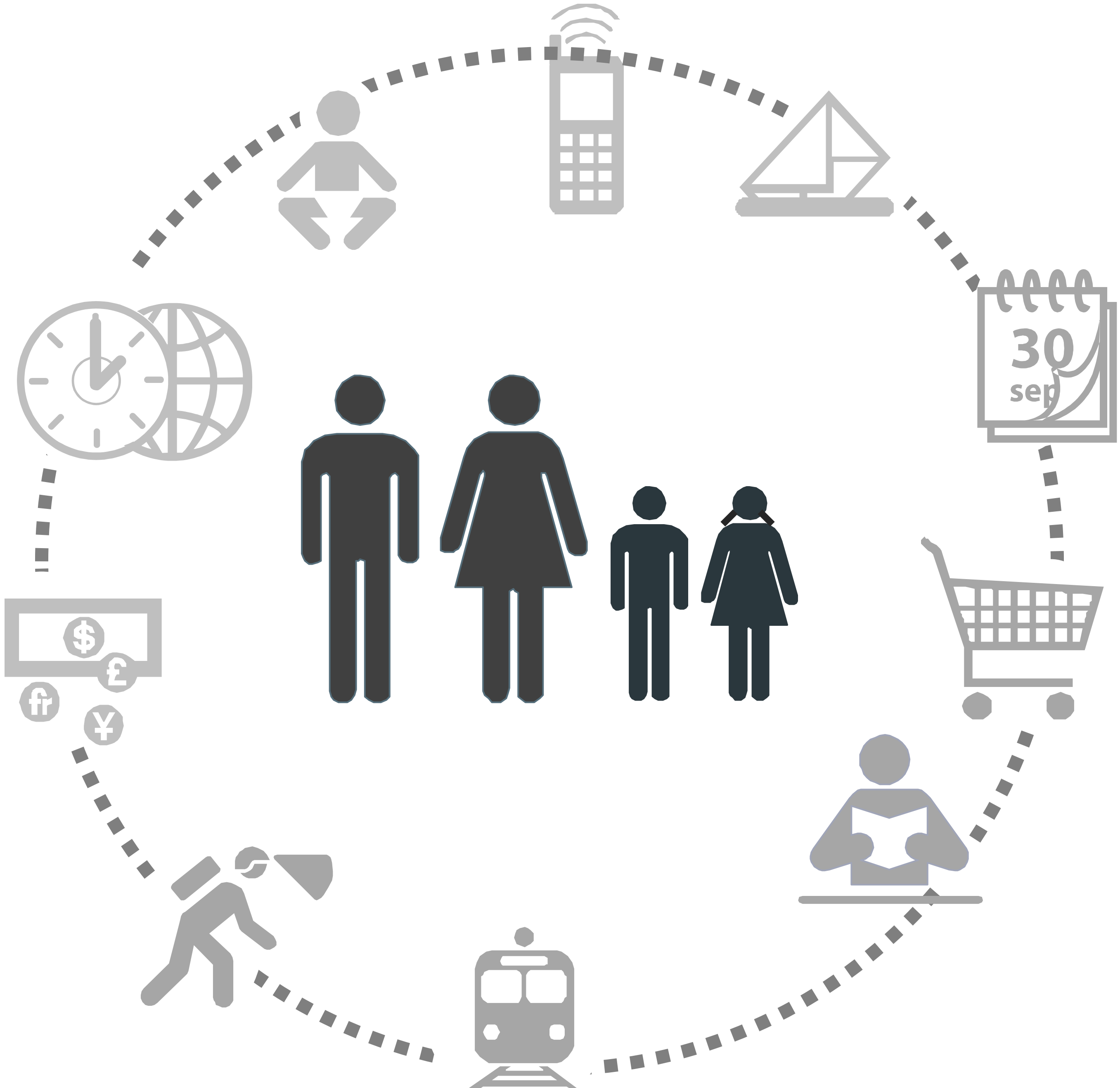
Why

INFORMATION VISUALIZATION



It is estimated that 4.4 ZB (4.4 x 10^{21}) of digital information was generated in 2013

http://www.emc.com/leadership/digital-universe/2014iview/executive-summary.htm]


30
sep

Hiring trends for data science

It's not easy to get a handle on jobs in data science. However, data from O'Reilly Research shows a steady year-over-year increase in Hadoop and Cassandra job listings, which are good proxies for the "data science" market as a whole. This graph shows the increase in Cassandra jobs, and the companies listing Cassandra positions, over time.

"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."

Hal Varian, chief economist at Google

Question

how can we effectively access data?

- understand its structure?
- make comparisons?
- make decisions?
- gain new knowledge?
- convince others?
- …

Many possible ways to address…

Information Visualization

Example

I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

Raw Data from Anscombe's Quartet

[Source: Anscombe's quartet, Wikipedia]

Statistical Analysis

For all four columns, the statistics are identical

I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

Mean of x	9.0
Variance of x	11.0
Mean of y	7.5
Variance of y	4.12
Correlation between x and y	0.816
Linear regression line	$y = 3 + 0.5x$

[Source: Anscombe's quartet, Wikipedia]

Visual Representation of the Data

Visual representation reveals a different story

I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
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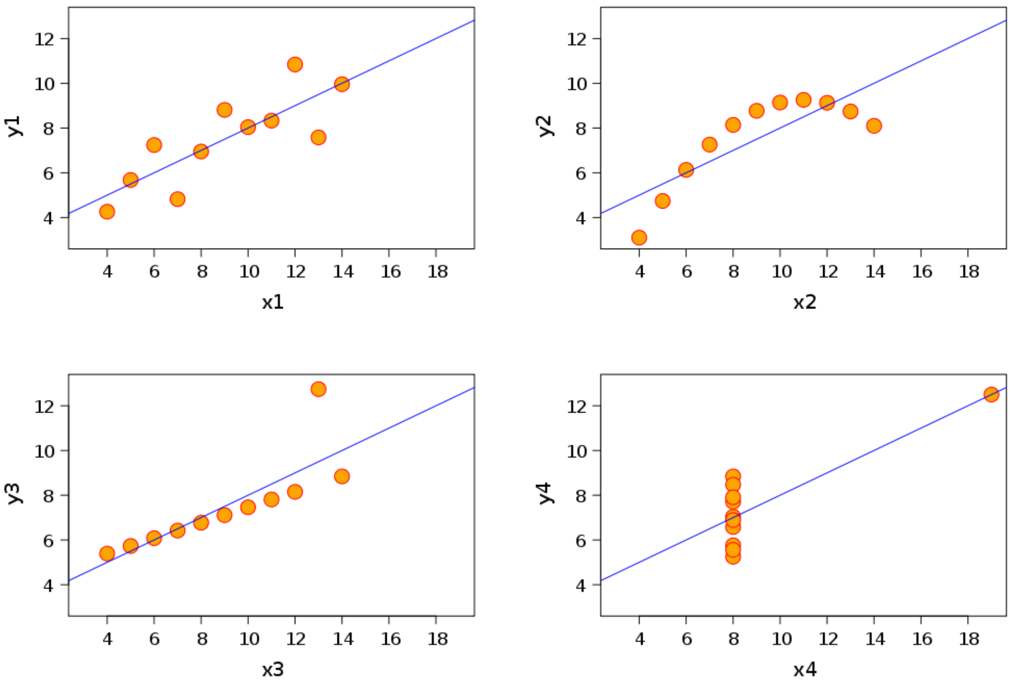
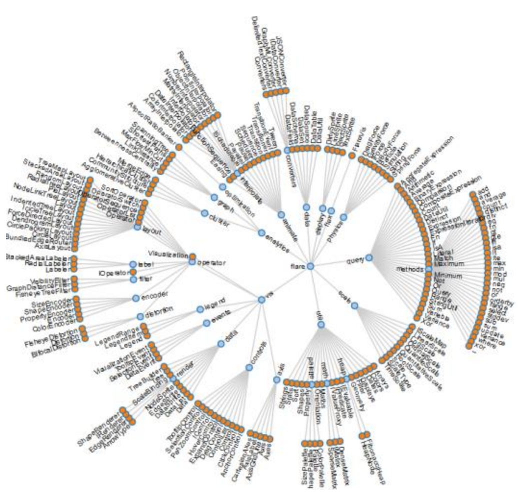


[Source: Anscombe's quartet, Wikipedia]

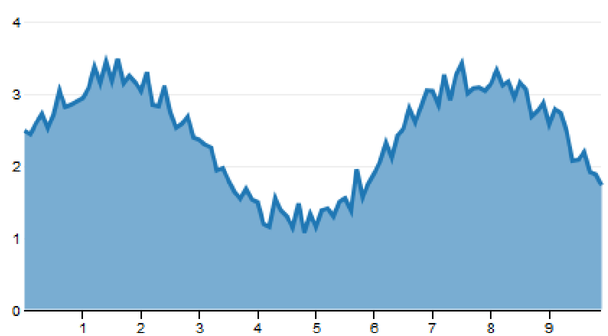
Why visual data representations?

- Vision is our most dominant sense
- We are very good at recognizing visual patterns
- We need to see and understand in order to explain, reason, and make decisions

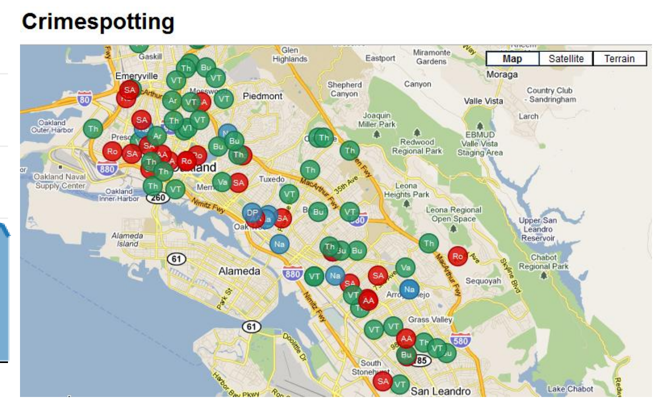
common examples:



graphs / hierarchies



charts



maps

all examples from: http://vis.stanford.edu/protovis/

Other benefits of visualization

- expand human working memory
  - offload cognitive resources to the visual system,
- reduce search
  - by representing a large amount of data in a small space,
- enhance the recognition of patterns
  - by making them visually explicit
- aid monitoring of a large number of potential events
- provides a manipulable medium & allows exploration of a space of parameter values.

百聞不如一見

"One hundred rumors are not comparable to one look."

An Old Chinese Inscription

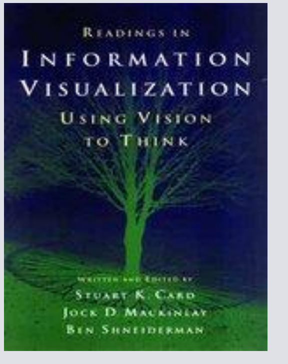
Via Brinton, Graphic Presentation, 1939

Information visualization

- Create visual representation
- Concentrates on abstract data
- Includes interaction

Official Definition:

The use of computer-supported, interactive, visual representations of abstract data to amplify cognition.
[Card et al., 1999]



Functions of Visualizations

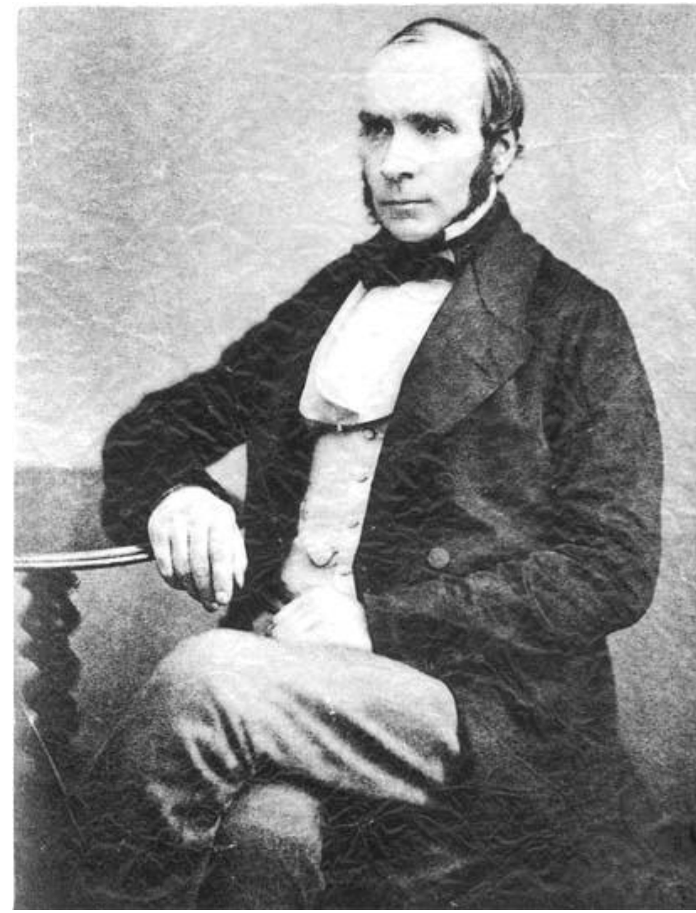
- Recording information
  - Tables, blueprints, satellite images
- Processing information
  - needs feedback and interaction
- Presenting information
  - share, collaborate, revise
  - for oneself, for one's peers and to teach
- Seeing the unseen

Visualization of abstract data has been practiced for hundreds of years…

HISTORICAL EXAMPLES

The Broadway Street Pump

- In 1854 cholera broke out in London
  - 127 people near Broad Street died within 3 days
  - 616 people died within 30 days
- "Miasma in the atmosphere"
- Dr. John Snow was the first to link contaminated water to the outbreak of cholera
- How did he do it?
  - he talked to local residents
  - identified a water pump as a likely source
  - used maps to illustrate his theory
  - convinced authorities to disable the pump



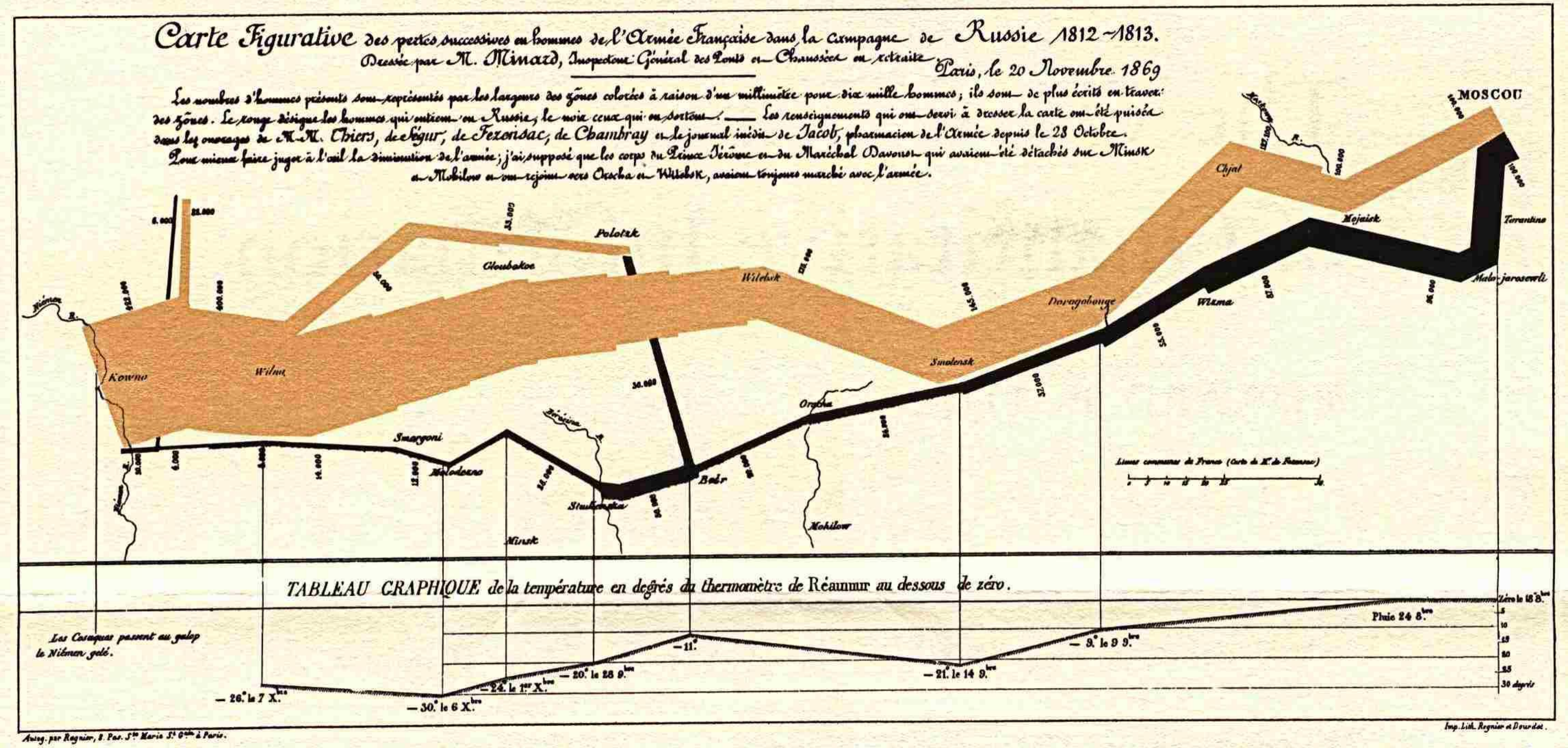
More info here: http://en.wikipedia.org/wiki/1854_Broad_Street_cholera_outbreak

John Snow, 1854

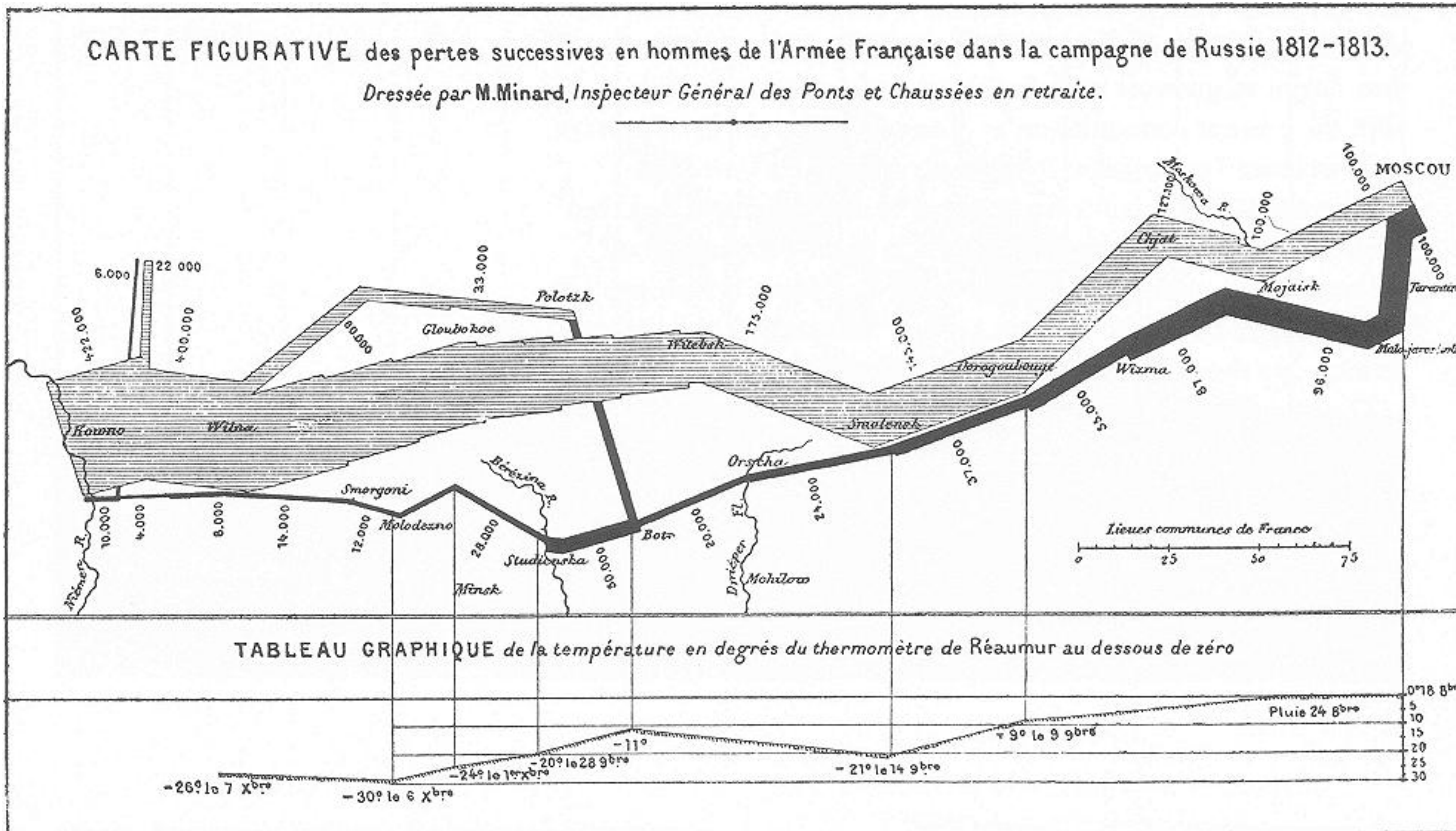
Napoleon's March on Moscow Charles Minard, 1869

Named the best statistical graphic ever drawn (by Edward Tufte)

- Includes: spatial layout linked with stats on: army size, temperature, time
- Tells a story in one overview



More info: The Visual Display of Quantitative Information (Tufte)


CARTE FIGURATIVE des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.
Dressée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite.
MOSCOU
100.000
Moskowa R.
127.100
100.000
Ojjat
Mojaisk
Tarantino
100.000
Malo-jarosl.
96.000
87.000
Wizma
55.000
Dorogoubouje
Smolensk
37.000
Orscha
24.000
Dnieper Fl.
Mohilow
175.000
Witebsk
Polotzk
33.000
Gloubokoe
60.000
6.000
22 000
422.000
400.000
Kowno
Wilna
Smorgoni
Molodezno
Bérézina R.
Studienska
Minsk
Niémen R.
10.000
4.000
8.000
14.000
12.000
28.000
50.000
20.000
Botr
Lieues communes de France
0
25
50
75
TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro
0° le 18 8bre
Pluie 24 8bre
+ 9° le 9 9bre
- 21° le 14 9bre
- 11°
- 20° le 28 9bre
- 24° le 1er Xbre
- 30° le 6 Xbre
- 26° le 7 Xbre
5
10
15
20
25
30

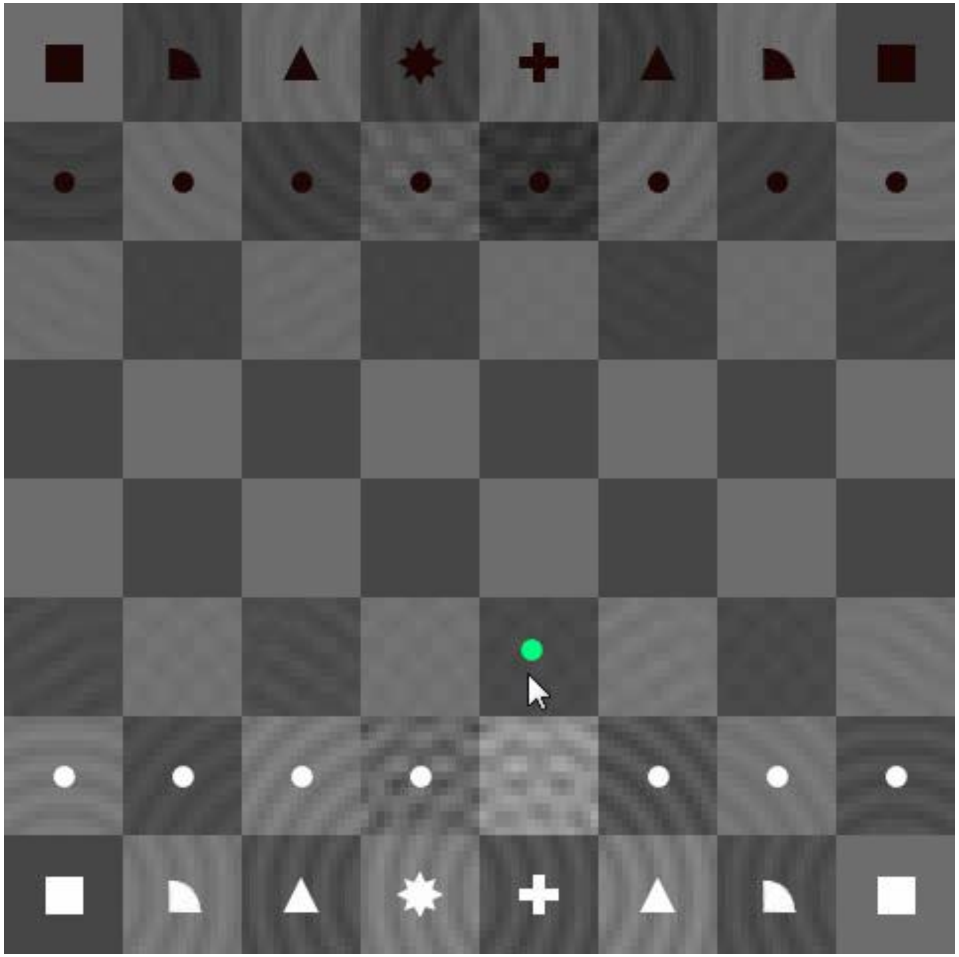
… AND VERY RECENTLY

TrashTrack

Winner of the NSF International Science & Engineering Visualization Challenge!

http://senseable.mit.edu/trashtrack/

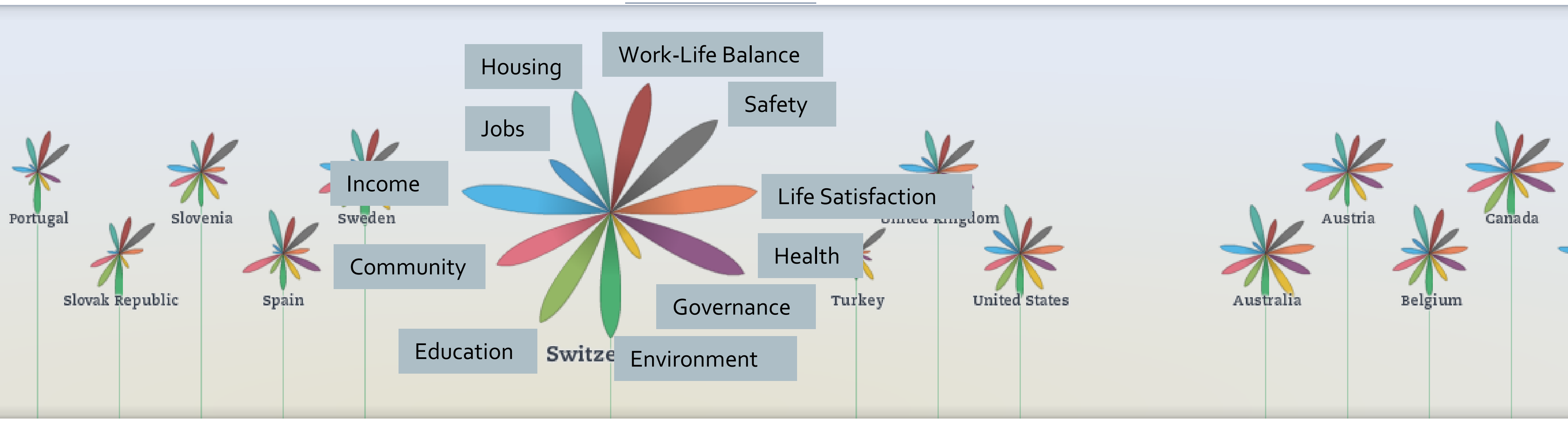
Artificial Intelligence



http://www.turbulence.org/spotlight/thinking/chess.html

Open Data

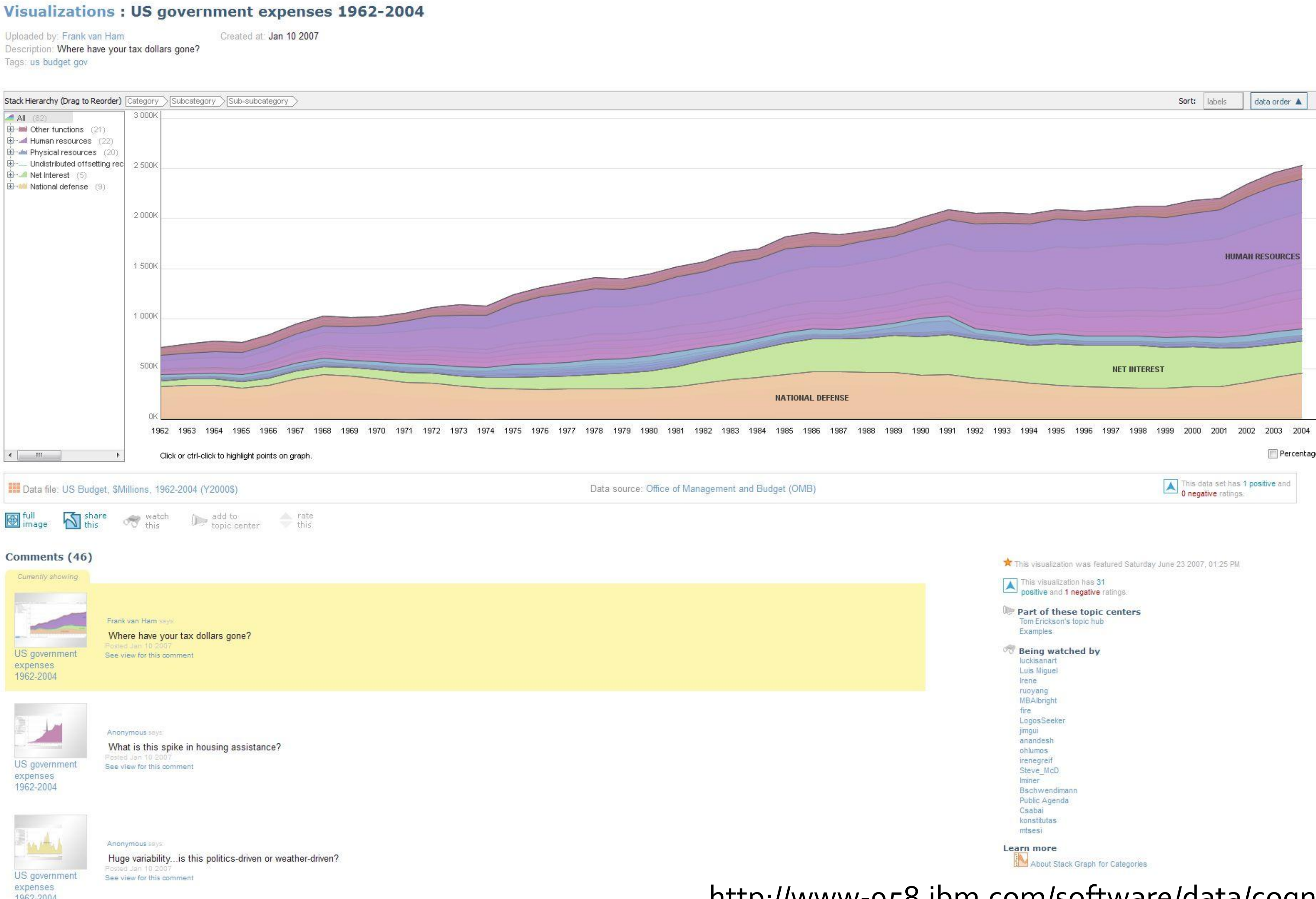
- Movement making government data freely available
- Encourage participation by everyone



OECD Better Life Index: http://www.oecdbetterlifeindex.org/

Many Eyes

- Upload data, create visualizations, discuss
- Distributed asynchronous collaboration



http://www-958.ibm.com/software/data/cognos/manyeyes/

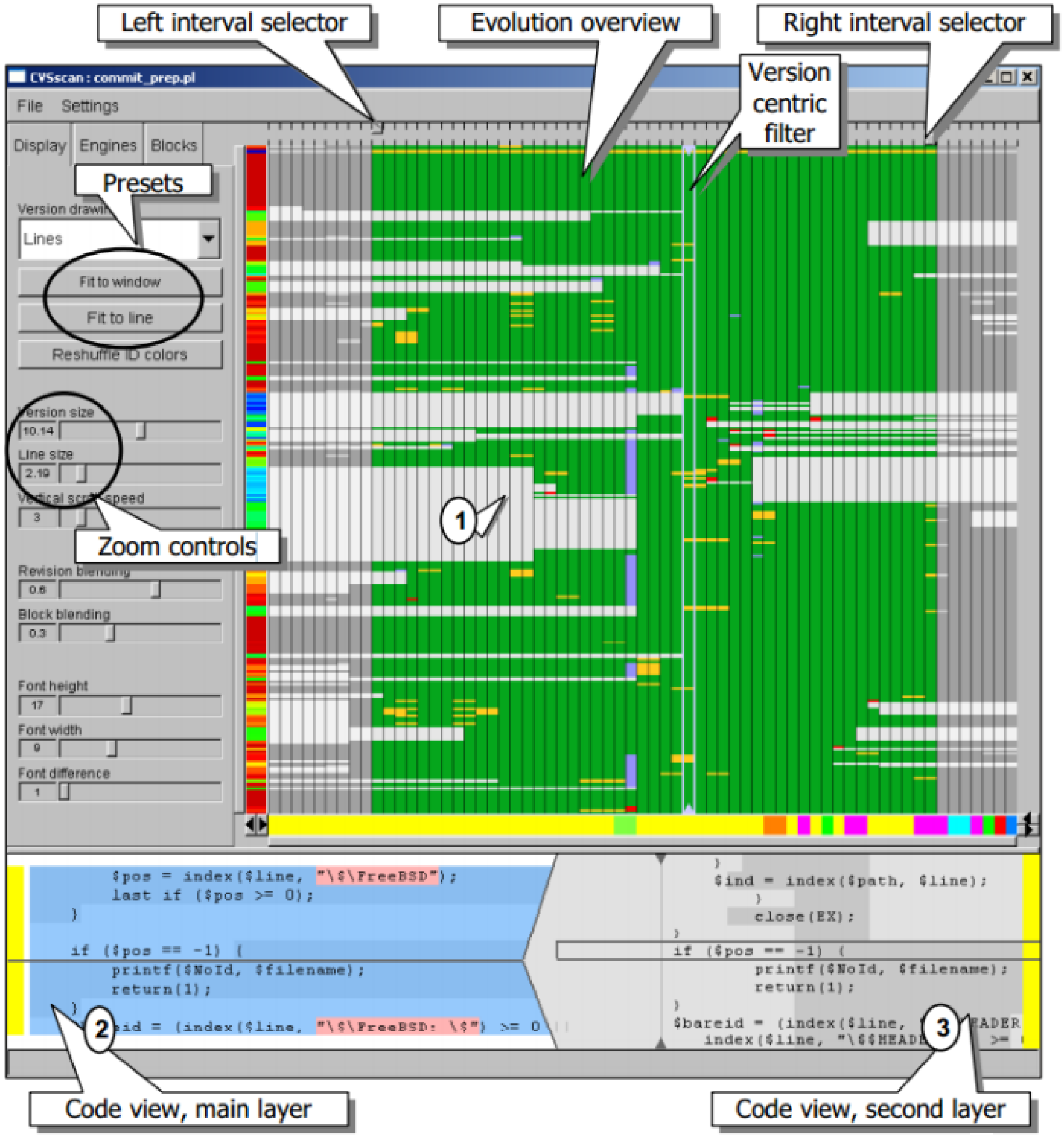
Specific Visualization Environments

Molecular visualisation in the Reality Cube
University of Groningen, NL

Tabletops for Visualization
University of Calgary

WILD Wall, INRIA

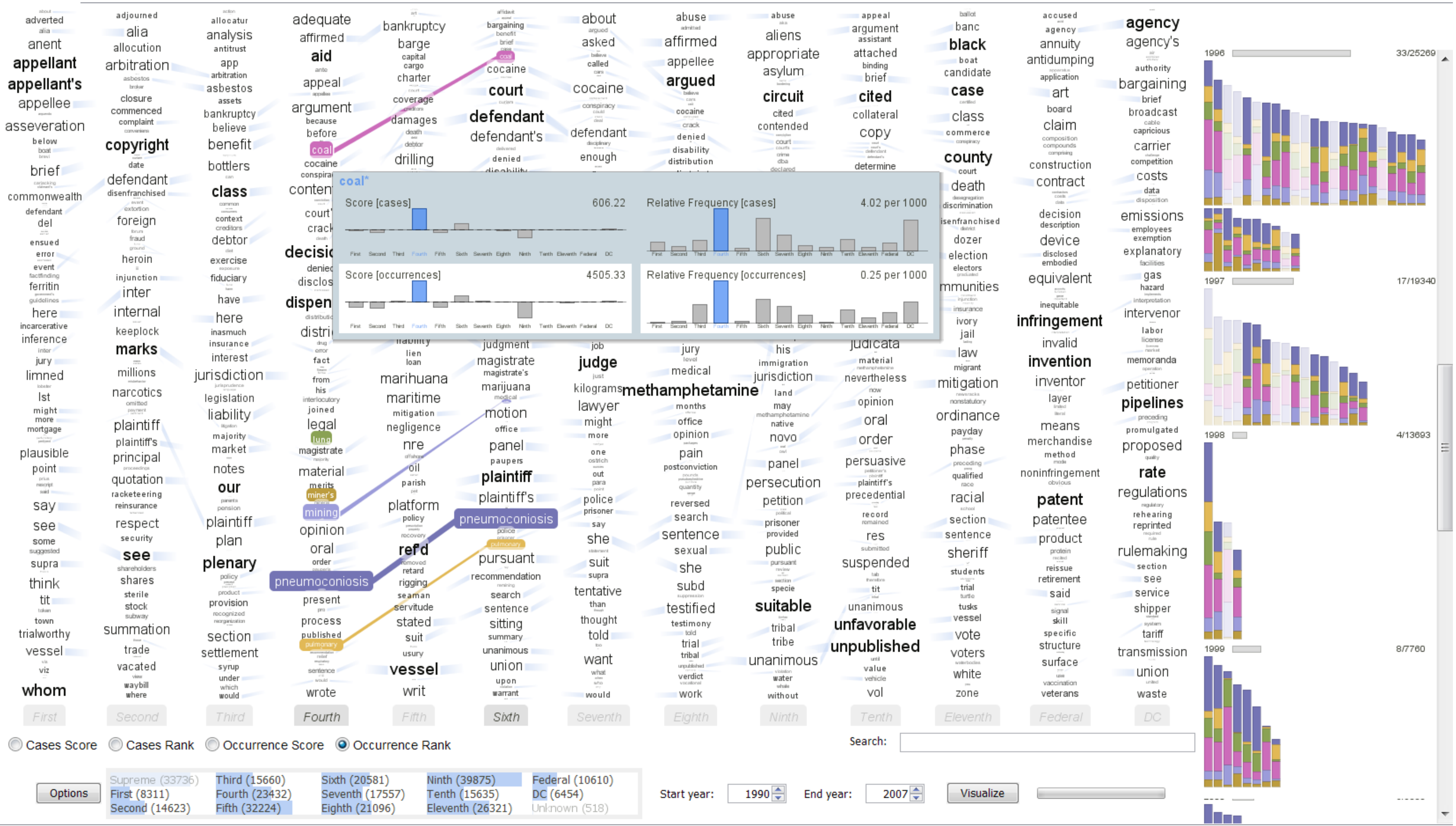
Software Visualization



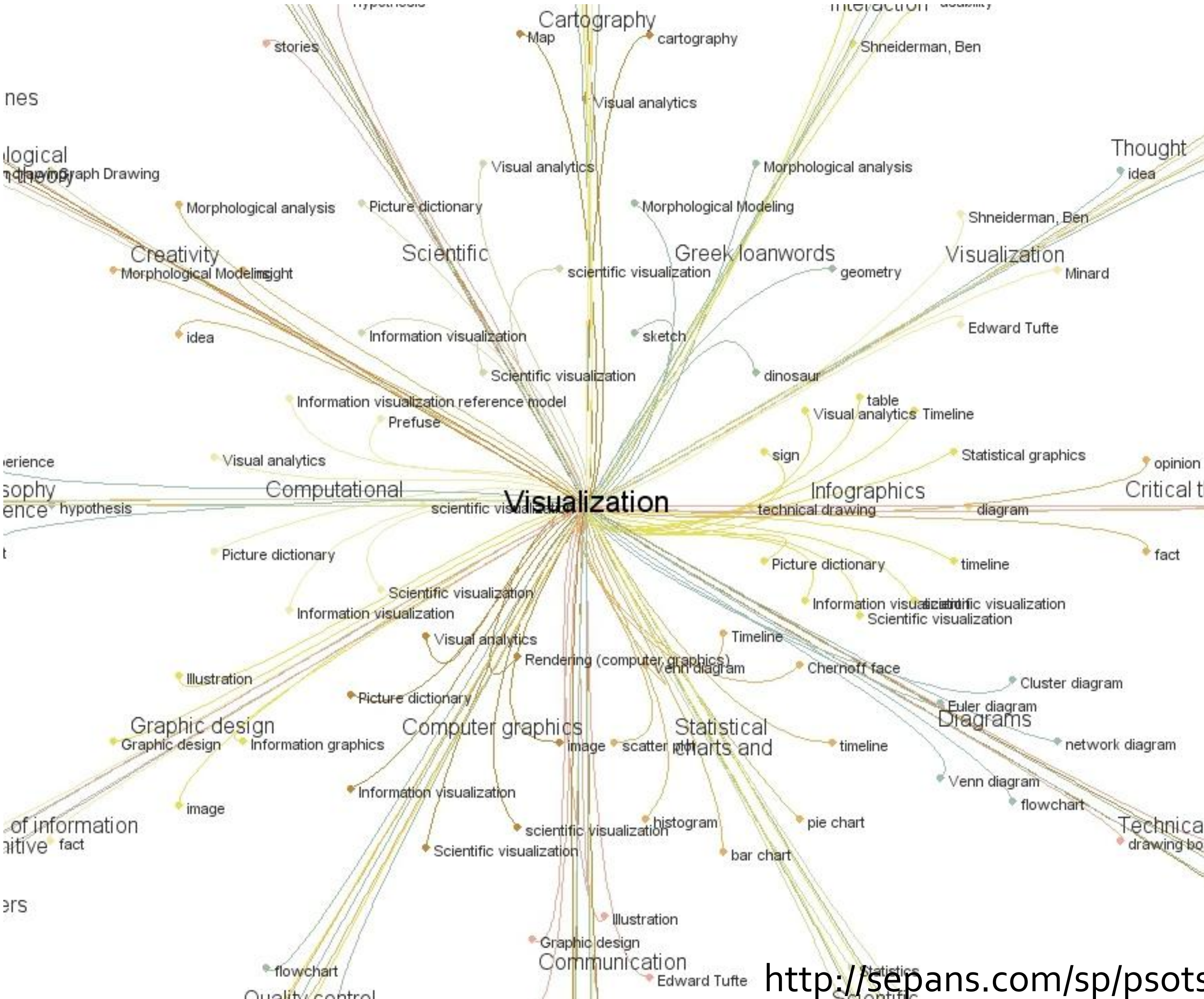
(Voineaet al., SoftVis, 2005)

Text Visualization

Parallel Tag Clouds to Explore Faceted Text Corpora (Collins et al., VAST 2009)

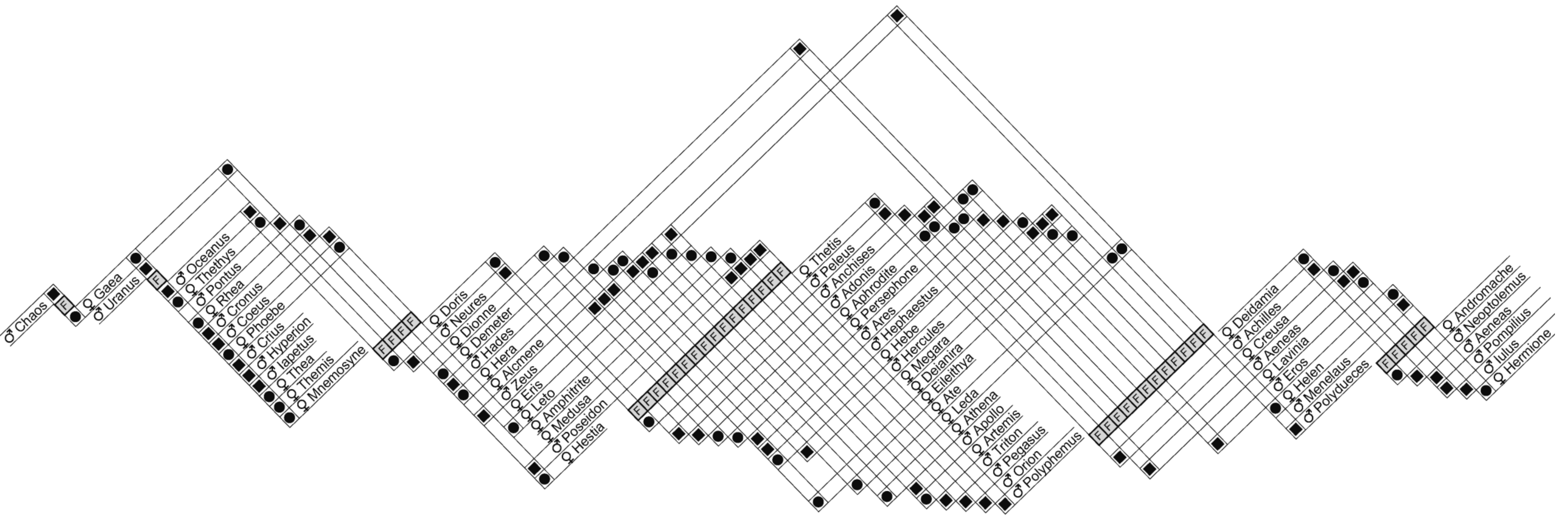


Graphs



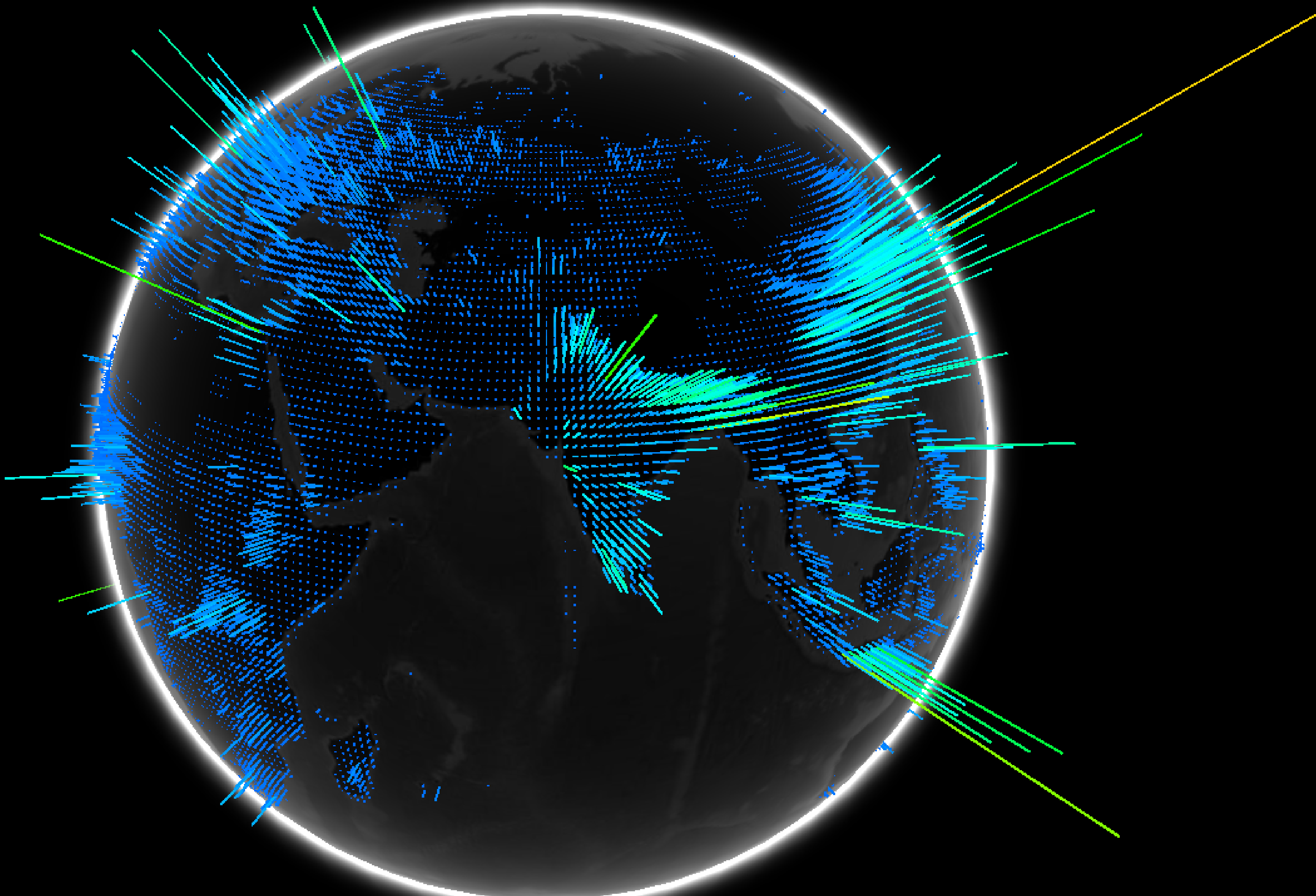
Here Wikipedia
http://sepans.com/sp/psots/wiki_category/

Family Trees



http://www.aviz.fr/geneaquilts/

Geographic Visualization

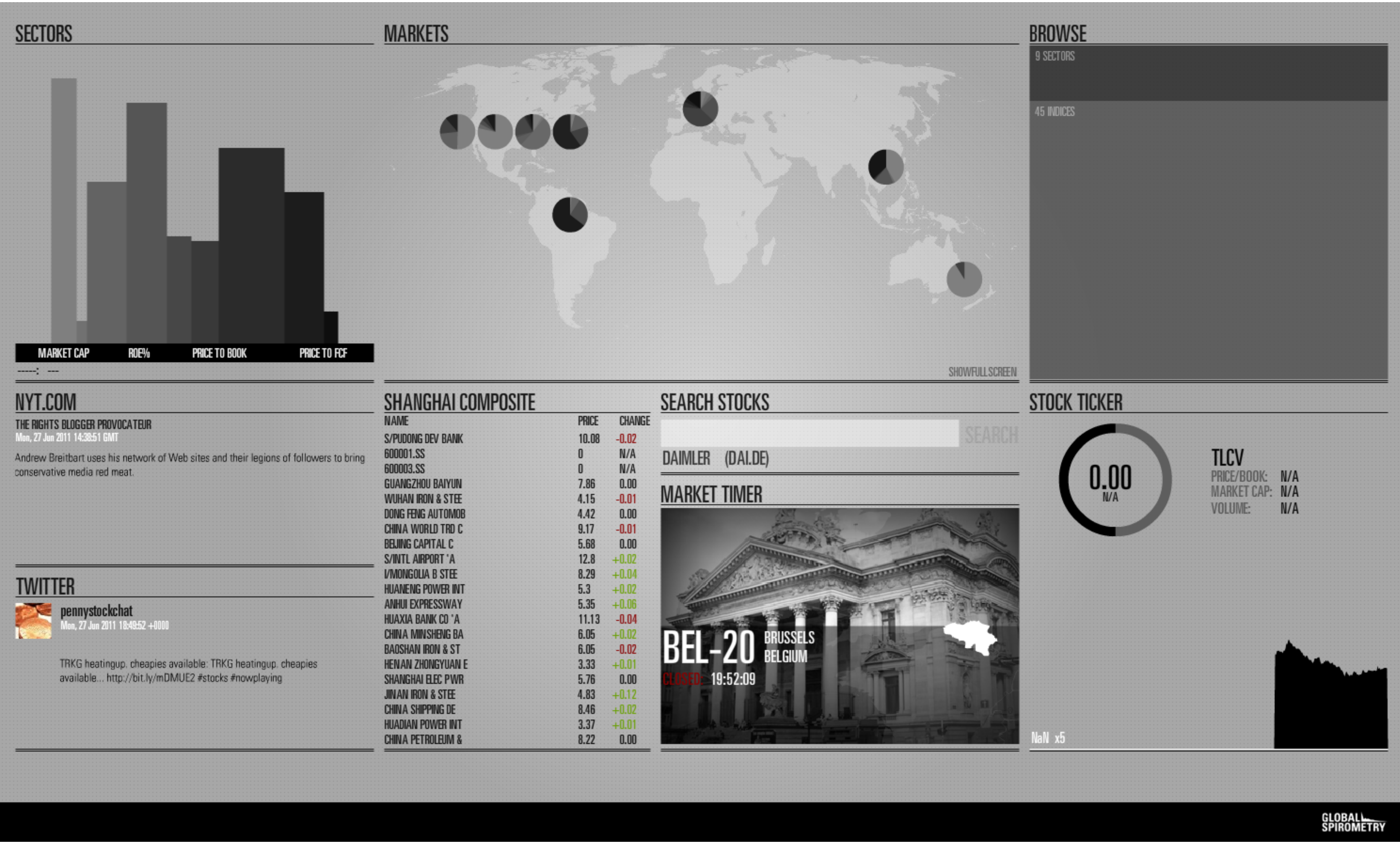


http://data-arts.appspot.com/globe

Weather

http://weatherspark.com/

Data Dashboards



http://globalspirometry.com

Resources for more examples

- Visualization conferences
- Blogs
  - http://infosthetics.com/
  - http://fellinlovewithdata.com/
  - http://eagereyes.org/
  - http://flowingdata.com/
  - http://www.informationisbeautiful.net/
- Books
  - Textbooks
    - Readings in Information Visualization: Using Vision to Think (a bit old now but good intro)
    - Information Visualization (Robert Spence – a light intro, I recommend as a start)
    - Information Visualization Perception for Design (Colin Ware, focused on perception and cognition)
    - Interactive Data Visualization: Foundations, Techniques, and Applications (Ward et al. – most recent)
  - Examples
    - Beautiful Data (McCandless)
    - Now You See it (Few)
    - Tufte Books: Visual Display of Quantitative Information (and others)
    - … (many more, ask me for details)

It is difficult to create

CREATE VISUALIZATIONS

GOOD


Cem

What is a representation?

- A representation is
  - a formal system or mapping by which the information can be specified (D. Marr)
  - a sign system in that it stands for something other than its self.
- for example: the number thirty-four

34	100010	XXXIV
decimal	binary	roman

Presentation

- different representations reveal different aspects of the information

  decimal: counting & information about powers of 10,

  binary: counting & information about powers of 2,

  roman: impress your friends (outperformed by positional system)

- presentation

  how the representation is placed or organized on the screen

  34, **34**, <u>34</u>

Principles of Graphical Excellence

- Well-designed presentation of interesting data – a matter of *substance*, *statistics*, *design*
- Complex ideas communicated with clarity, precision, efficiency
- Gives the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space
- Involves almost always multiple variables
- Tell the truth about the data

The Visual Display of Quantitative Information, Tufte

Or a bit more simply…

- Solving a problem simply means representing it so as to make the solution transparent … (Simon, 1981)
- Good representations:
  – allow people to find relevant information
    - information may be present but hard to find
  – allow people to compute desired conclusions
    - computations may be difficult or “for free” depending on representations

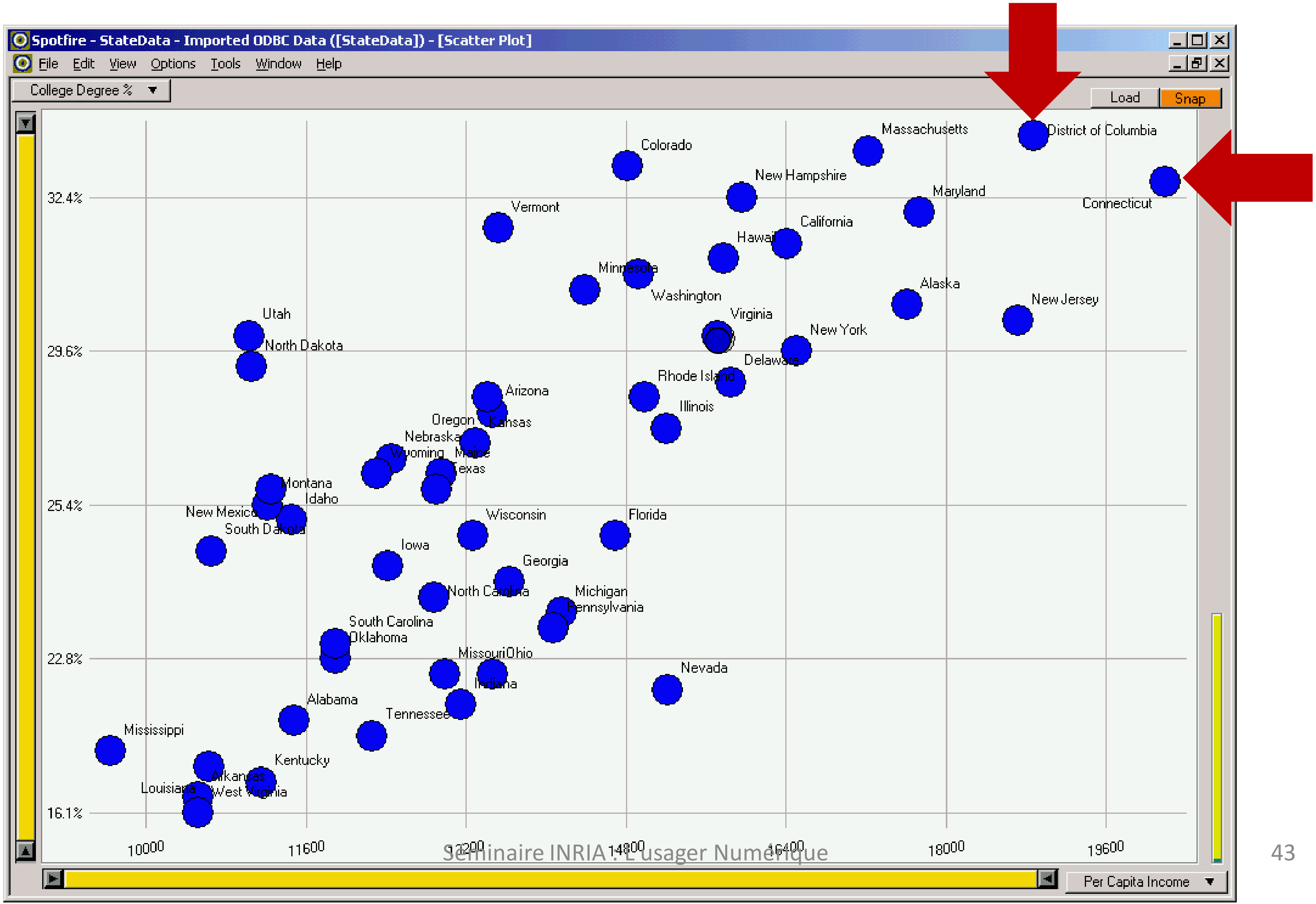
Good representation?

Table - StateData ()

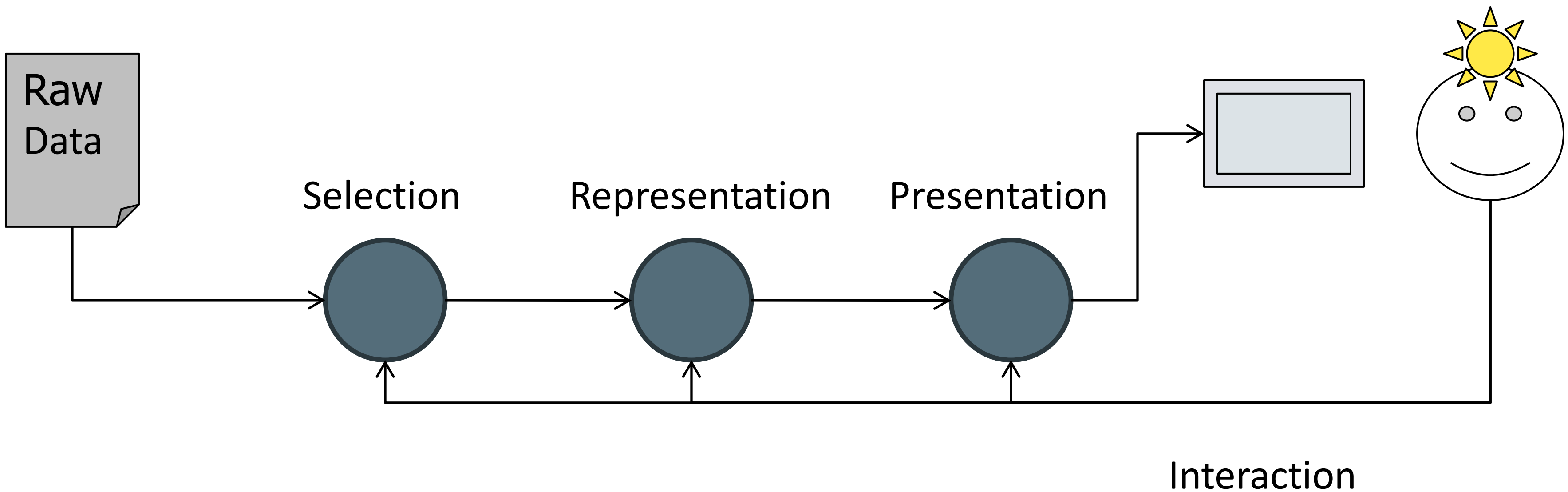
Load | Snap

State	College Degree %	Per Capita Income
Alabama	20.6%	11486
Alaska	30.3%	17610
Arizona	27.1%	13461
Arkansas	17.0%	10520
California	31.3%	16409
Colorado	33.9%	14821
Connecticut	33.8%	20189
Delaware	27.9%	15854
District of Columbia	36.4%	18881
Florida	24.9%	14698
Georgia	24.3%	13631
Hawaii	31.2%	15770
Idaho	25.2%	11457
Illinois	26.8%	15201
Indiana	20.9%	13149
Iowa	24.5%	12422
Kansas	26.5%	13300
Kentucky	17.7%	11153
Louisiana	19.4%	10635
Maine	25.7%	12957
Maryland	31.7%	17730
Massachusetts	34.5%	17224
Michigan	24.1%	14154
Minnesota	30.4%	14389
Mississippi	19.9%	9648
Missouri	22.3%	12989
Montana	25.4%	11213
Nebraska	26.0%	12452
Nevada	21.5%	15214
New Hampshire	32.4%	15959
New Jersey	30.1%	18714
New Mexico	25.5%	11246
New York	29.6%	16501
North Carolina	24.2%	12885
North Dakota	28.1%	11051
Ohio	22.3%	13461
Oklahoma	22.8%	11893
Oregon	27.5%	13418
Pennsylvania	23.2%	14068
Rhode Island	27.5%	14981
South Carolina	23.0%	11897
South Dakota	24.6%	10661
Tennessee	20.1%	12255
Texas	25.5%	12904
Utah	30.0%	11029
Vermont	31.5%	13527
Virginia	30.0%	15713
Washington	30.9%	14923
West Virginia	16.1%	10520
Wisconsin	24.9%	13276
Wyoming	25.7%	12311

Good representation!



How do we arrive at a visualization?

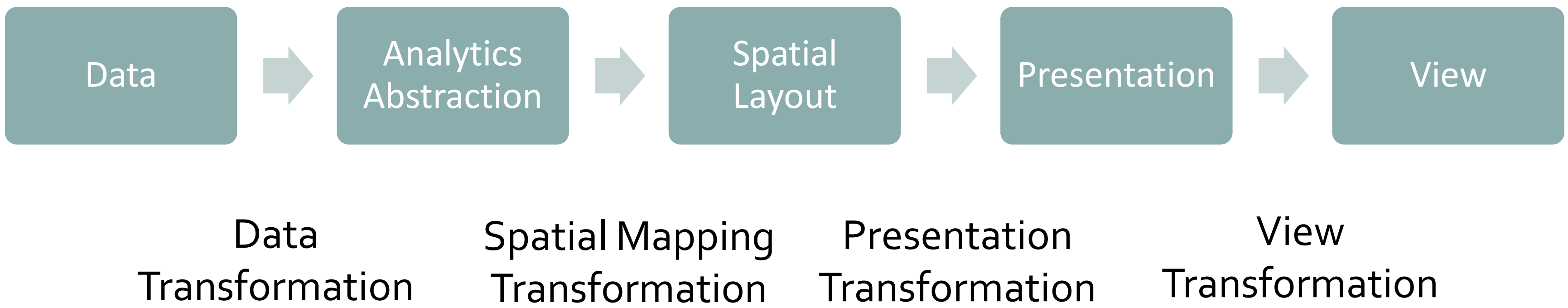


The Visualization Pipeline

From [Spence, 2000]

Visualization Reference Model

Also a visualization pipeline a bit expanded



From [Card et al., Readings in Information Visualization]

Pitfalls

- Selecting the wrong data
- Selecting the wrong data structure
- Filtering out important data
- Failed understanding of the types of things that need to be shown
- Choosing the wrong representation
- Choosing the wrong presentation format
- Inappropriate interactions provided to explore the data

Recap

- So far you
  - learned what information visualization is
  - learned about the advantages of visualization
  - saw a number of examples (historical and new)
  - tried to create your own first visualization from a dataset

- Next
  - you will get to know your data
  - you will learn about the basic components of visualization
  - try another example

Data

- Data is the foundation of any visualization
- The visualization designer needs to understand
  - the data properties
  - know what meta-data is available
  - know what people want from the data

Nominal, Ordinal and Quantitative

- Nominal (labels)
  - Fruits: apples, oranges
- Ordered
  - Quality of meat: grade A, AA, AAA
  - Can be counted and ordered, but not measured
- Quantitative: Interval
  - no clear zero (or arbitrary)
  - e.g. dates, longitude, latitude
  - usually compare differences (intervals)
- Quantitative: Ratio
  - meaningful origin (zero)
  - physical measurements (temperature, mass, length)
  - counts and amounts

S.S. Stevens, On the theory of scales of measurements, 1946

Nominal, Ordinal and Quantitative

- Nominal (labels)
  - Operations: =, ≠
- Ordered
  - Operations: =, ≠, <, >
- Quantitative: Interval
  - Operations: =, ≠, <, >, -, +
  - Can measure distances or spans
- Quantitative: Ratio
  - Operationrs: =, ≠, <, >, - , +, ×, ÷
  - Can measure ratios or proportions

 ≠ 

 > 

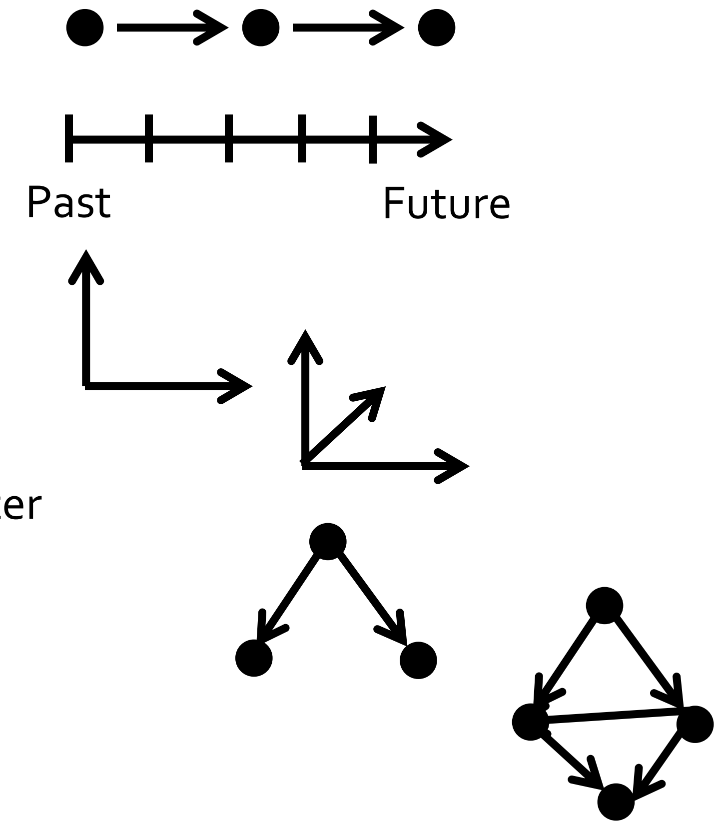
[1989 – 1999] + [2002 – 2012]

10kg / 5kg

S.S. Stevens, On the theory of scales of measurements, 1946

Data-Type Taxonomy

- 1D (linear)
- Temporal
- 2D (maps)
- 3D
- nD (relational) vis examples later
- Trees (hierarchies)
- Networks (graphs)



Shneiderman: The Eyes Have It

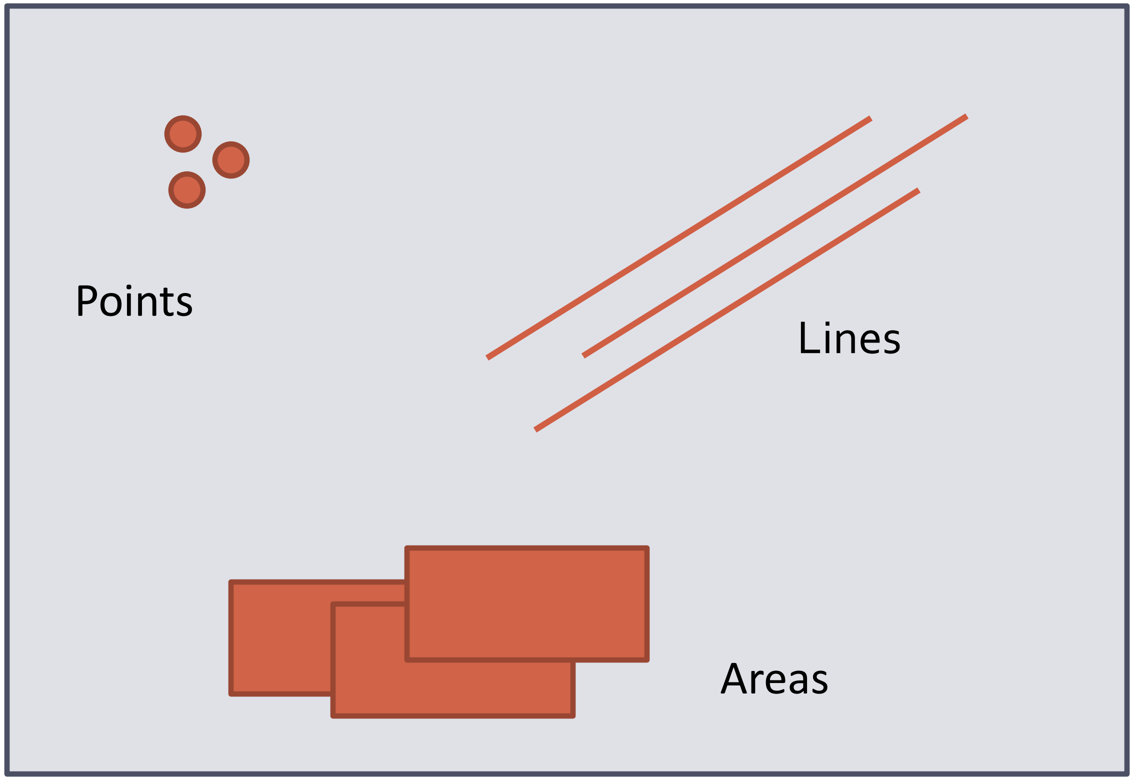
Why is this important?

- Nominal, ordinal, and quantitative data are best expressed in different ways visually
- Data types often have inherent tasks
  - temporal data (comparison of events)
  - trees (understand parent-child relationships)
  - …

- But:
  - any data type (1D, 2D,…) can be expressed in a multitude of ways!

Visualization's Main Building Blocks

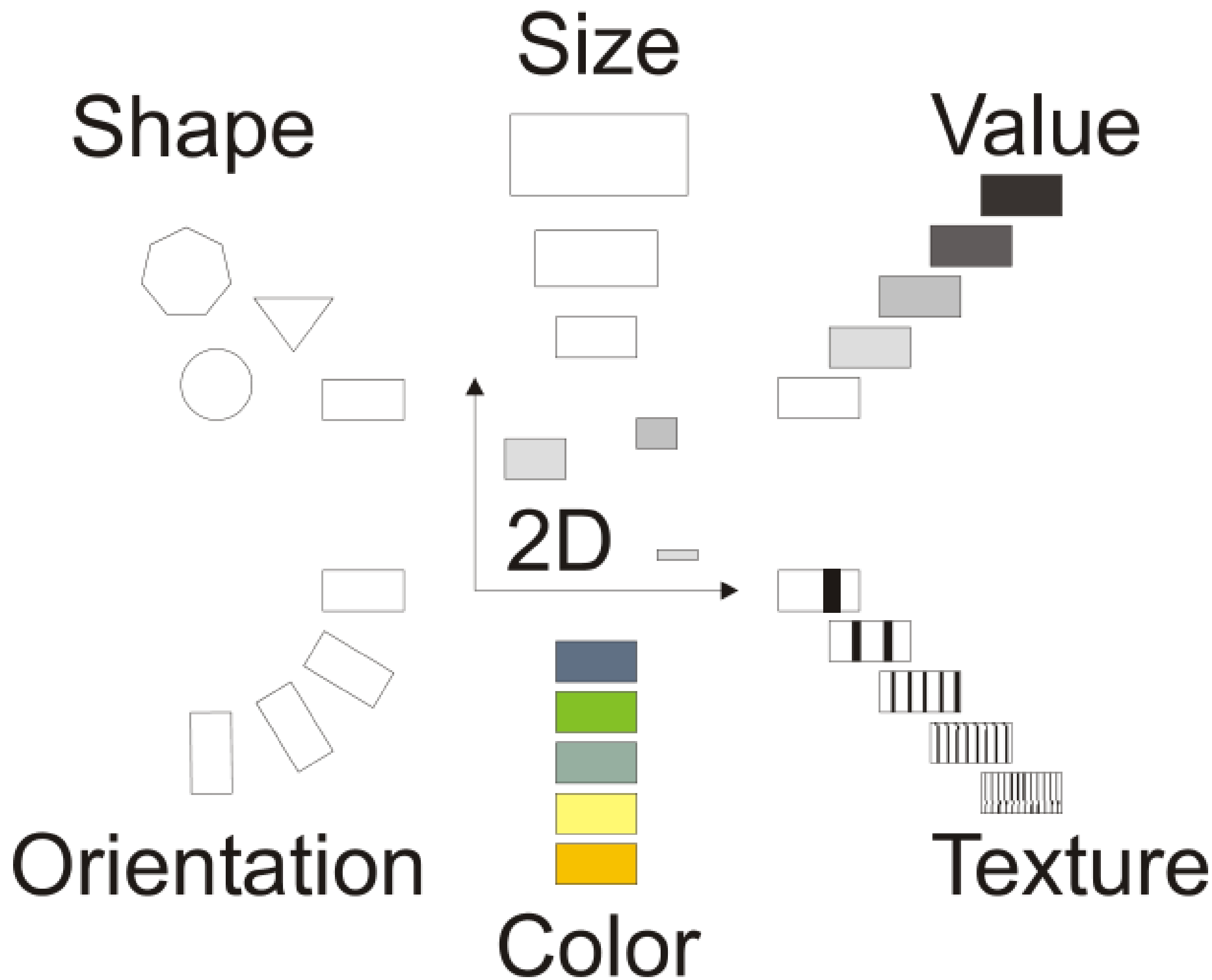
Marks which represent:



From Semiology of Graphics (Bertin)

The following slides on the topic adapted from Sheelagh Carpendale

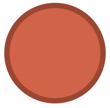
Visual Variables Applicable to Marks



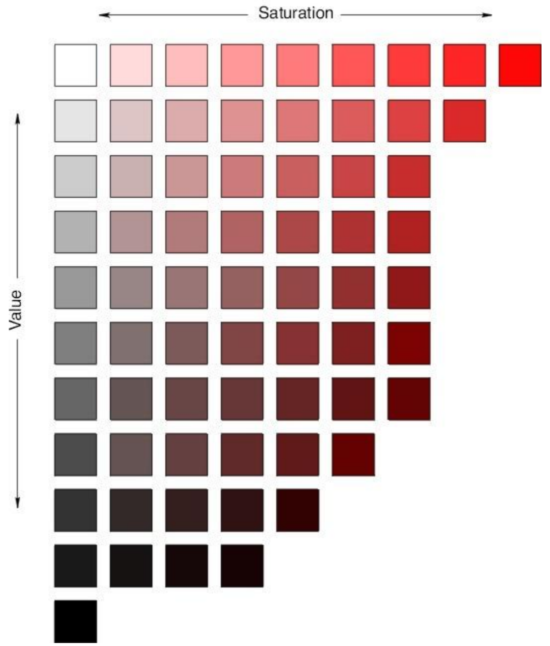
From Semiology of Graphics (Bertin)

Additional Variables for Computers

- **motion**
  - direction, acceleration, speed, frequency, onset, 'personality'



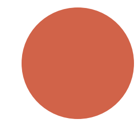
- **saturation**
  - colour as Bertin uses largely refers to hue, saturation != value



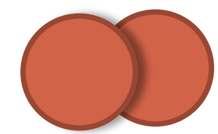
Extending those from Semiology of Graphics (Bertin)

Additional Variables for Computers

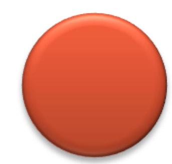
- **flicker**
  - frequency, rhythm, appearance



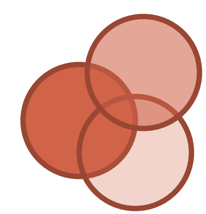
- **depth?** ‘quasi’ 3D
  - depth, occlusion, aerial perspective, binocular disparity



- **Illumination**



- **transparency**



From Semiology of Graphics (Bertin)

Characteristics of Visual Variables

- Selective:
  Is a change in this variable enough to allow us to select it from a group?
- Associative:
  Is a change in this variable enough to allow us to perceive them as a group?
- Quantitative:
  Is there a numerical reading obtainable from changes in this variable?
- Order:
  Are changes in this variable perceived as ordered?
- Length (resolution):
  Across how many changes in this variable are distinctions possible?

From Semiology of Graphics (Bertin)

Visual Variables

Visual Variable	Selective	Associative	Quantitative	Order	Length
Position	Yes	Yes	Yes	Yes	Dependant on resolution
Size	Yes	Yes	Approximate	Yes	Association: 5; Distinction: 20
Shape	With Effort	With Effort	No	No	Infinite
Value	Yes	Yes	No	Yes	Association: 7; Distinction: 10
Hue	Yes	Yes	No	No	Association: 7; Distinction: 10
Orientation	Yes	Yes	No	No	4
Grain	Yes	Yes	No	No	5
Texture	Yes	Yes	No	No	Infinite
Motion	Yes	Yes	No	Yes	Unknown

Carpendale, 2003

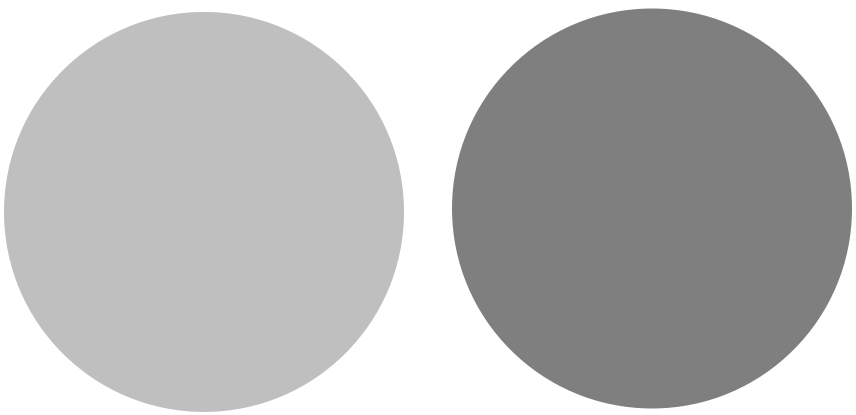
Elementary Graphical Perception Tasks

William S. Cleveland 1980s

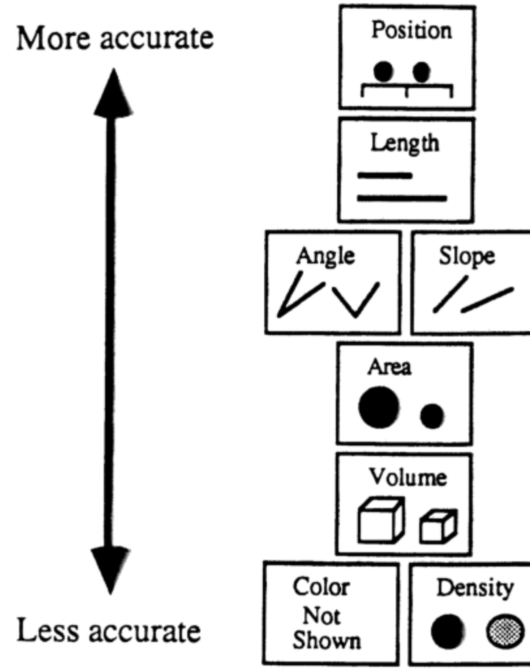
- Performed controlled experiments to find out how effectively people could judge changes in visual features
- Focus on quantitative information
- Variables used: angle, area (size), color hue, color saturation, density (value), length, position, slope, volume

Value

- What percentage in value is the right from the left (=100%) ?

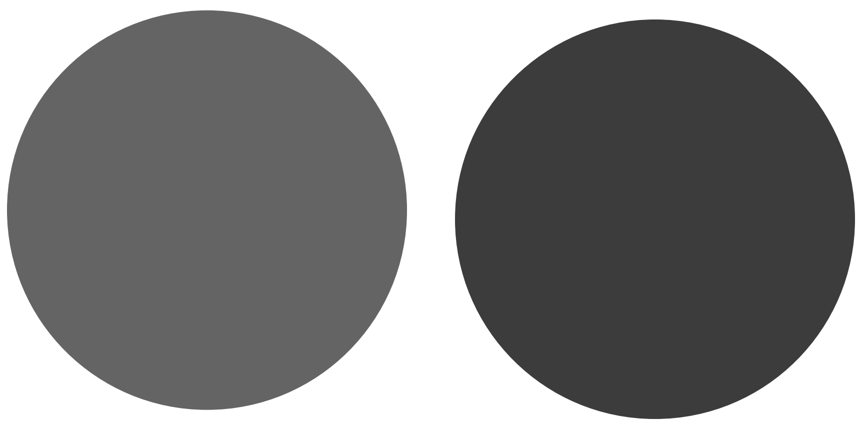


66%

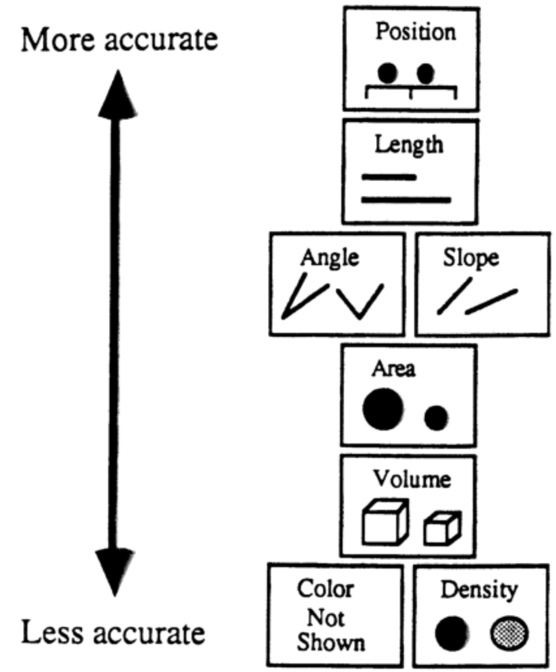


Value

- What percentage in value is the right from the left (=100%)?

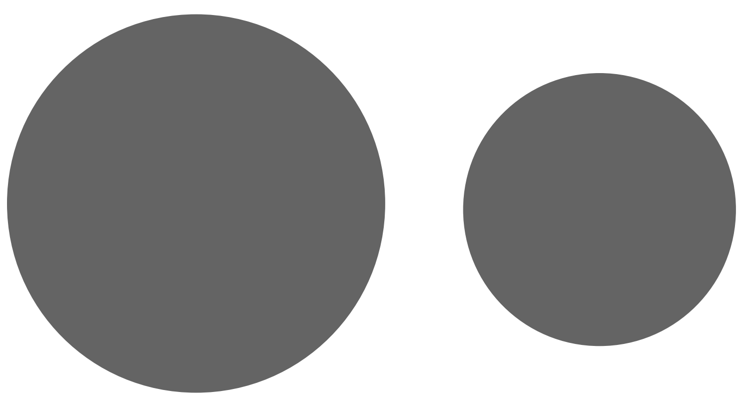


60%

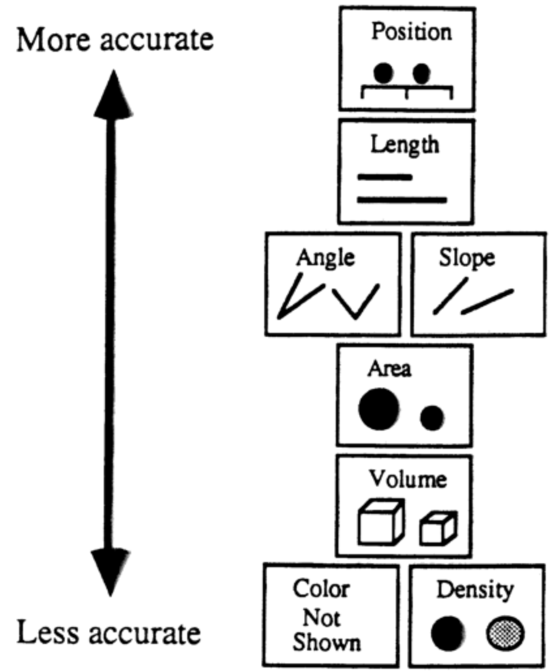


Area

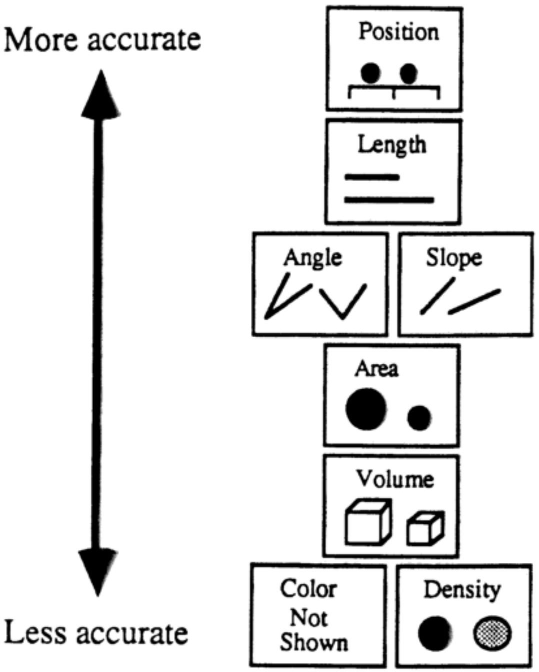
- What percentage in size is the right from the left (=100%)?



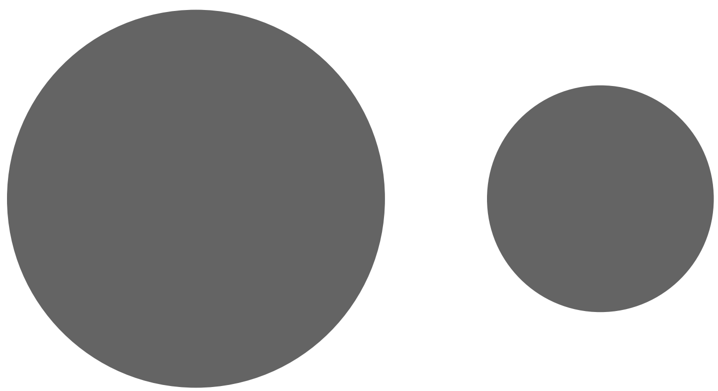
52%



Area



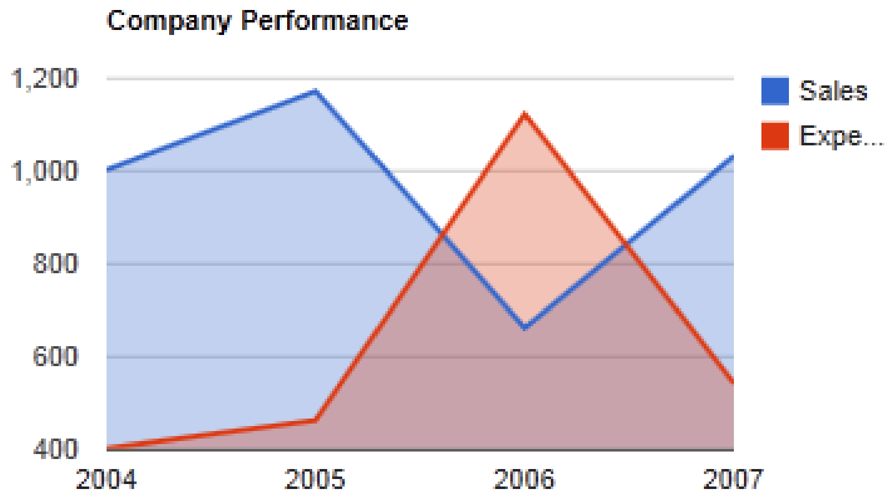
- What percentage in size is the right from the left (=100%)?

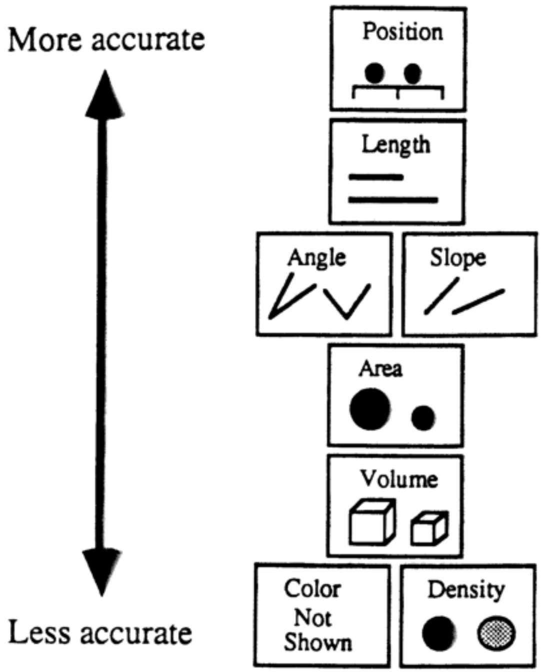


36%

Area

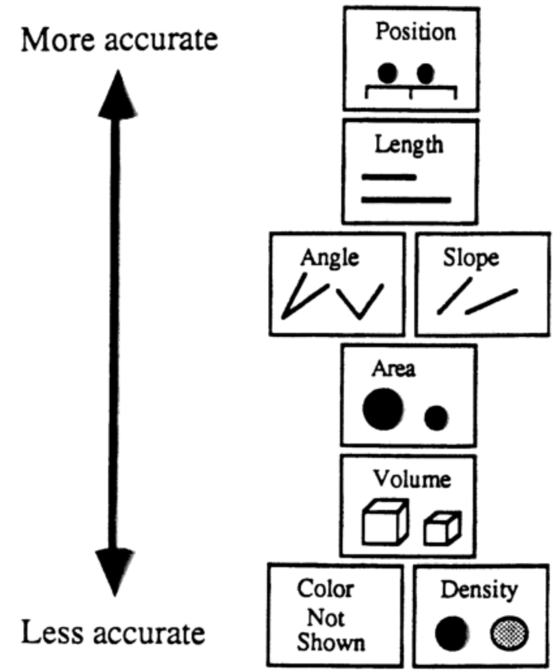
- What percentage in size is the red from the blue (=100%)?





no idea – this is very difficult

Length

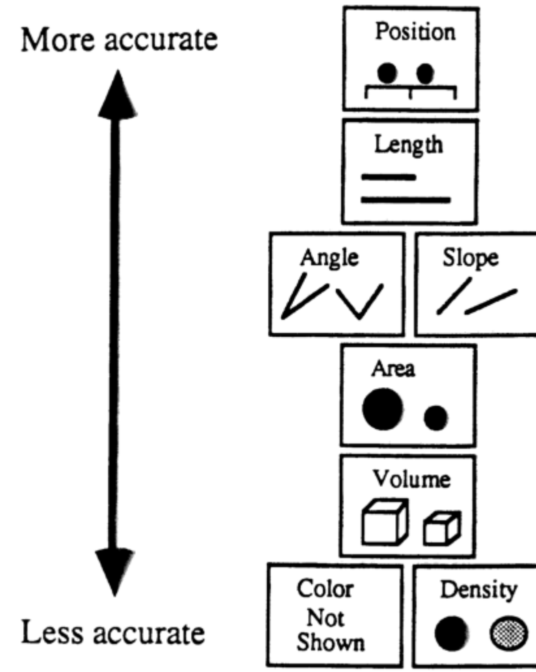


- What percentage in length is the right from the left (=100%)?

75%

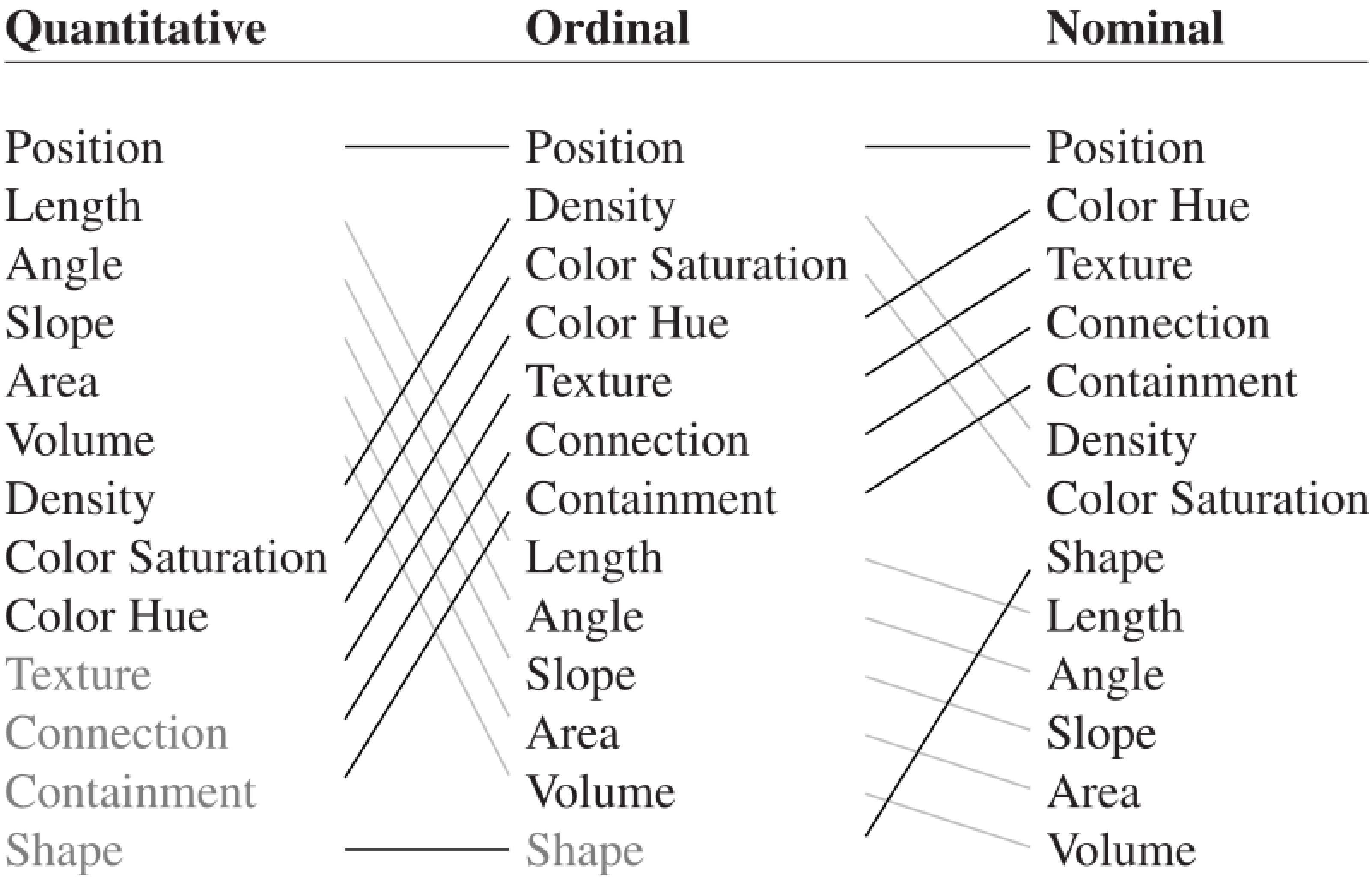
Length / Position

- What percentage in length is the right from the left (=100%)?



25%

Effectiveness of Data Encodings (Conjecture)



Mackinlay 1986

Applying what we know to

ASSESS VISUAL REPRESENTATIONS

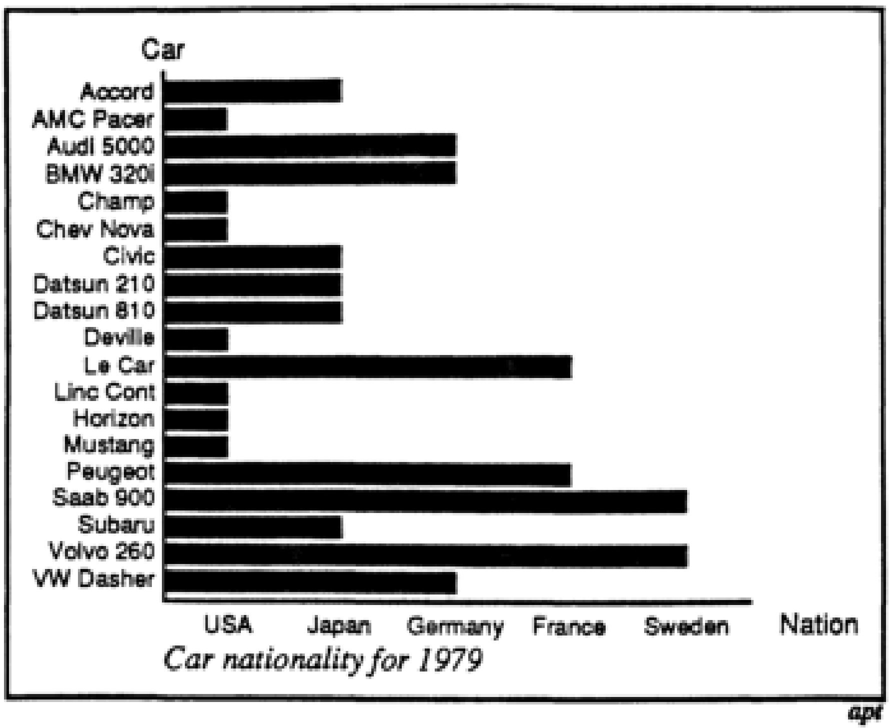
Let's evaluate…

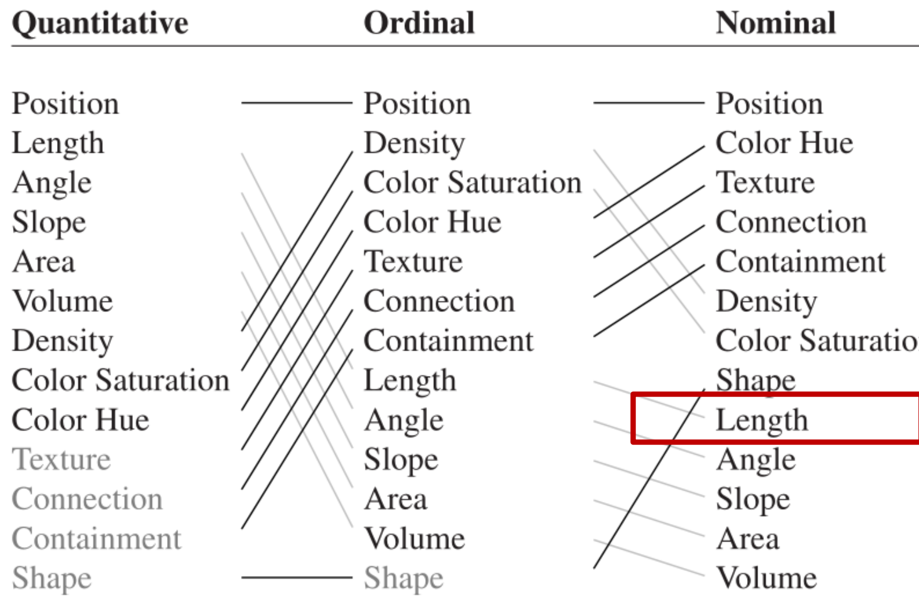
Car / Nation	USA	Japan	Germany	France	Sweden
Accord		x			
AMC Pacer	x				
Audi 5000			x		
BMW 320i			x		
Champ	x				
Chev Nova	x				
Saab 9000				x	

What kind of data are we looking at?

Nations: Nominal
Cars: Nominal
(Nation,Car): Nominal

Let's evaluate…

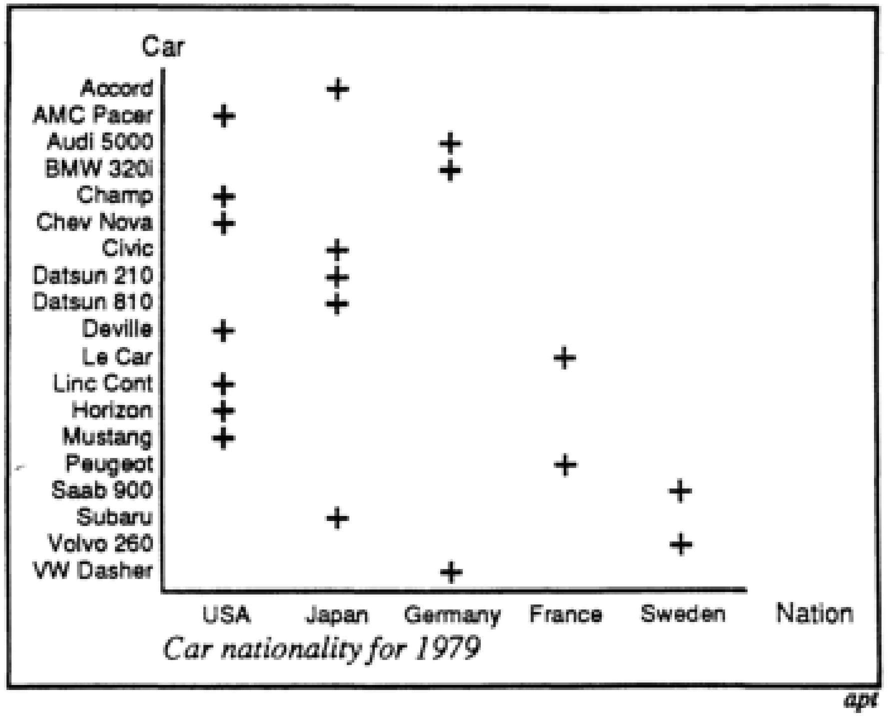


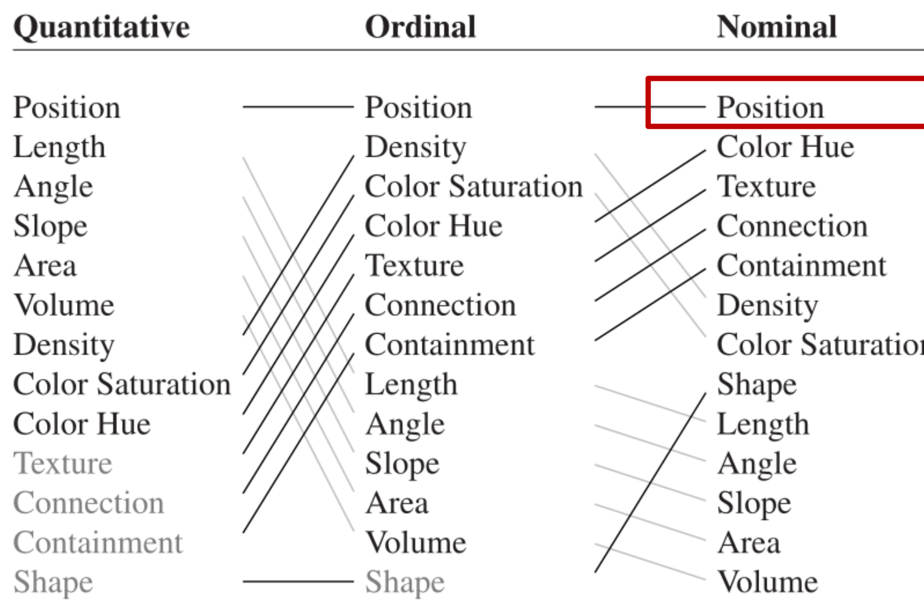


Problem:

Length of bar suggests an order or quantity (e.g. Swedish cars are better)

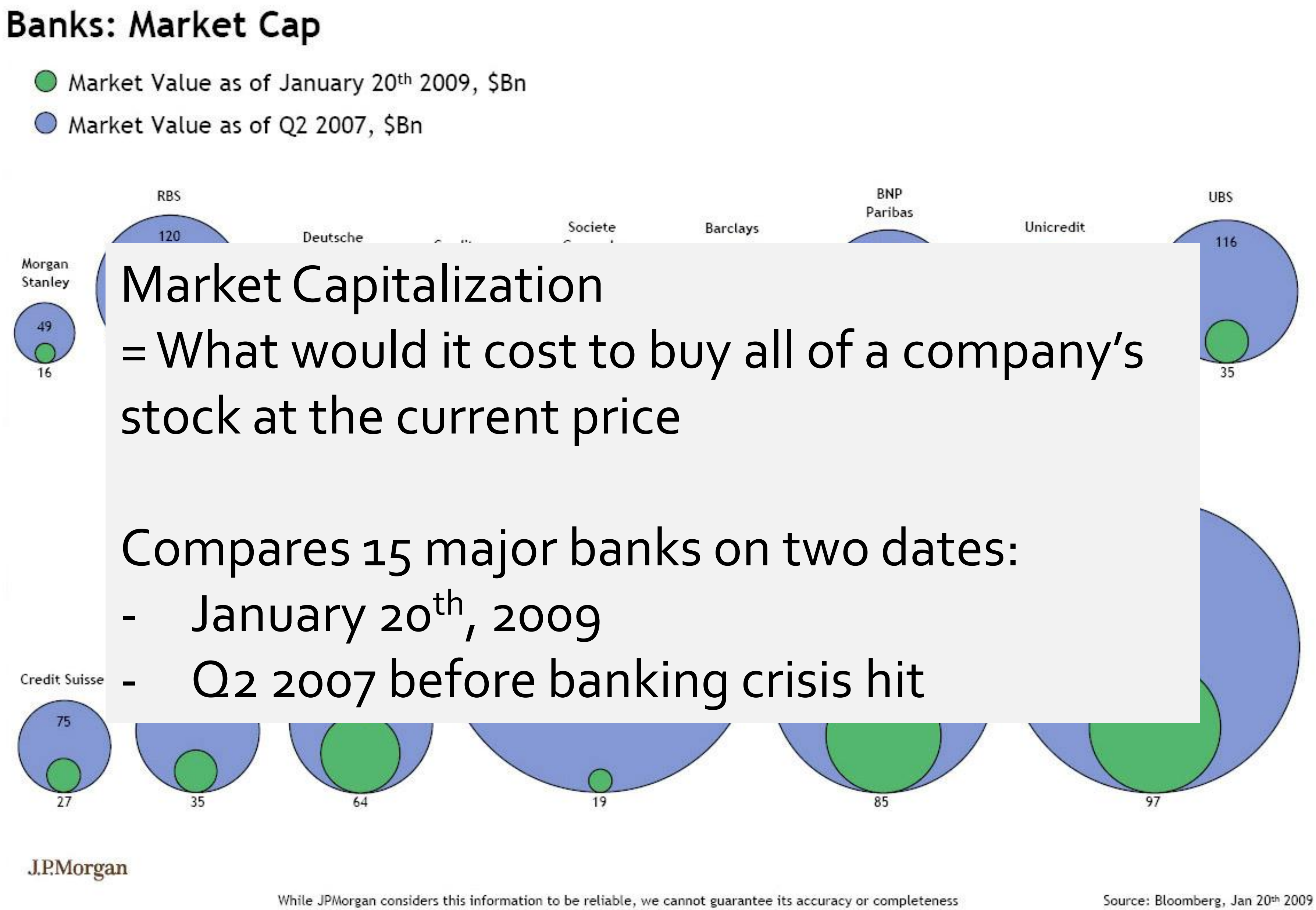
Let's evaluate…





Better!

Let's evaluate…



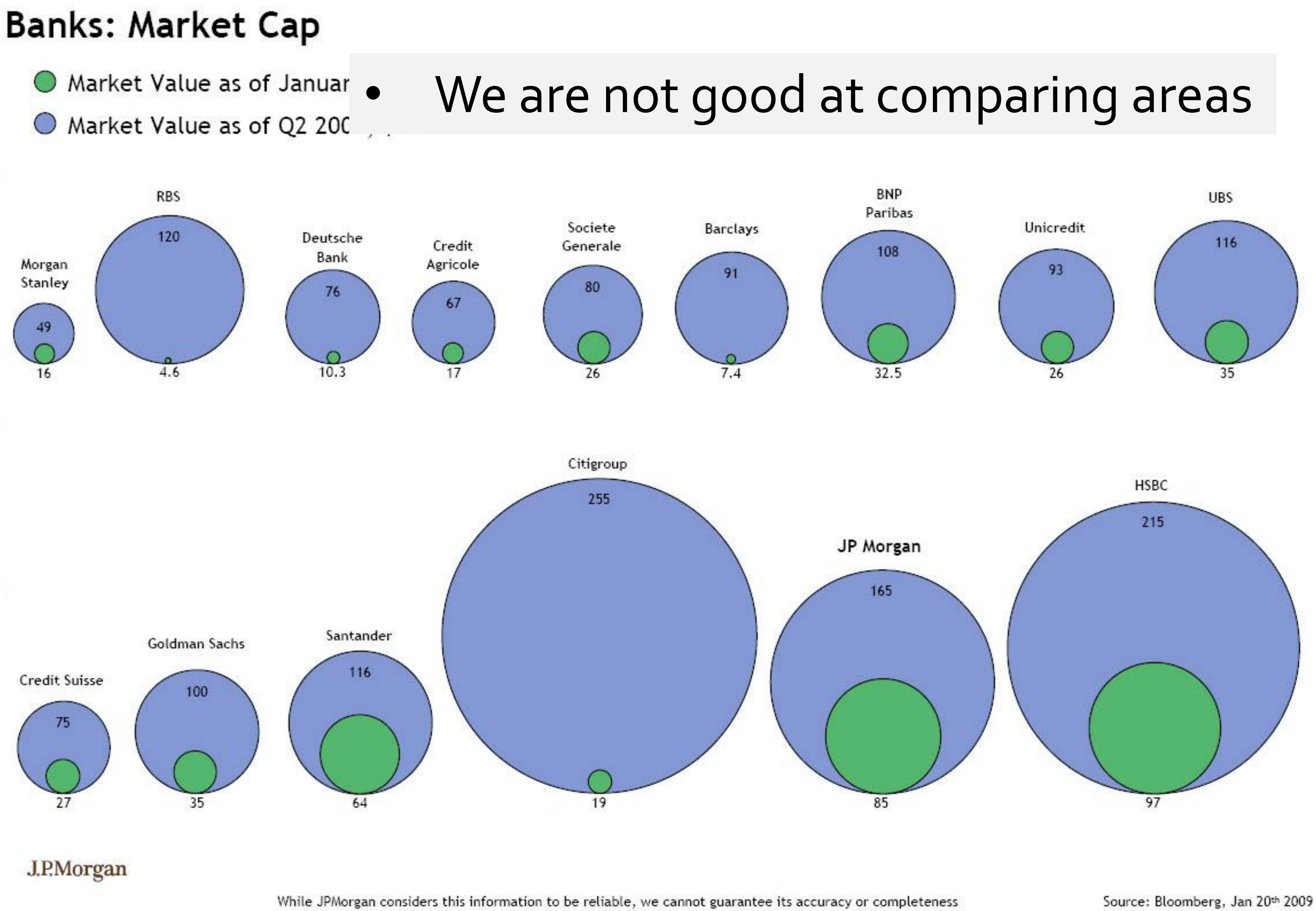
Market Capitalization
= What would it cost to buy all of a company's stock at the current price

Compares 15 major banks on two dates:

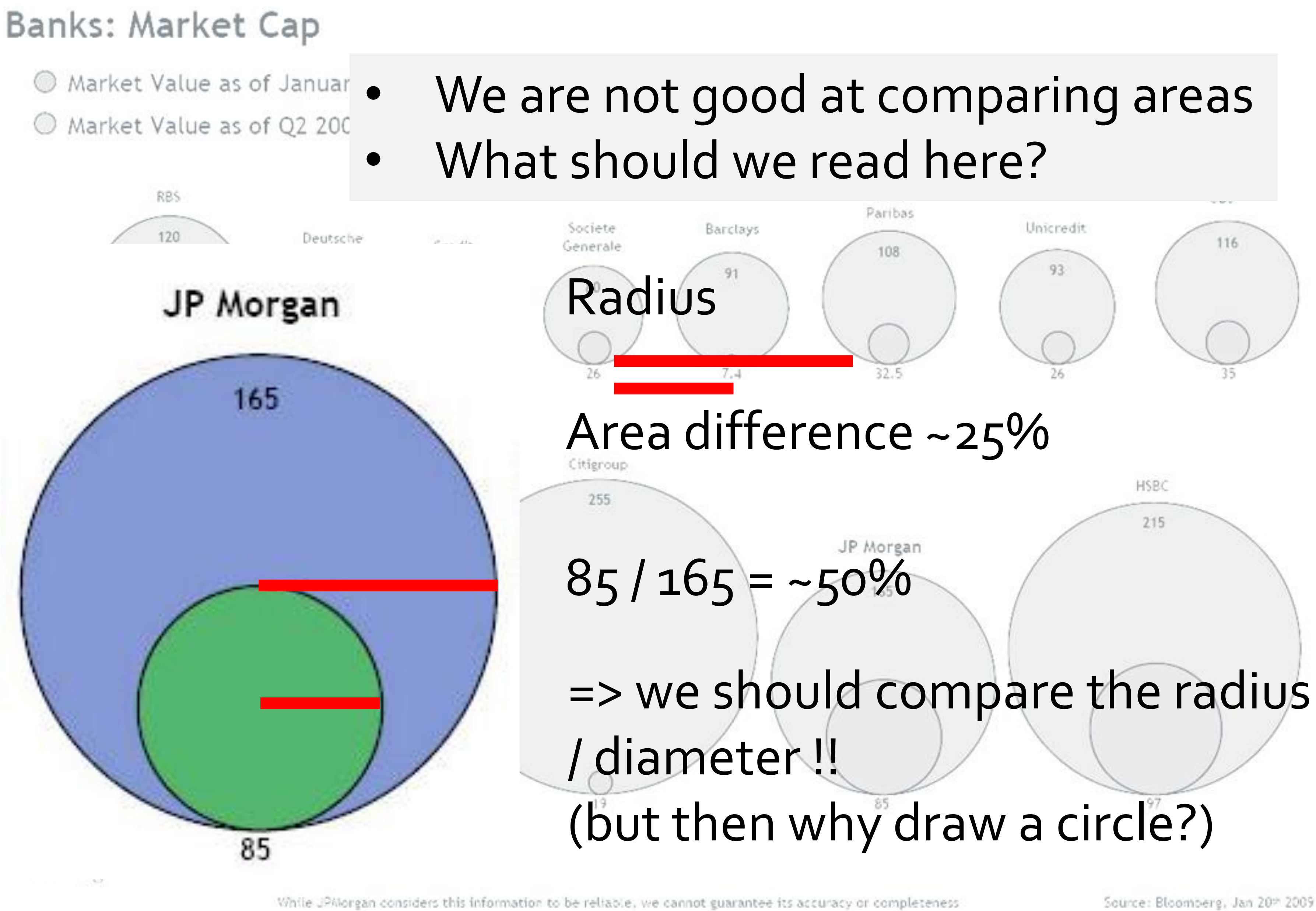
- January 20th, 2009
- Q2 2007 before banking crisis hit

Problems here?

- We are not good at comparing areas



Problems here?



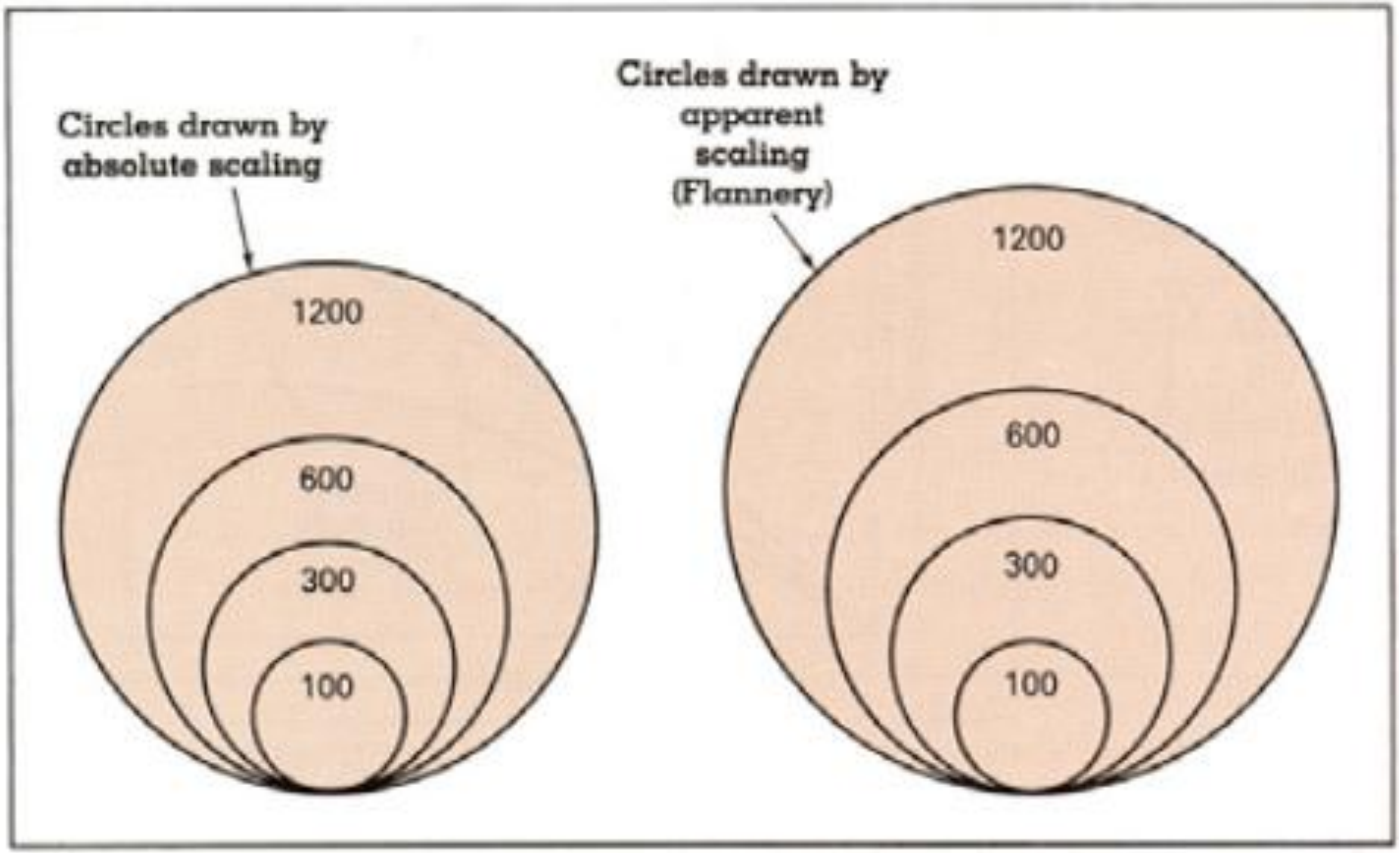
- We are not good at comparing areas
- What should we read here?

Radius

Area difference ~25%

85 / 165 = ~50%

=> we should compare the radius / diameter !!
(but then why draw a circle?)



[Cartography: Thematic Map Design, Figure 8.6, p. 170, Dent, 96]

$S = 0.98A^{0.87}$ [from Flannery 71]

Magnitude estimation experiments

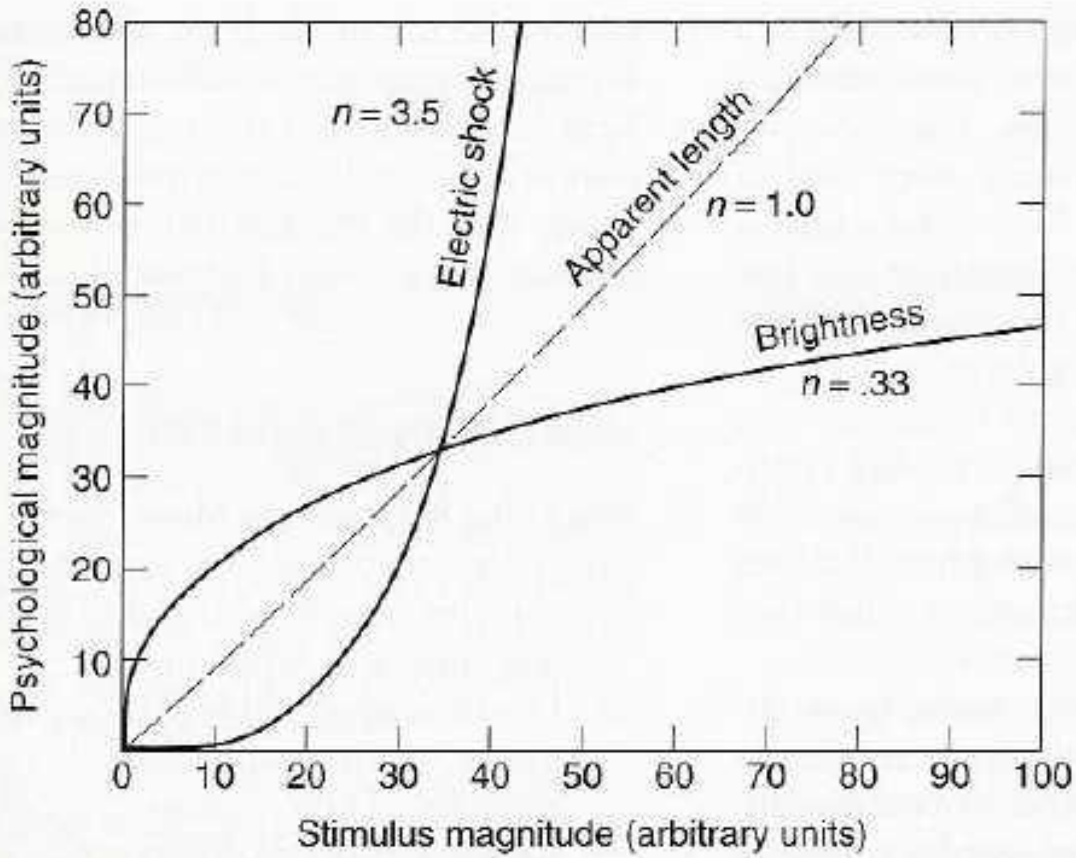
- We did a very(!) simplified magnitude estimation experiment earlier (comparing stimulus/modulus)

100%

?

- **Stevens' power law** describes a relationship between a physical stimulus (S) and its **perceived** intensity or strength (P)

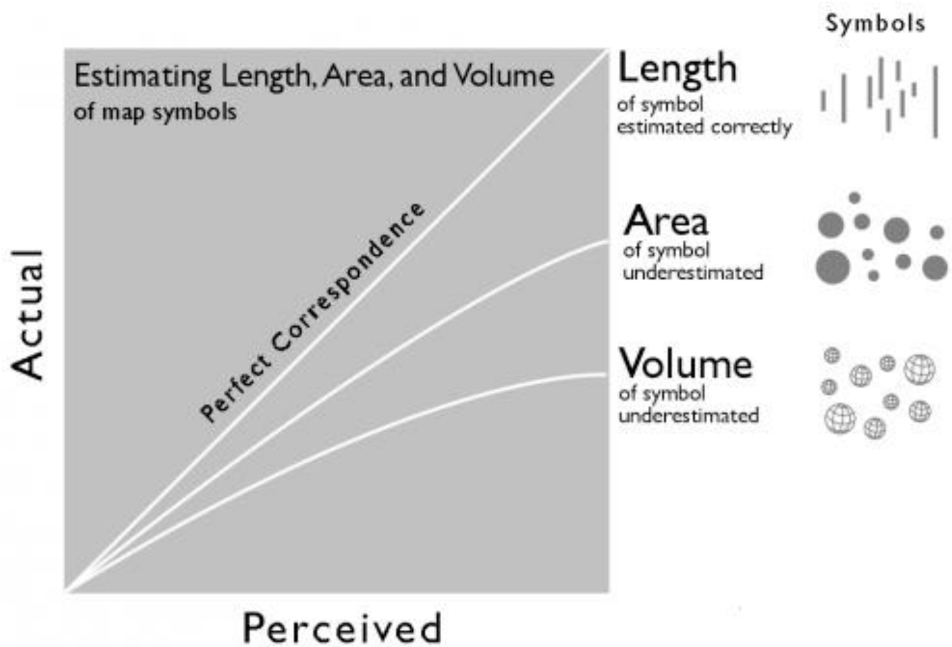
$$P = kS^n$$



Psychological magnitude (arbitrary units)
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
Stimulus magnitude (arbitrary units)
n = 3.5
Electric shock
Apparent length
n = 1.0
Brightness
n = .33

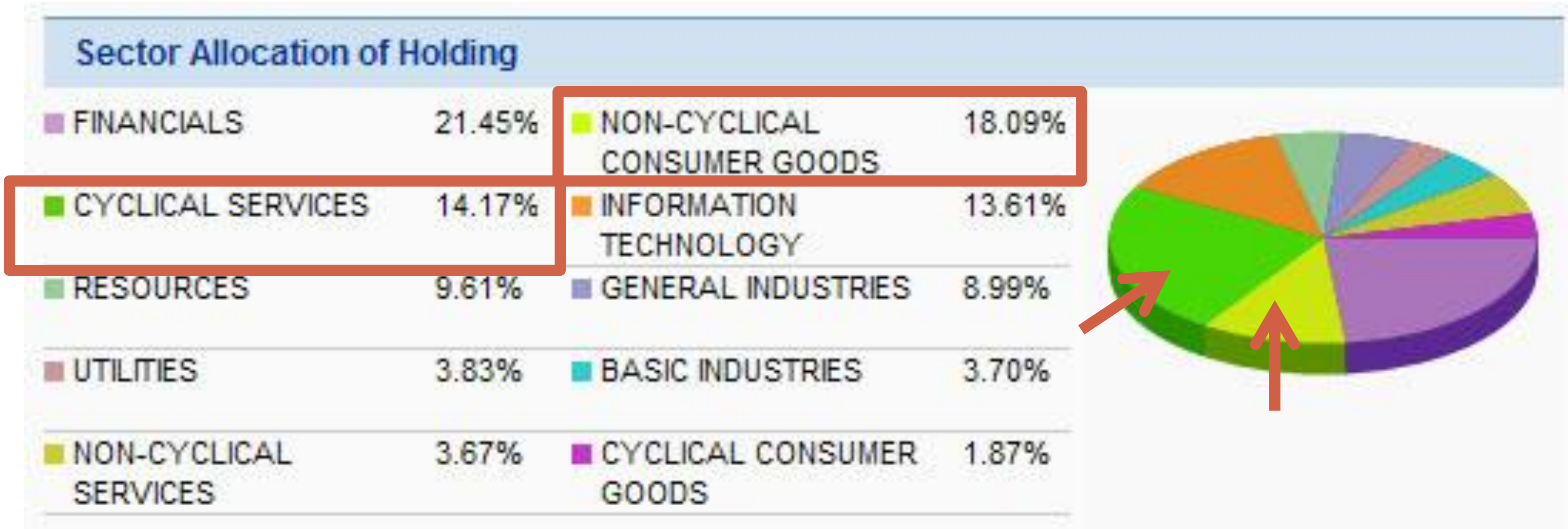
Perception

- People tend to **correctly estimate lengths**
- They tend to **underestimate areas and volumes.**
  - When asked to pick a circle that is two times the size of another most people would pick a circle ~1.8 times the size. This tendency gets worse with larger areas, and is worse in general for estimations of volumes.



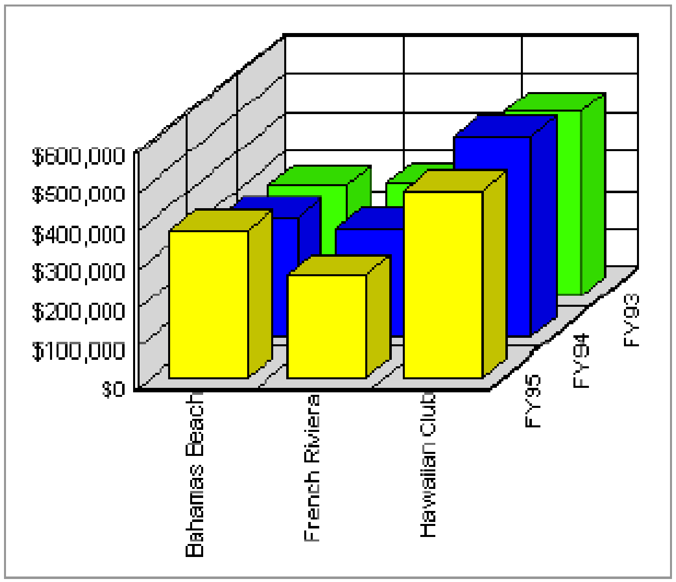
http://makingmaps.net/2007/08/28/perceptual-scaling-of-map-symbols/

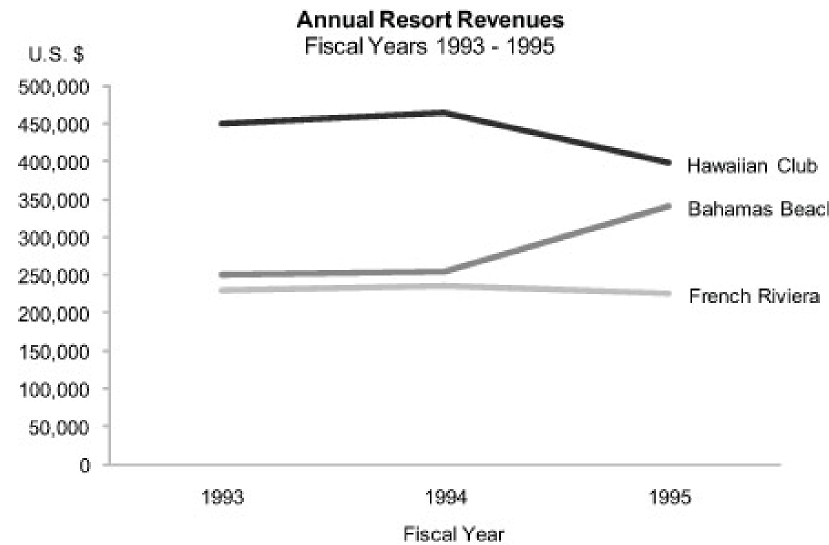
Problem here?



- Pie slices are difficult to compare in area
- There is likely a bug or error in the data
- Perspective distortion adds to the problem
- Colors are difficult to distinguish

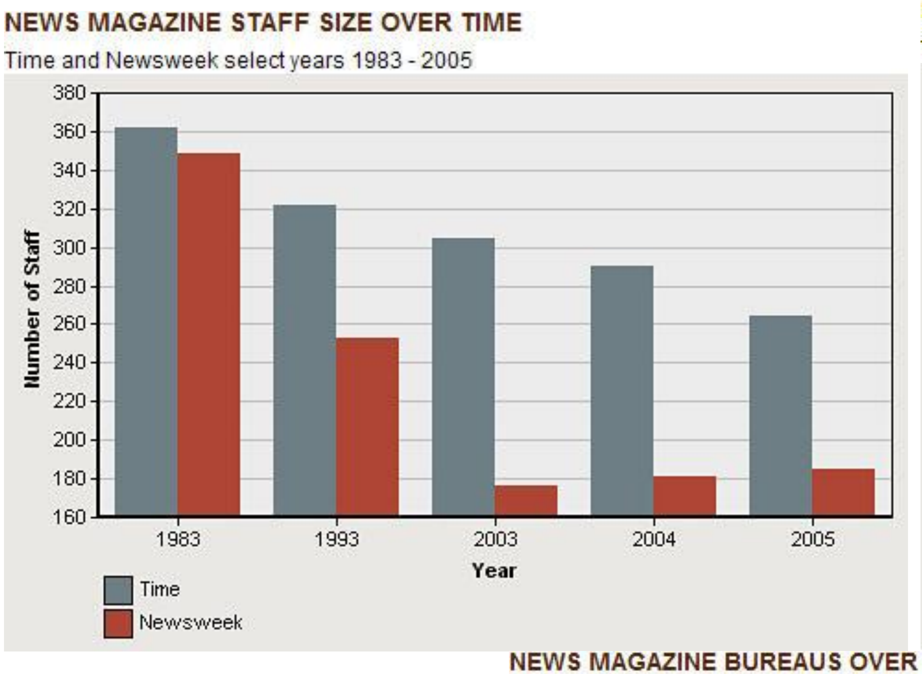
Similarly…3D bar charts are not recommended

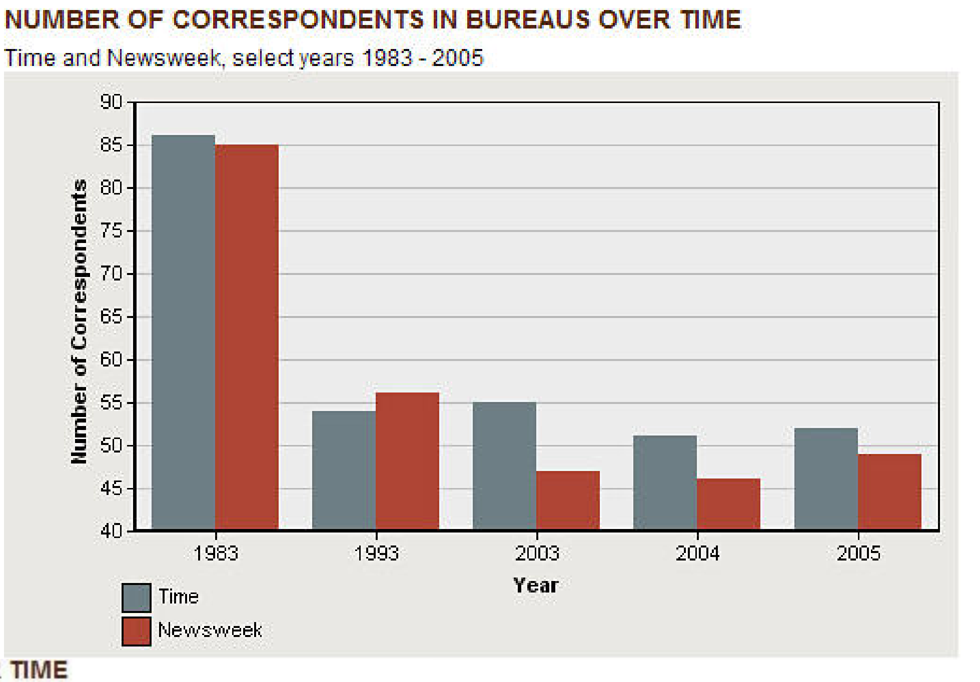


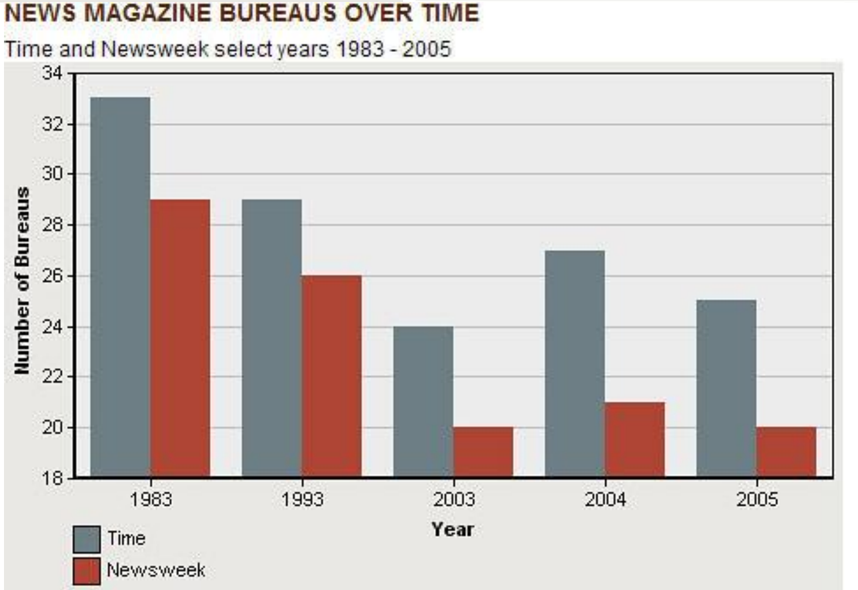


This is much easier to see and compare!

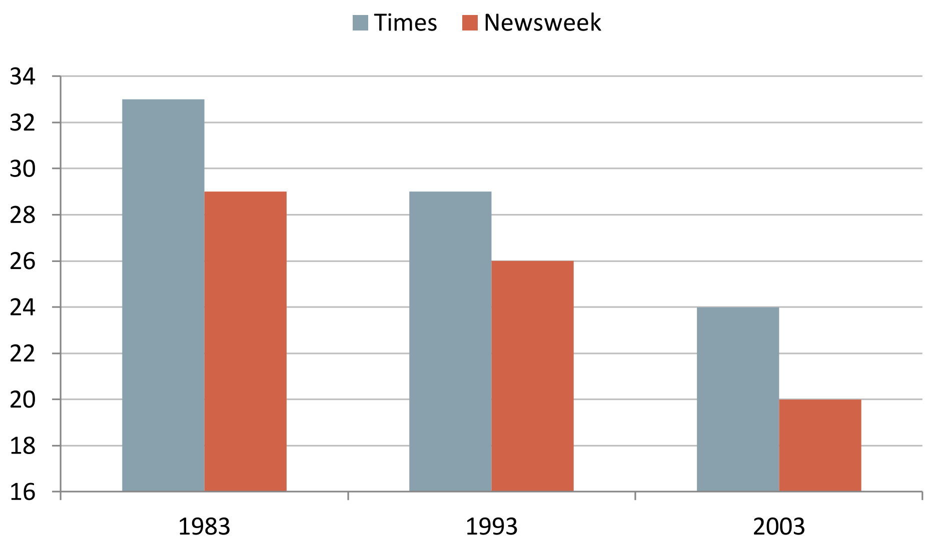
Problem here?

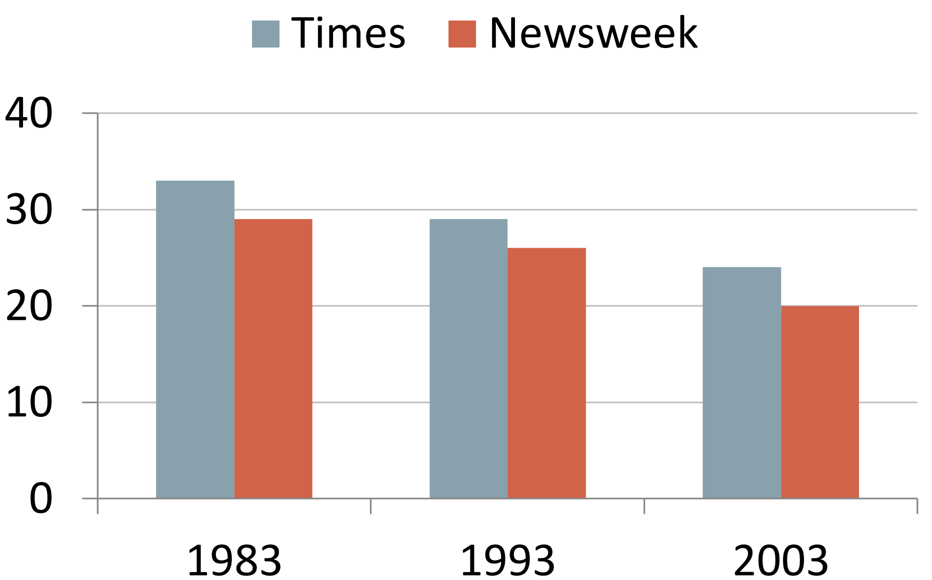






Length Comparison

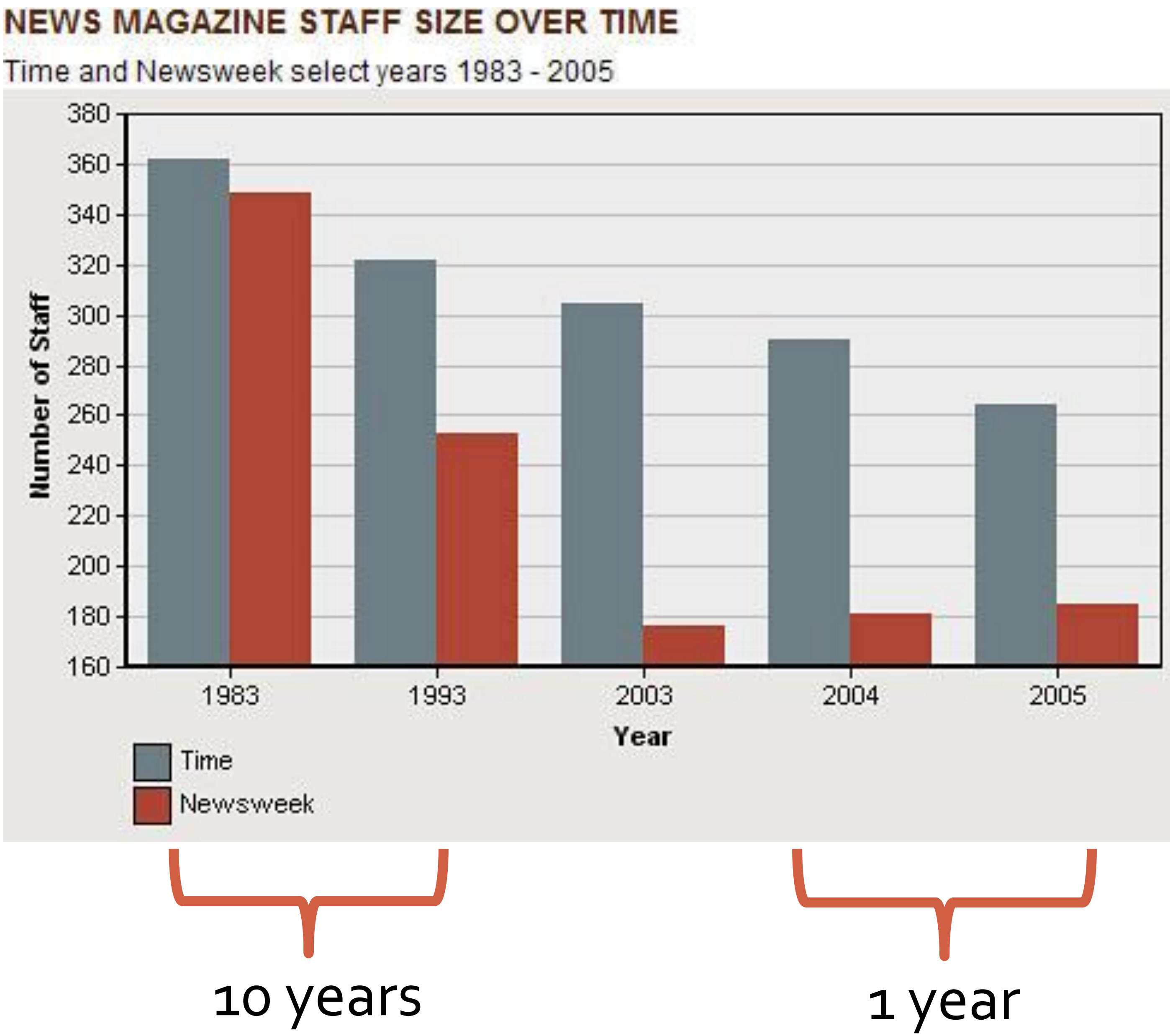




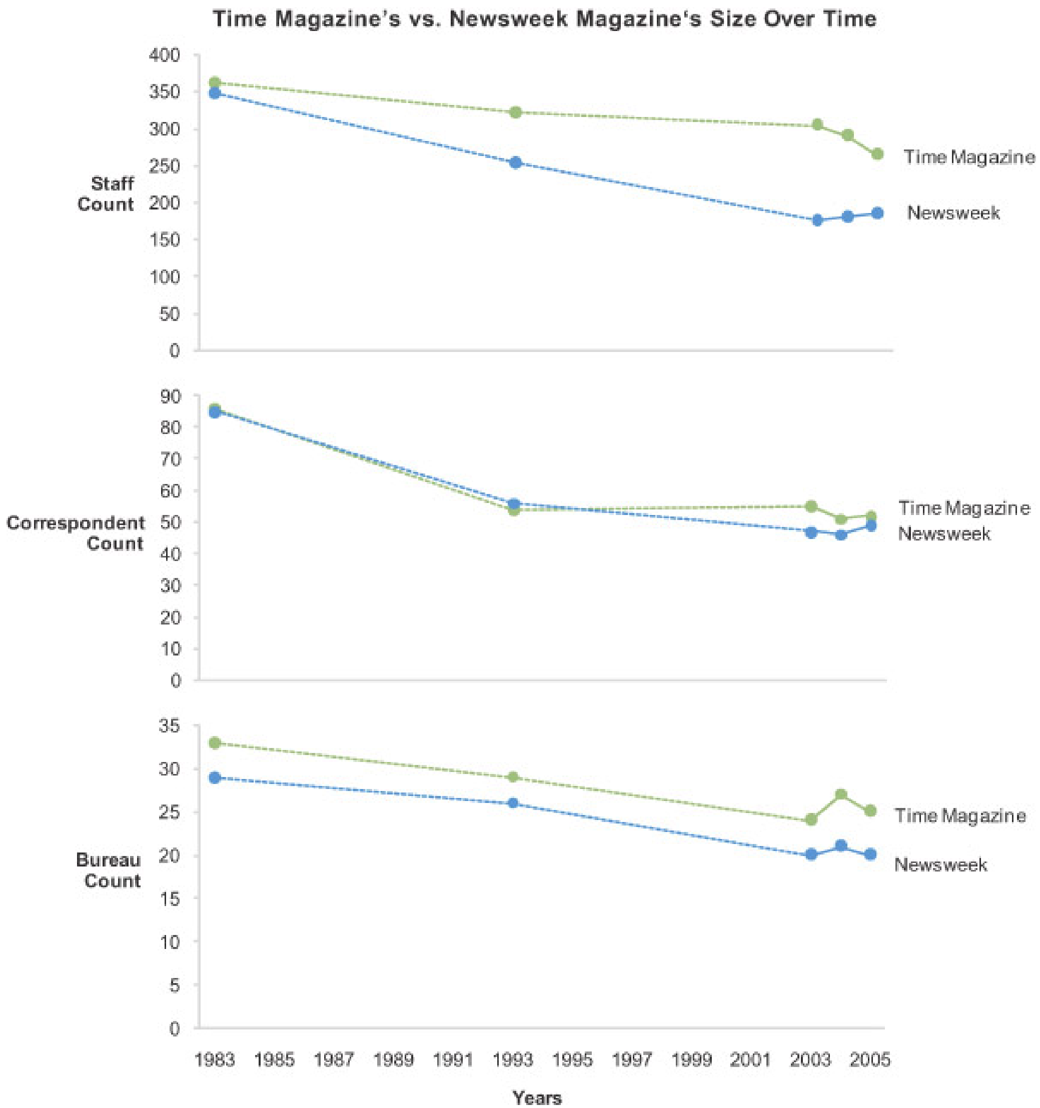
At first glance:
2003: Newsweek is 50% of Times

If we add a proper 0:
2003: Newsweek is ~80% of Times

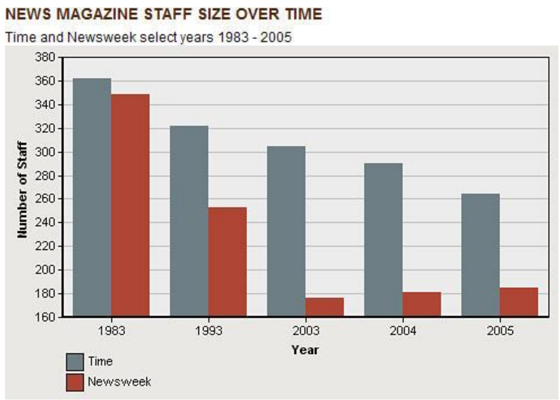
Moreover…

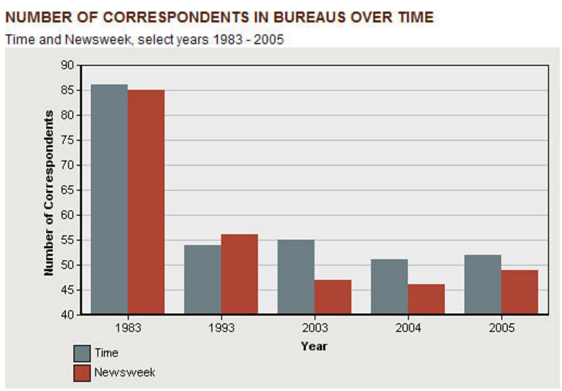

NEWS MAGAZINE STAFF SIZE OVER TIME
Time and Newsweek select years 1983 - 2005
Number of Staff
380
360
340
320
300
280
260
240
220
200
180
160
1983
1993
2003
2004
2005
Year
Time
Newsweek
10 years
1 year

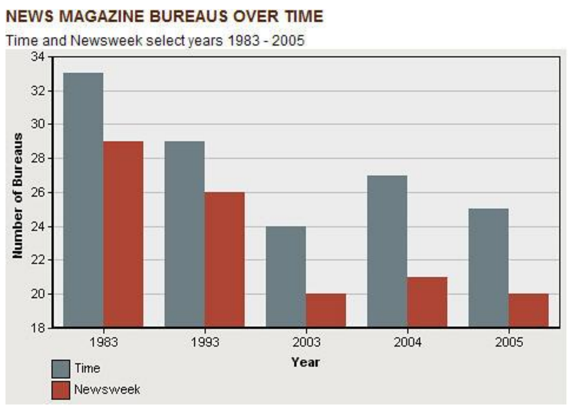
Redesign (by Stephen Few)



Note: A dashed line connecting two points indicates that there are years between the points for which values were not available. If the values were available, the shape of the lines might vary significantly.

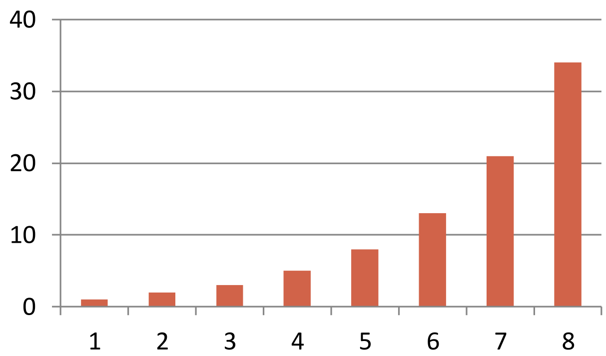


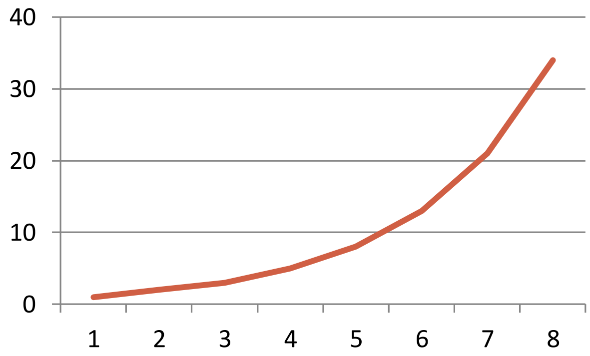


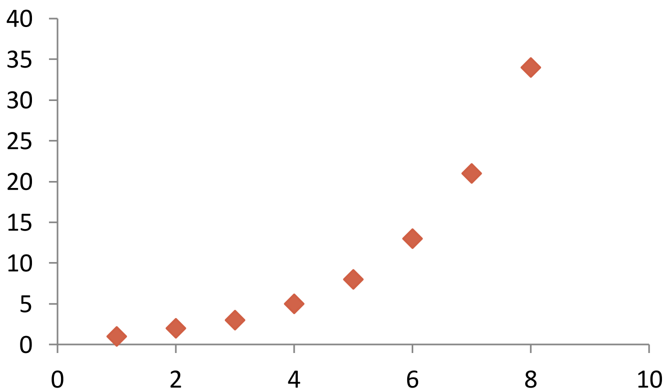


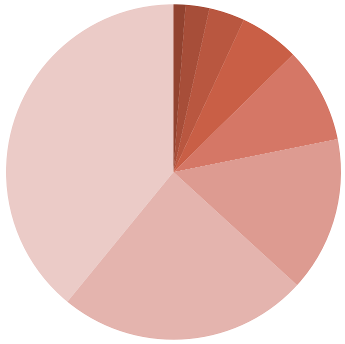
Perception and Charts

- Bar Charts
- Line Charts
- Pie Charts
- Dot Charts
- …

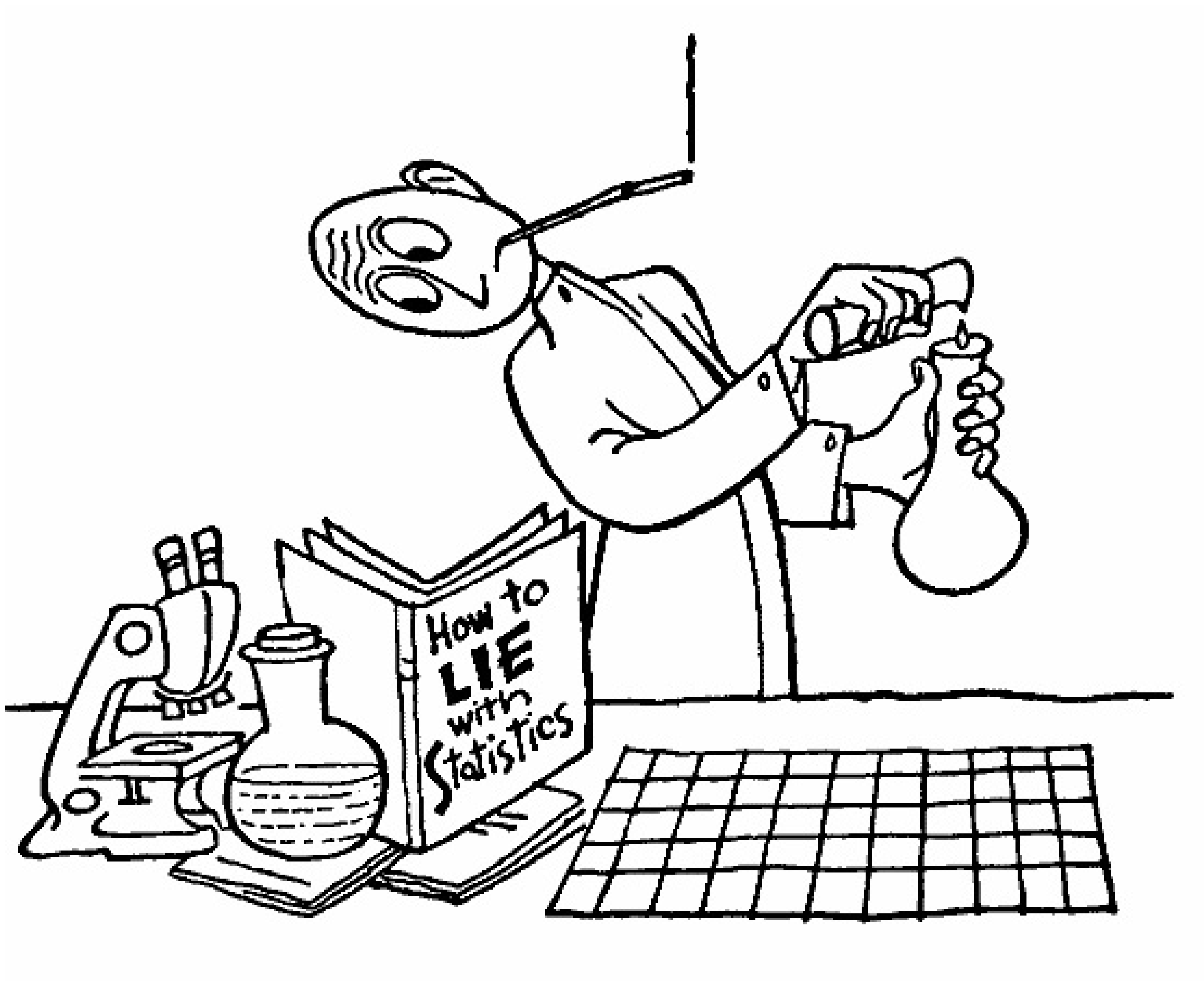








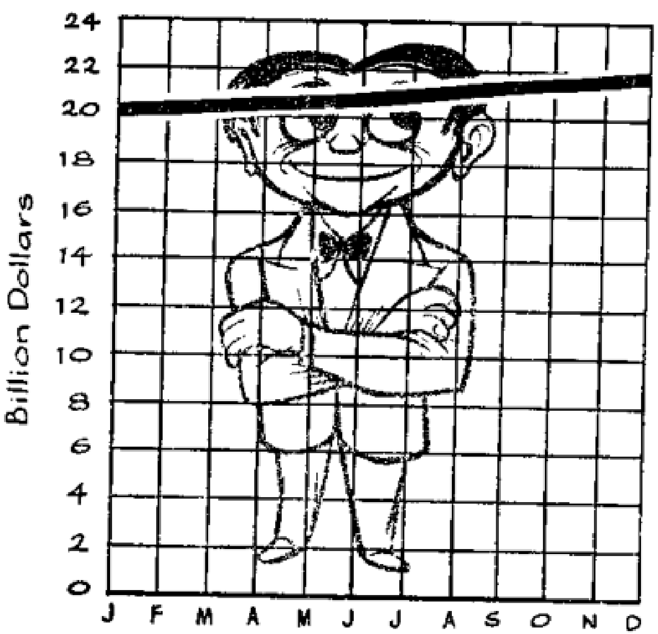
A few more words on charts



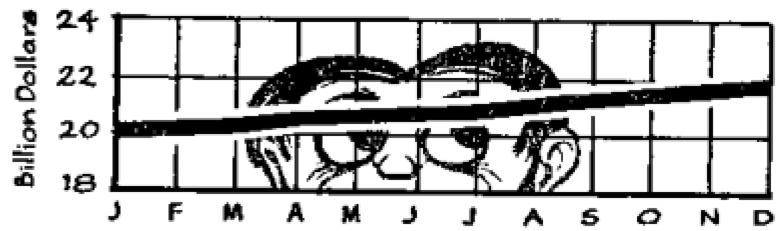
Good reference: How to Lie with Statistics, by Darrell Huff

Chart Rules

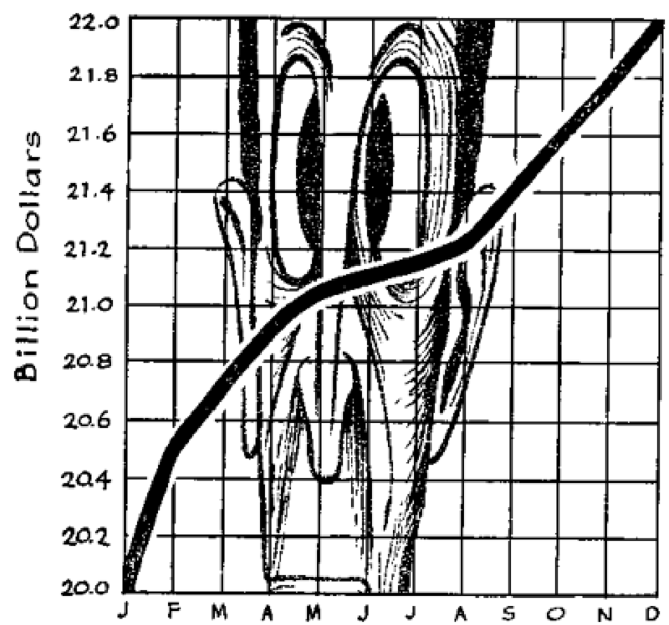
- Provide a proper baseline



A 10% increase. Good!



Already looks more impressive



Wow!

Chart Rules

- Provide a proper baseline & label your axes

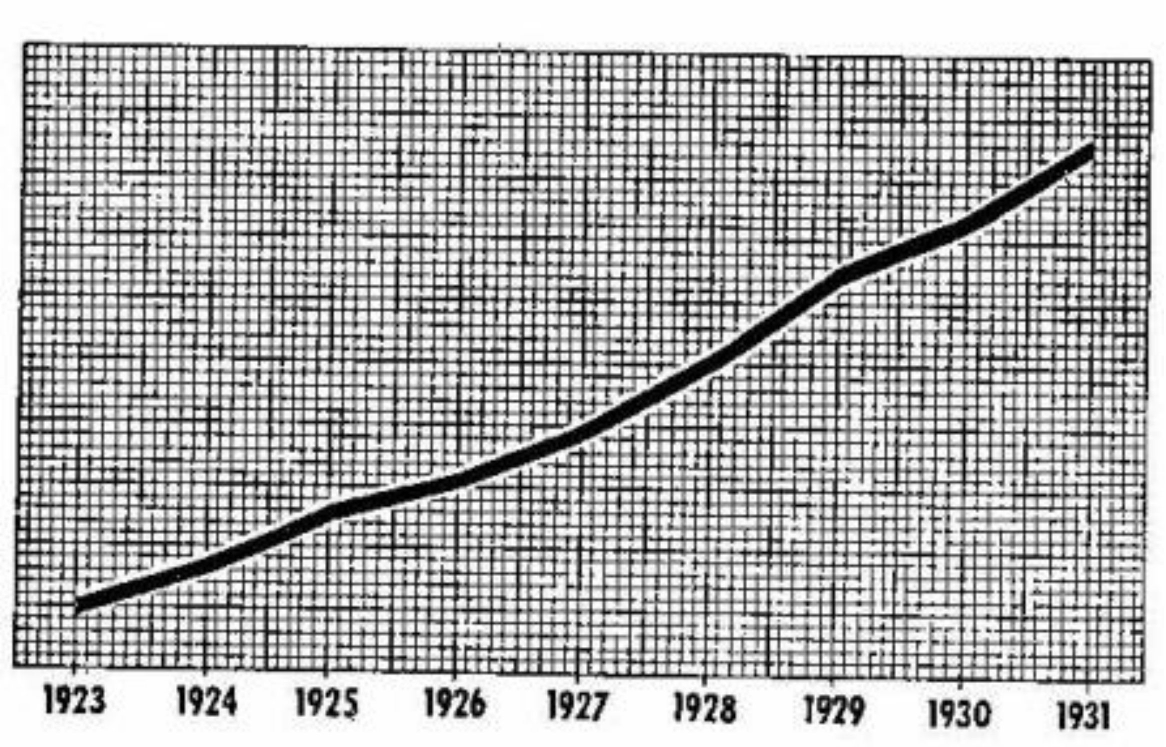
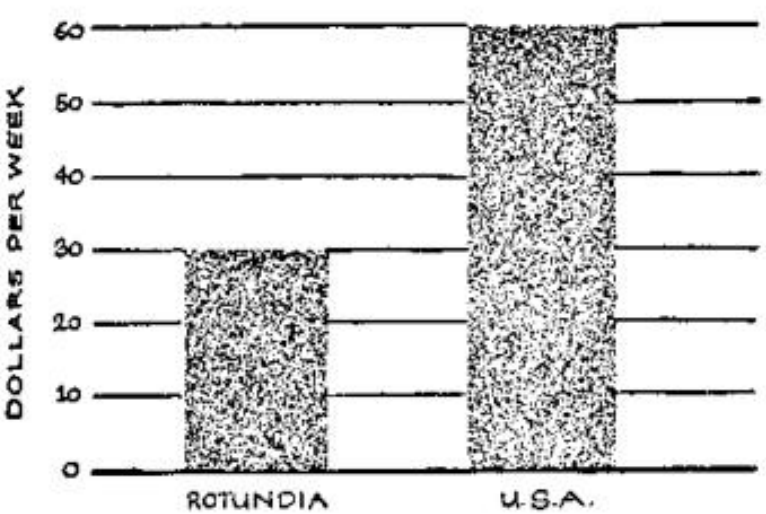
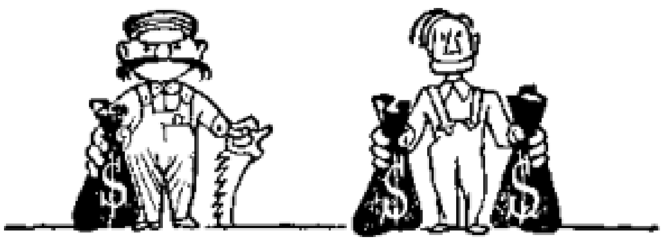


Chart Rules

- Provide a proper baseline & label your axes
- Avoid eye-candy



True data

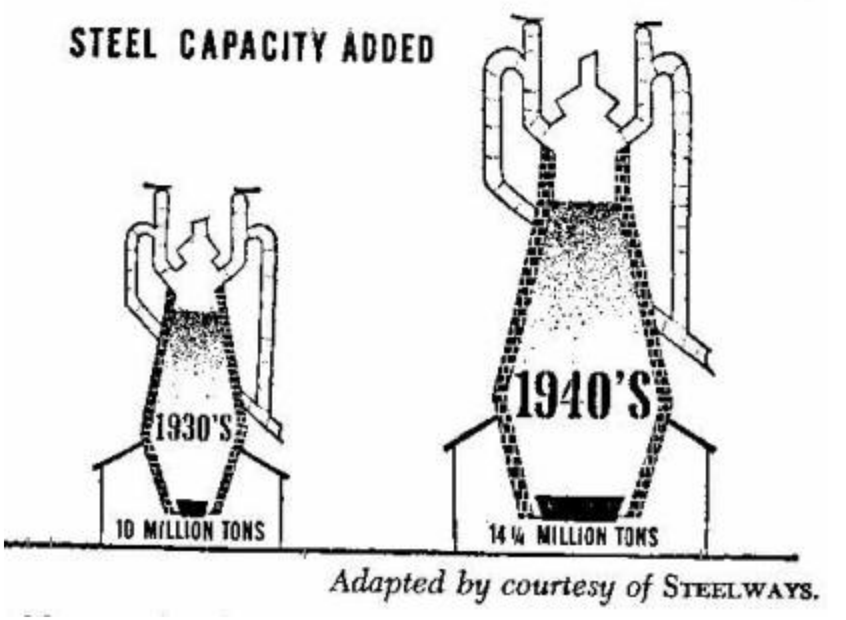


same data with eye-candy & no numbers but tells the same general story

impressive but a lie!

Chart Rules

- Provide a proper baseline & label your axes
- Avoid eye-candy
- Don't make people compare areas when not necessary



Schwimmende Schlote

Der internationale Schiffsverkehr boomt. Seit 1990 hat sich der Treibstoffverbrauch auf dem Meer verdoppelt. Die dreckigen Abgase der Schiffe gelangen weitgehend ungefiltert in die Atmosphäre

http://images.zeit.de/wissen/2011-04/s41-infografik-schiffsverkehr.pdf

Do the boxes represent the little white numbers??

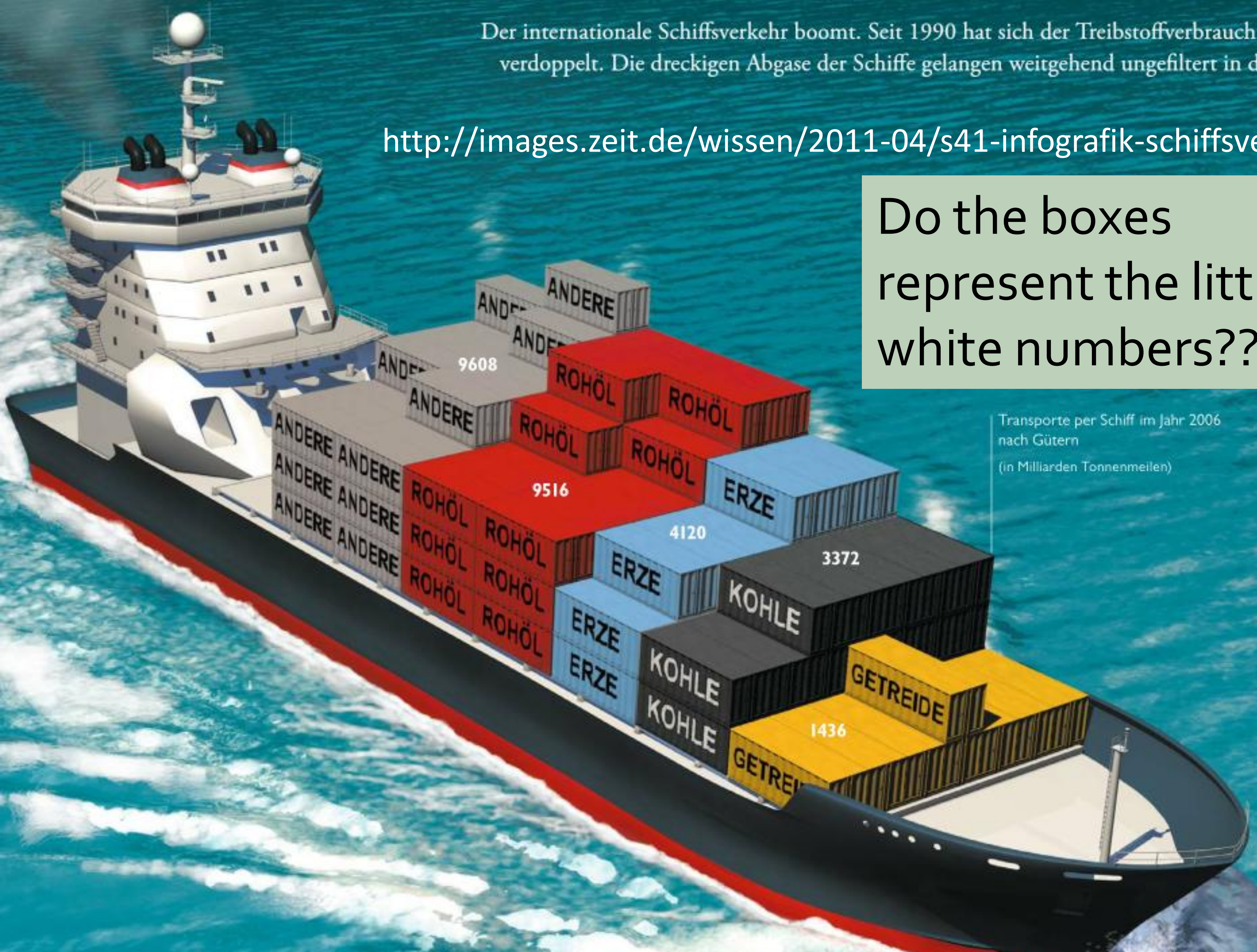
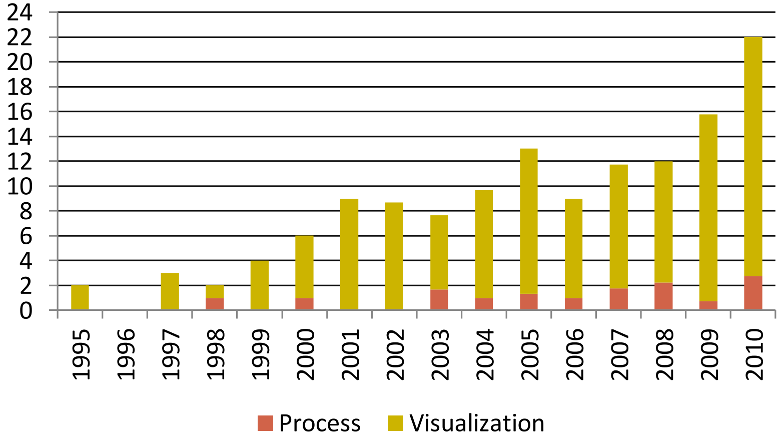


Chart Rules

- Provide a proper baseline & label your axes
- Avoid eye-candy
- Don’t make people compare areas when not necessary
- Provide legends

Chart Rules

- Provide a proper baseline & label your axes
- Avoid eye-candy
- Don't make people compare areas when not necessary
- Provide legends
- Grids help but make them subtle (no black lines!)



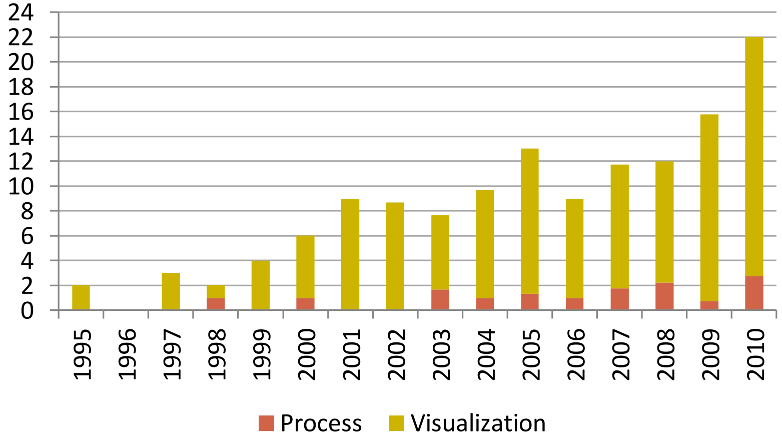
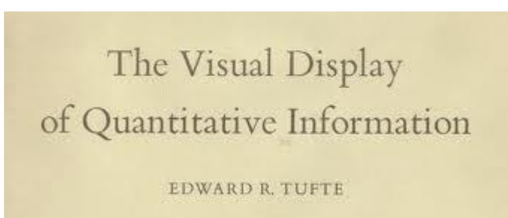
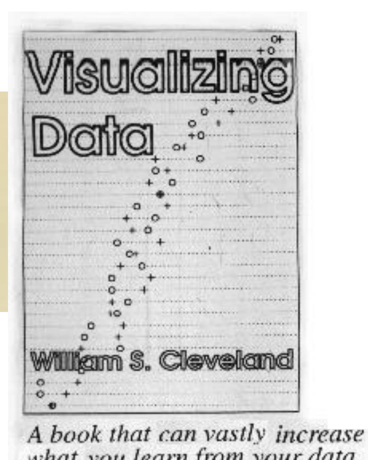
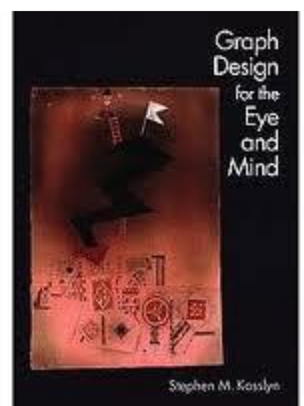


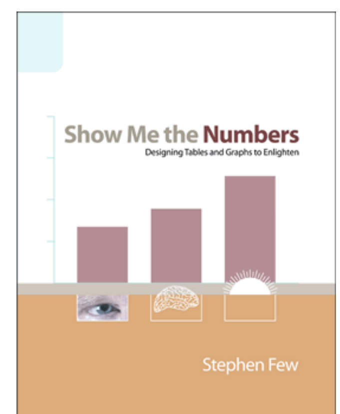
Chart Rules

- Provide a proper baseline & label your axes
- Avoid eye-candy
- Don't make people compare areas when not necessary
- Provide legends
- Grids help but make them subtle (no black lines!)
- Many more…









Summary

- Now you know the main building blocks are **marks**
- Marks are modified by **visual variables**
- Visual variables have **specific characteristics**
- These characteristics influence how the data will be perceived

15 minute break then

LAB

What will the exam be about?

- lectures 1-6
- mainly (not a comprehensive list):
  - user interfaces
  - user interface design cycle
  - evaluation for requirements and during design
- 3 parts
  - course questions
  - UI critique
  - creative task
- memorization alone will not help you. You need to be able to apply your knowledge

top 10: how best to fail the exam?

10 I don’t bother reading the instructions at the top. Questions are what counts!
9 I never read questions through completely, and also read them only once.
8 I start answering the questions without reading the whole exam first, so later questions remain a surprise and the last 10 minutes are exciting!
7 Once I am through, I hand in my answers immediately; by going though everything again I would only risk finding mistakes in my replies.
6 I never check that I really answered all questions, that’s for losers.
5 If a question asks me for some fact **and** to briefly **explain** it, I only give fact/result, but not the explanation – that would be silly.
4 I ignore **bold** or *italic* parts, this is just fancy typesetting with no meaning.
3 I do not write keywords but essays – this nicely fills the limited exam time.
2 If the question asks for 3 things, I give **one** and name it slightly differently 3x. Surely the instructor won’t notice!
1 I completely ignore the number of points given per question. I write 1 sentence for a 10-point question, but a whole page for a 1-point question.

Now lab time…

recap: Jakob Nielsen's Heuristics

1. Visibility of system status
2. Match between system and real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition over recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognize, diagnose, and recover from errors
10. Help and documentation

heuristic evaluation

- idea: apply heuristics to eval of a user interface
- we will use your vertical prototype

heuristic evaluation – step by step

1. plan your evaluation by either
    1. **developing a set of tasks for your evaluators**
    2. providing evaluators with the goal of the tool and let them come up with their own tasks (works well if they know the users well)
    3. ask evaluators to go through each screen / dialog and assess it
2. choose your evaluators (preferably with experience)
3. review heuristics
4. conduct the analysis
5. analyze the results

5 minutes: develop a task description

- meet with your project team
- write down a task description for your evaluators

15 minutes 2x

- go into specific groups (pre-assigned)
- guide:
  - one person from development team
  - gives the task, says what the system can do and gives short usage instructions
  - take a HE worksheet
- evaluators:
  - together evaluate the UI by stepping through the task and the UI components (dialogs, widgets, screens, etc.) and answering the
  - use the HE worksheet to record the problems found

15 minutes: heuristic eval I

- Accurate Learning
  - Guide:
  - Evaluators:
- Cook and Shop
  - Guide:
  - Evaluators:
- EasyCracy
  - Guide:
  - Evaluators:
- FocusMore!
  - Guide:
  - Evaluators:
- CroceryShopping
  - Guide:
  - Evaluators:
- Project Aggregator
  - Guide:
  - Evaluators:
- SmartNews
  - Guide:
  - Evaluators:
- Social Penguin
  - Guide:
  - Evaluators:
- Travel for Dummies
  - Guide:
  - Evaluators:
- WhaleManager
  - Guide:
  - Evaluators:

15 minutes: heuristic eval II

- Accurate Learning
  - Guide:
  - Evaluators:
- Cook and Shop
  - Guide:
  - Evaluators:
- EasyCracy
  - Guide:
  - Evaluators:
- FocusMore!
  - Guide:
  - Evaluators:
- CroceryShopping
  - Guide:
  - Evaluators:
- Project Aggregator
  - Guide:
  - Evaluators:
- SmartNews
  - Guide:
  - Evaluators:
- Social Penguin
  - Guide:
  - Evaluators:
- Travel for Dummies
  - Guide:
  - Evaluators:
- WhaleManager
  - Guide:
  - Evaluators:

10 minutes: analysis + presentation of the results

- go back to your project team
- review the two worksheets filled in by the evaluators
- write a list of high priority fixes for your tool

- present your list to class