

CSCI 4550/6550 Interactive Visualization

<https://www.cs.rpi.edu/~cutler/classes/visualization/S24/>

Lecture 2: Visualization Design & Memorable Chart Junk

Reminder: “Rules” for the course

- As class participation is 5% of your grade:
 - *Using laptops during class is strongly discouraged*
 - If you're using your laptop you need to participate twice as much as everyone else because I'm going to assume you're doing something else.
- Use of laptops for reference during paper discussion is allowed
- *Sit in a different seat, next to different people, each lecture*
 - Work with a different person for each in-class “worksheet”

Today

- “Good” Design (30 min)
 - Photography tips
 - Principles of Effective Website Design
 - Principles of Good User Interface Design
 - Examples of Good (Bad) Visualization Design
- Today’s Reading (30 min): “Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts”
- Worksheet: Time-based Data & Simple Charts (20 min)
- Graph Drawing Preview: Terminology & Goals (15 min)
- Readings for Tuesday: Graph Drawing

Kodak

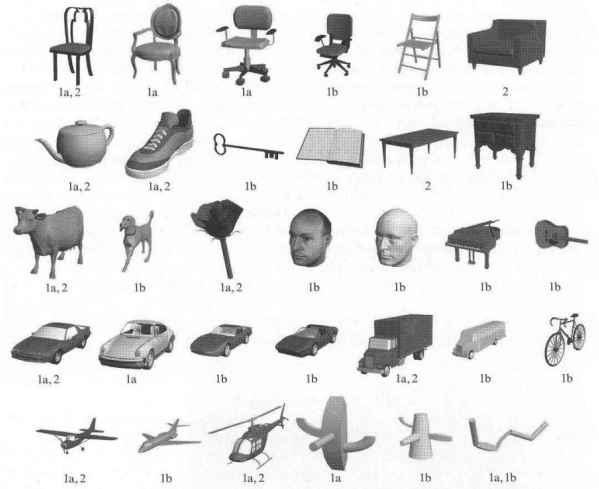
Top Ten Tips

- 1 Get down on their level
- 2 Use a plain background
- 3 Use flash outdoors
- 4 Move in close
- 5 Take some vertical pictures
- 6 Lock the focus
- 7 Move it from the middle
- 8 Know your flash's range
- 9 Watch the light
- 10 Be a picture director

Tips & Projects Center ▶

“Canonical” Viewpoints

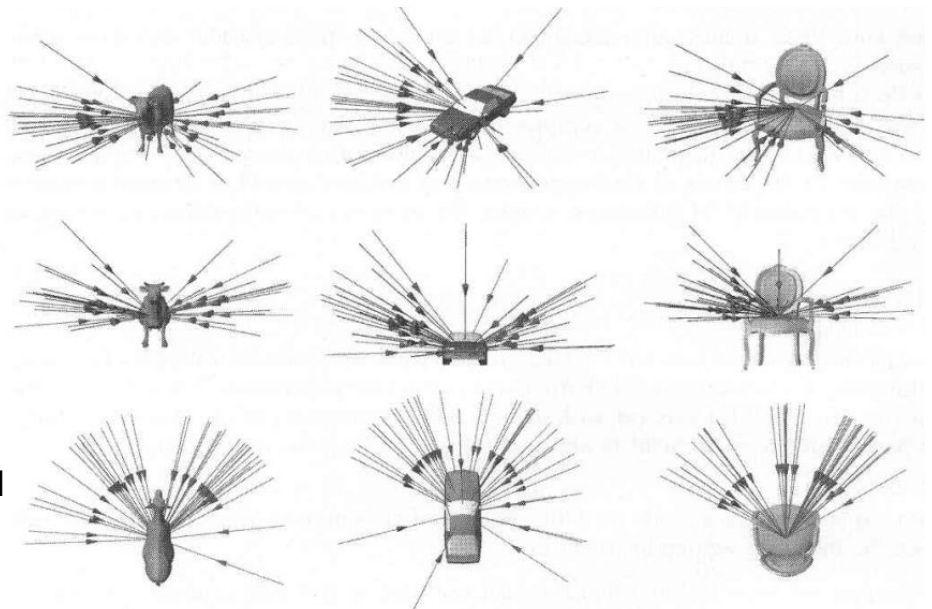
- From Dictionary.com:
 - authorized; recognized; accepted
 - the body of rules, principles, or standards accepted as axiomatic and universally binding in a field of study or art: the neoclassical canon
 - a fundamental principle or general rule: the canons of good behavior
 - a standard; criterion: the canons of taste



“What object attributes determine canonical views?” Blanz, Tarr, & Bulthoff, Perception 1999

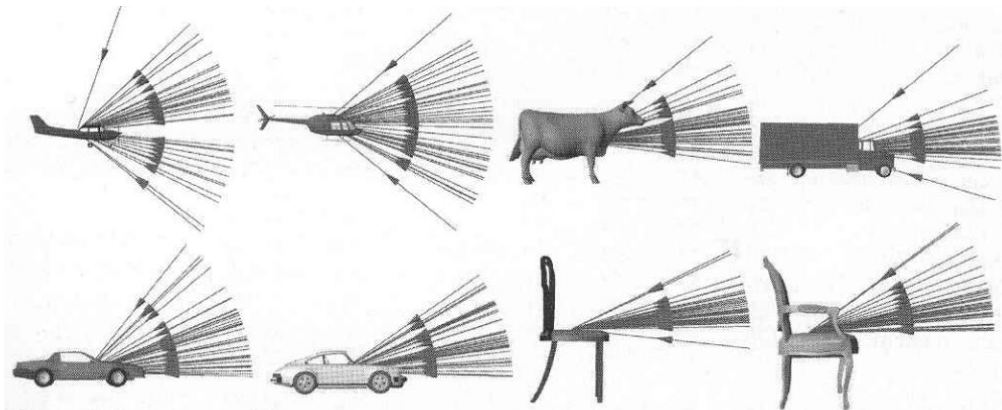
Suppose you are making a brochure and must choose a single image to give your customers the best possible impression.

Which view would you choose?

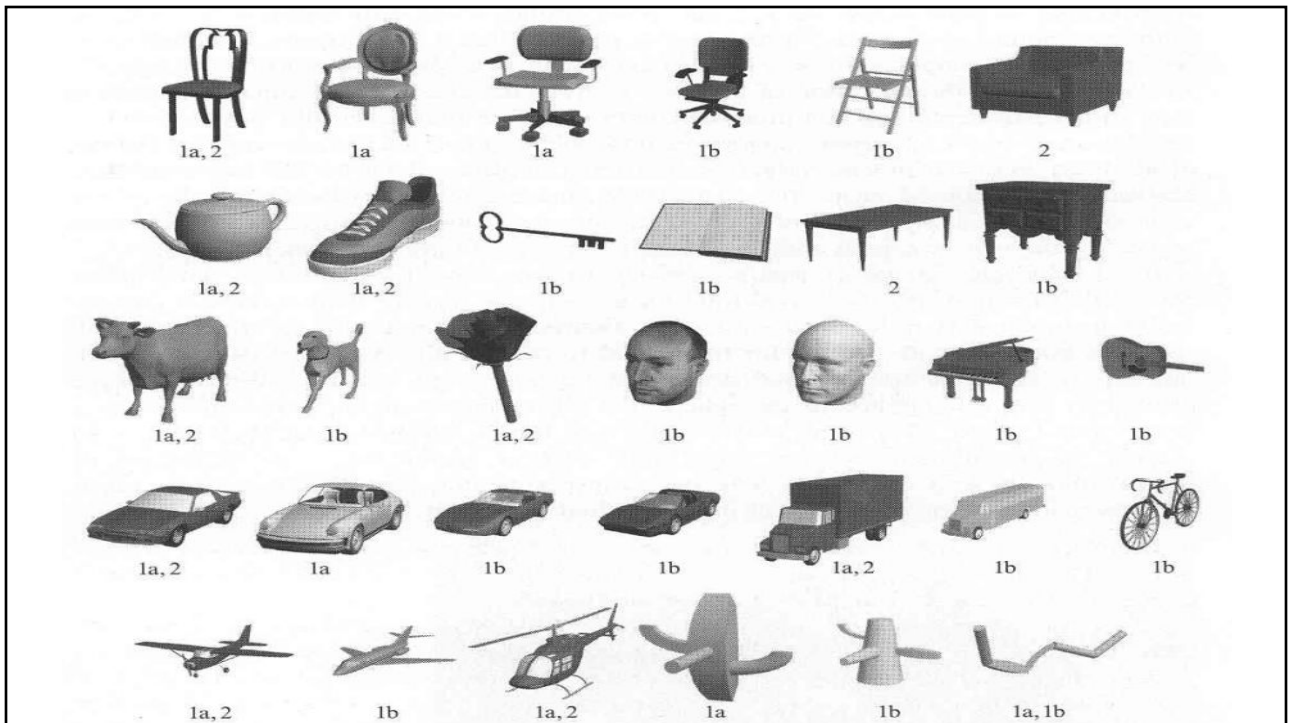


“What object attributes determine canonical views?” Blanz, Tarr, & Bulthoff, Perception 1999

- Salience and significance of the features
- Stability of viewpoint to small transformations
- Minimize number of occluded features
- Familiarity, functionality, aesthetic criteria



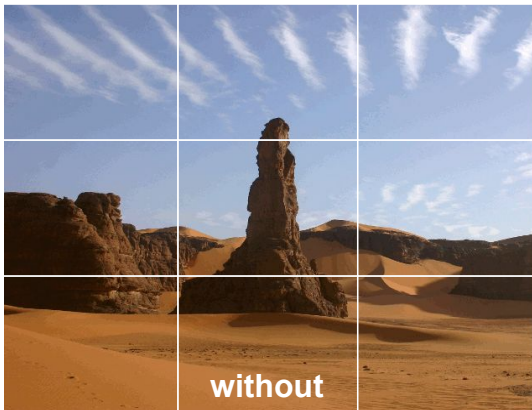
“What object attributes determine canonical views?” Blanz, Tarr, & Bulthoff, Perception 1999



Rule of Thirds

http://en.wikipedia.org/wiki/Rule_of_thirds

- Place horizon at top or bottom line.
- Place subject on guide lines and intersection points
- Avoid placing subject at center, avoid dividing picture in half



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Principles of Effective Website Design

- Guiding the eye (position, color, contrast, size, design elements)
- Spacing, padding, white/empty space, reduce cognitive load
- Navigation/orientation
- Typography (font, size, color, paragraphs)
- Usability/standards/conventions, be obvious, "Don't make users think"
- Consistency
- Alignment, polished, simplicity
- Effective writing
- Clarity, sharpness, contrast, exaggeration

<http://psd.tutsplus.com/tutorials/designing-tutorials/9-essential-principles-for-good-web-design/>
<http://uxdesign.smashingmagazine.com/2008/01/31/10-principles-of-effective-web-design/>

Principles of Good User Interface Design

- Consistency and standards
 - Match real world: words, phrases and concepts familiar to the user, real-world conventions, natural and logical order, coherency
- Flexibility and efficiency of use: cater/tailor to both inexperienced and experienced users
 - Know your user, user testing, listen to the user
- User control and freedom: a clearly marked "emergency exit" to leave the unwanted, support undo and redo
- Aesthetic and minimalist design: every extra unit of information competes with and diminishes visibility of relevant information
 - System status: keep users informed
- Recognize, diagnose, and recover from errors
 - Error prevention: good error messages, eliminate error-prone conditions, confirmation option
- Help and documentation
 - Recognition rather than recall: information/instructions should be visible or easily retrievable

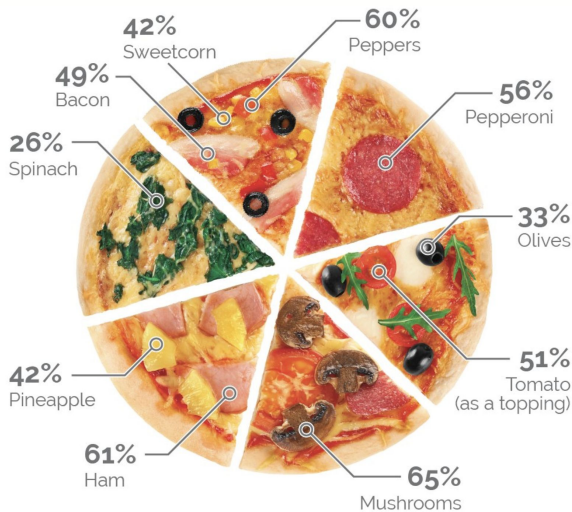
http://www.sylvantech.com/~talin/projects/ui_design.html http://www.useit.com/papers/heuristic/heuristic_list.html

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Mushroom is the UK’s most liked pizza topping

Generally speaking, which of the following toppings do you like on a pizza? Select as many as you like

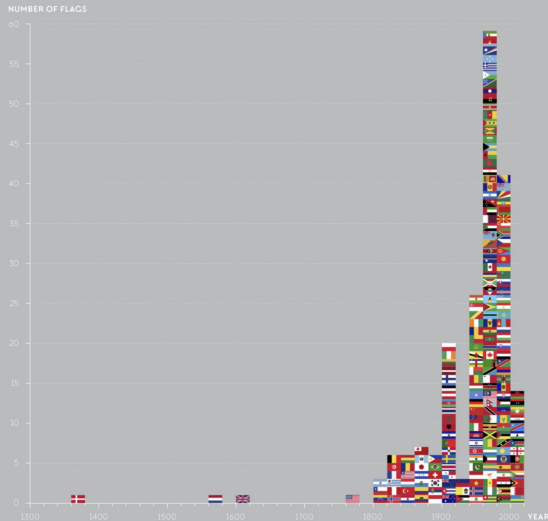


Other items not depicted include: onions (62%), chicken (56%), beef (36%), chillies (31%), jalapeños (30%), pork (25%), tuna (22%), anchovies (18%), 2% of people say they only like Margherita pizzas

Worst pie chart ever?

How old are national flags?

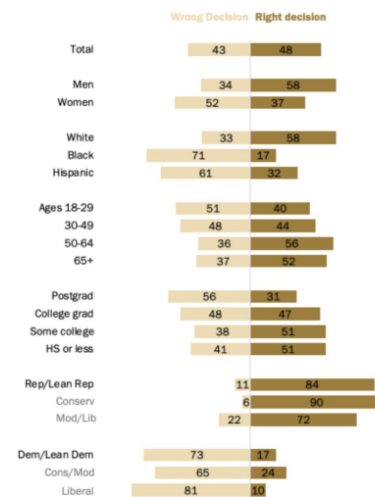
This timeline is based on the date in which each nation adopted their current national flag and is sorted by a 20 year interval. As you can see only four of the current national flags are dated before the 19th century.



*Excellent use-case
For on-chart imagery*

Wide partisan, demographic differences in views of U.S. decision to conduct airstrike that killed Soleimani

% who say U.S. decision to conduct the airstrike that killed Iranian Gen. Soleimani was the ...

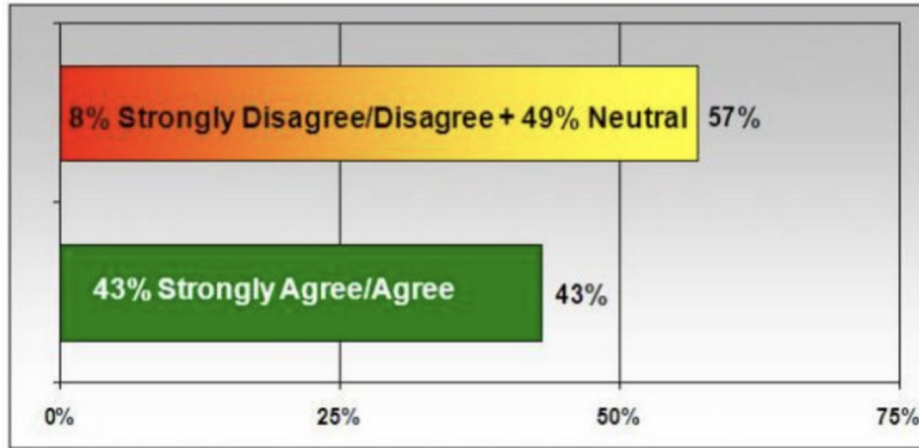


Notes: Don't know responses not shown. Whites and blacks include only those who are not Hispanic; Hispanics are of any race.
Source: Survey of U.S. adults conducted Jan. 8-13, 2020.

PEW RESEARCH CENTER

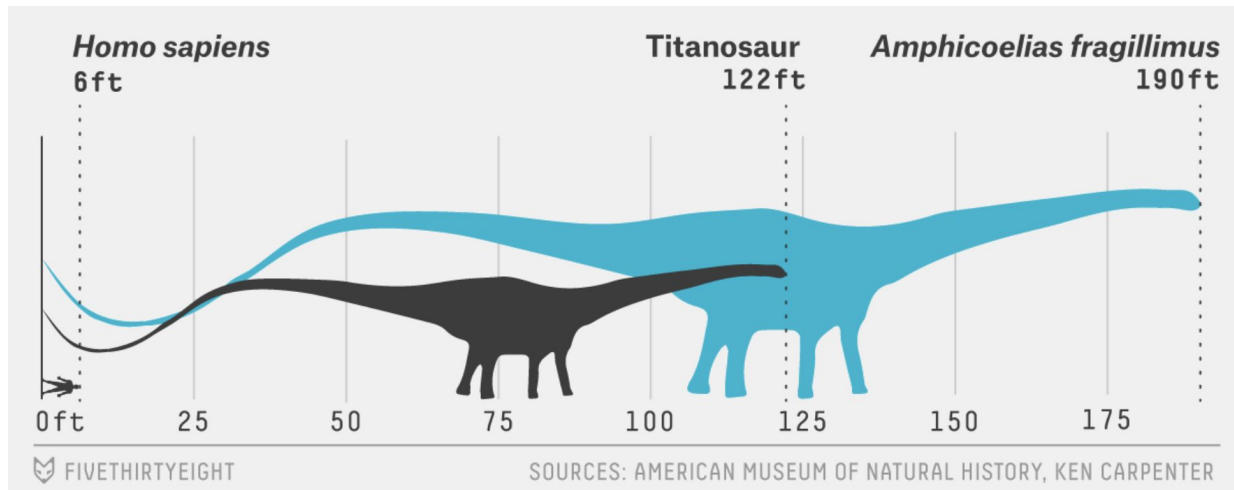
*Unbiased reporting
Good data-ink ratio*

**Figure 2. Parent Response to
"New vaccines are safe for my child(ren)."**



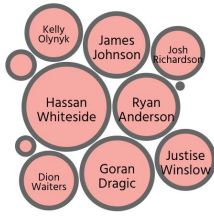
Source: C.S. Mott Children's Hospital National Poll on Children's Health, March 2007

*Oversimplification?
Manipulative visualization?
Confusing / unnecessary colors/gradient*

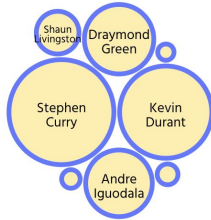


*Simple, intuitive, effective
Educational for all ages*

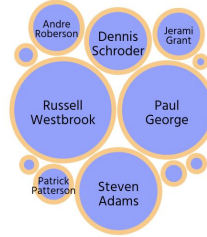
Miami Heat - \$129.6M



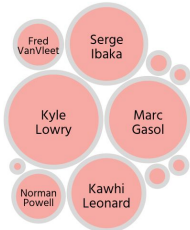
Golden State Warriors - \$121.0M



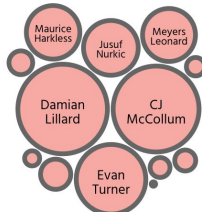
Oklahoma City Thunder - \$146.8M



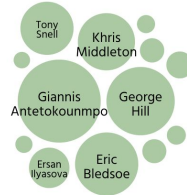
Toronto Raptors - \$131.4M



Portland Trail Blazers - \$126.0M



Milwaukee Bucks - \$107.4M

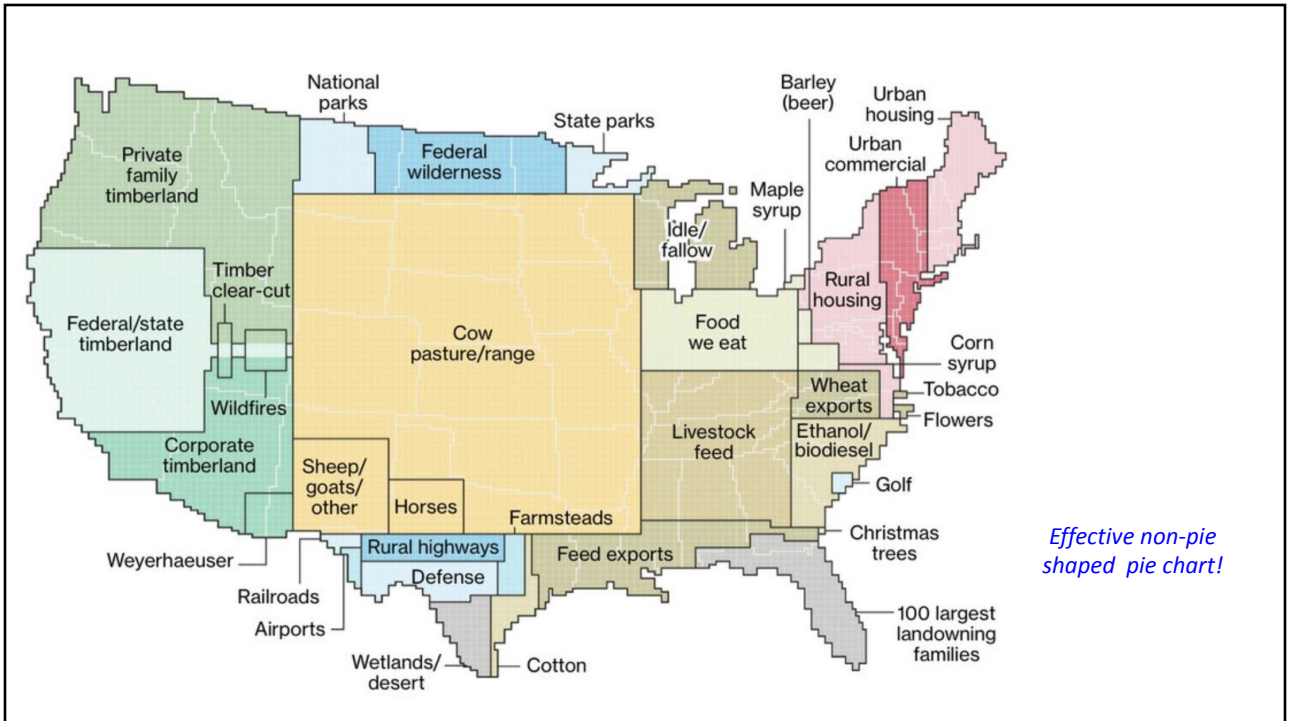


Compare players within team

Compare players on different teams

Different team choices/strategies

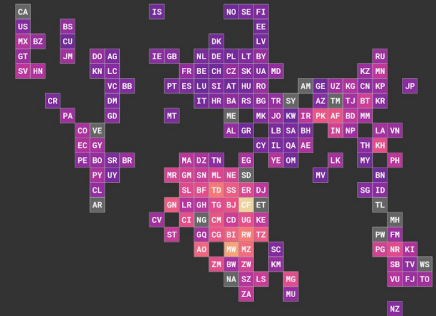
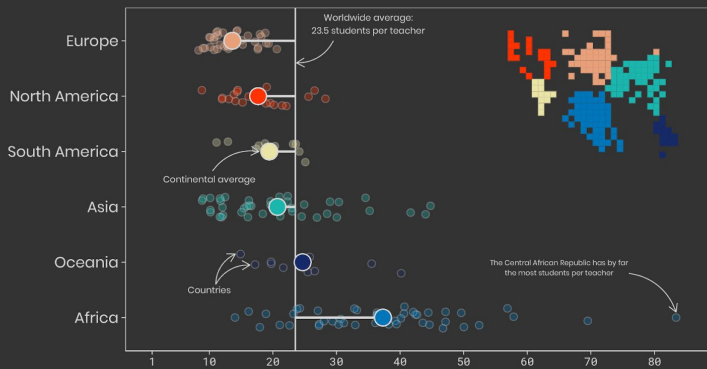
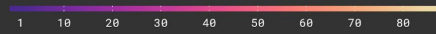
<http://cahaber.me/#/basketball>



Effective non-pie shaped pie chart!

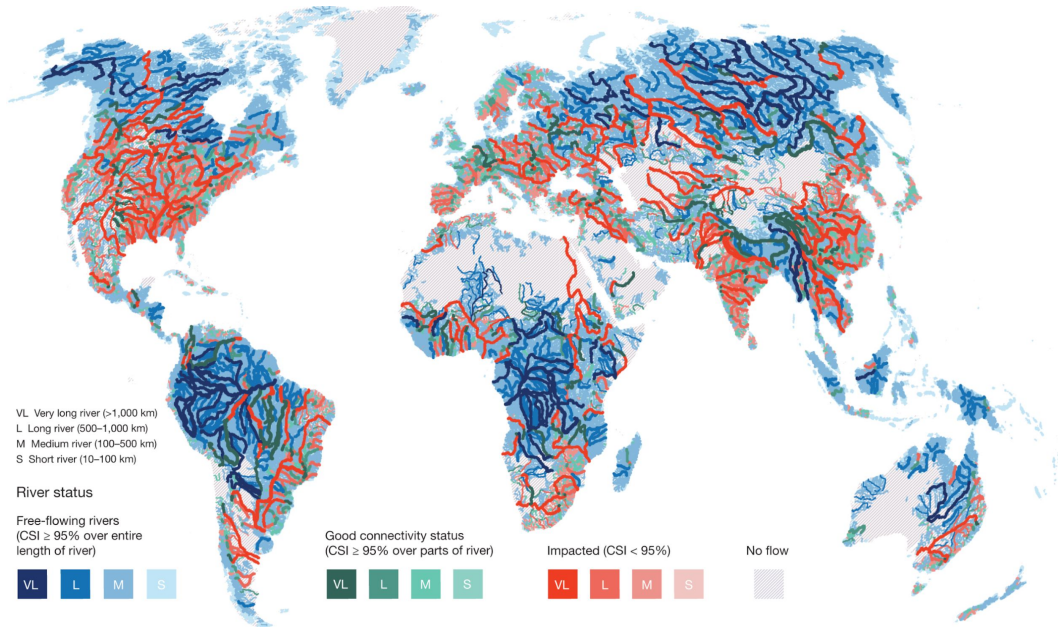
Global student to teacher ratios in primary education

Latest reported student to teacher ratio per country and continent (2012–2018)



Visualization by Cédric Scherer | Data: "eAtlas of Teachers" by UNESCO

Are all datasets relevant to plot on a world map?

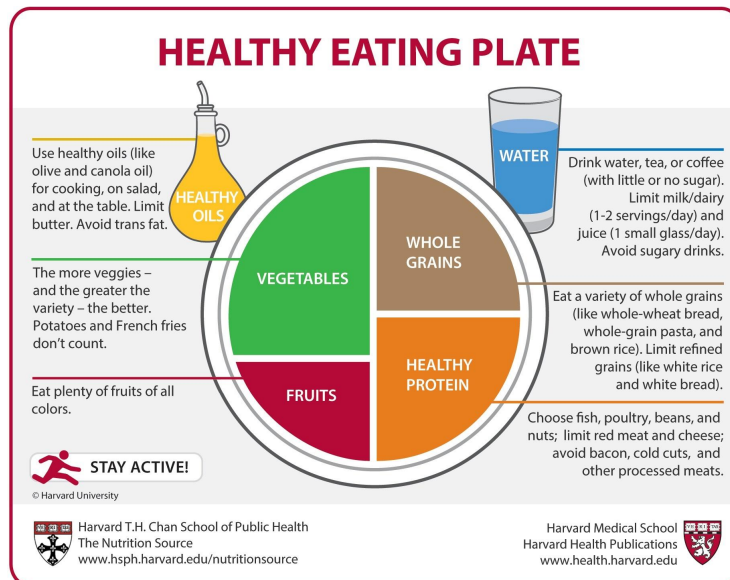


Allows us to clearly see significant variations in distributions of rivers AND use (overuse?) of technology to control nature



http://www3.gehealthcare.com/en/Products/Categories/Healthcare_IT/Quality_Management#tabs/tab1900328377C74CAC8AD7E8D4A2072591

Stereotypical Infographic



<https://cdn1.sph.harvard.edu/wp-content/uploads/sites/30/2012/09/HEPJan2015.jpg>

Vast improvement on original food pyramid

- **Scientific Visualization (SciVis)**
 - really large quantities of data
 - data usually has inherent structure
 - often has a spatial and/or temporal component (coordinate system)
 - often appropriate to use of 3D visualization techniques
 - such as medical, hurricane, computational fluid dynamics (CFD) data
- **Information Visualization (InfoVis)**
 - smaller datasets
 - data that does not have an inherent structure (may not have coordinate system)
 - financial stock market data, demographic census data, genetic data, etc.
- **Visual Analytics**
 - involves a cycle of rapidly creating visualizations to answer questions and generate new questions about a dataset
- Infographics are typically in the realm of InfoVis, and often they show the results of the visual analytics process, but SciVis is not really a part of most infographics.
- Annual IEEE Visualization and IEEE InfoVis (Information Visualization) conferences are two separate entities. The set of people organizing, attending and involved one conference is almost disjoint from the other set.

<http://blog.visual.ly/the-beautiful-world-of-scivis/>

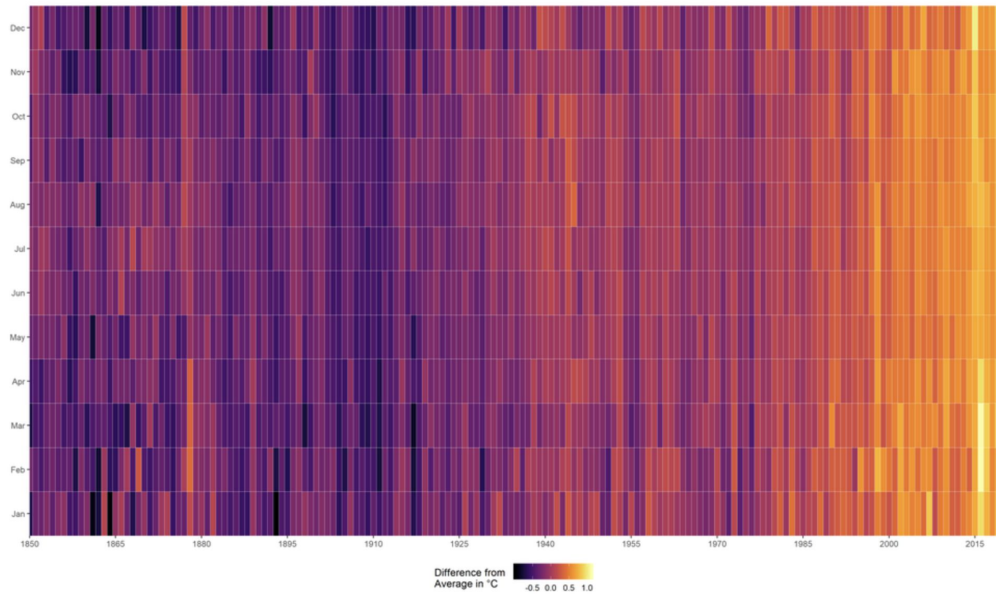
<https://visualizeit.wordpress.com/2007/06/07/the-great-infovis-and-scivis-divide/>



*An Interactive Visualization!
(interactive data collection)*

Average World Temperature Since 1850

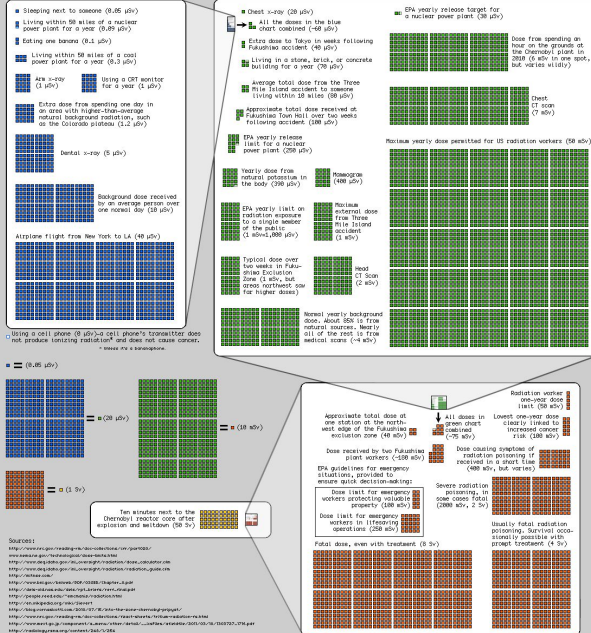
20th century average 13.7°C, Data HadCRUT4



Visualization Challenge: very large datasets

Radiation Dose Chart

This is a chart of the ionizing radiation dose a person can expect from various sources. The unit for absorbed dose is "röntgen" (R), and measures the effect a dose of radiation will have on the cells of the body; the smallest (0.1 R) dose will kill one cell, and too many more will kill you, but we rarely discuss such amounts of natural radiation daily. Note: The same number of sieverts absorbed in a shorter time will generally cause more damage, but your cumulative (long-term) dose plays a big role in things like cancer risk.



<https://xkcd.com/radiation/>

Visualization Challenge: representing different scales

Chart by Randall Murray, with help from Ellen, Senior Reactor Operator at the Reactor Research Institute, who suggested the idea and provided a list of the sources. I'm sure I've missed in lots of mistakes; it's for general education only. If you're using radiation safety procedures on an internet PRC page and things go wrong, you have no one to blame but yourself.

Periodic Table of Elements

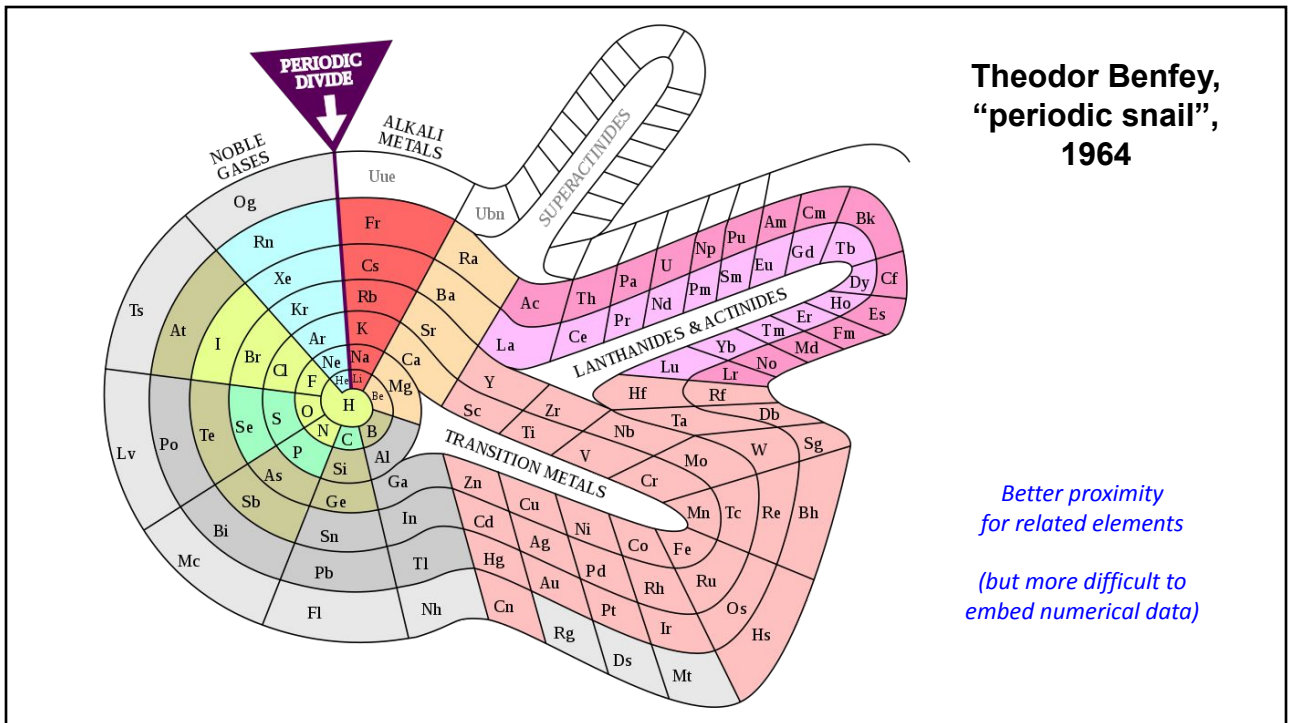
<http://www.ptable.com/>

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1 H Hydrogen 1.00794	2 He Helium 4.002602																	
3 Li Lithium 6.941	4 Be Beryllium 9.012182																	
11 Na Sodium 22.98976928	12 Mg Magnesium 24.3050																	
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798	
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90584	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.96	43 Tc Technetium 97.9072	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.757	52 Te Tellurium 127.6	53 I Iodine 126.90545	54 Xe Xenon 131.29	
55 Cs Cesium 132.90545196	56 Ba Barium 137.327	57-71 Lanthanoids		72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.222	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium 209	85 At Astatine 210	86 Rn Radon 222.01753
87 Fr Francium 223	88 Ra Radium 226	89-103 Actinoids		104 Rf Rutherfordium 261	105 Db Dubnium 262	106 Sg Seaborgium 263	107 Bh Bohrium 264	108 Hs Hassium 265	109 Mt Meitnerium 266	110 Ds Darmstadtium 271	111 Rg Roentgenium 272	112 Uub Ununbium 285	113 Uut Ununtrium 286	114 Uuq Ununquadium 289	115 Uup Ununpentium 288	116 Uuh Ununhexium 289	117 Uus Ununseptium 289	118 Uuo Ununoctium 289

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

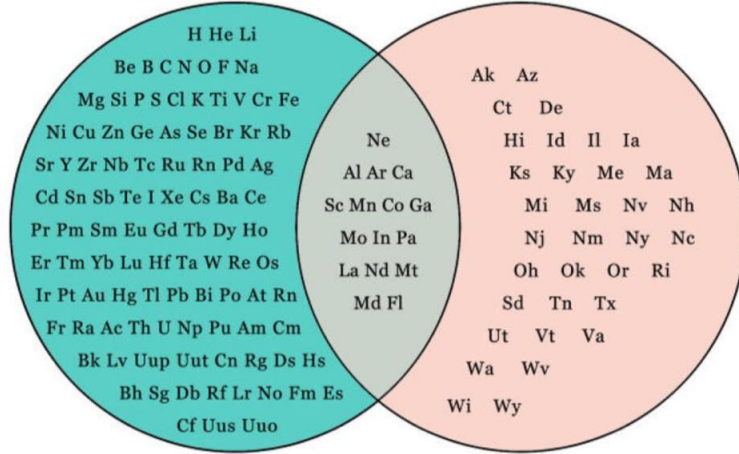
Design and interface Copyright © 1997 Michael Dayah (michael@dayah.com). <http://www.ptable.com/>

Ptable.com



chemical elements

us states



chicanaspice

this information is so satisfying but idk what to do with it

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

Dessiné par M. Micaud, Inspecteur Général des Ponts et Chaussées et gravé par Lavois, 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 le plus précis en ce qui concerne les zones. Le rouge désigne les hommes qui ont été tués en Russie, le noir ceux qui ont survécu. Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M. M. Chéris, de Schir, de Fizez, de Chambray et le journal inédit de Natch, 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 du Prince Némoïa et du Maréchal Davoust, qui avaient été détachés sur Minsk et Mielnik et qui rejoignirent l'armée à Witebsk, avaient toujours marché avec l'armée.

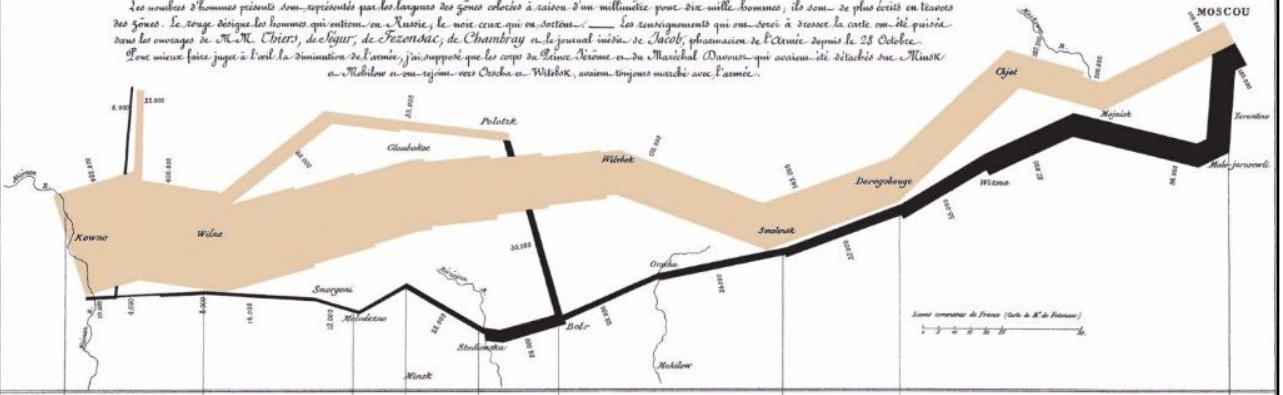


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.

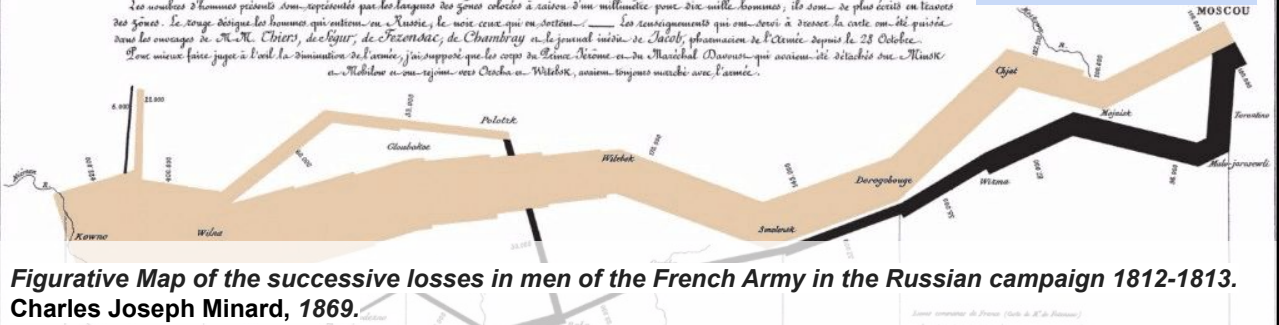
Les Chapeaux passent au gilet le Nilsson, gilet.



Edward Tufte says it "may well be the best statistical graphic ever drawn"

Carte Figurative des pertes successives en hommes de l'Armée Française dans la Campagne de Russie 1812-1813.
 Dessiné par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite. Paris, le 20 Novembre 1869.

Les nombres d'hommes présents sont représentés par les largeurs 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. Thiers, de Ségur, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre. Une seule fois jugé à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davout, qui avaient été détachés sur Minsk et Mogilev et qui rejoignent vers Orcha et Vitebsk, avaient toujours marché avec l'armée.

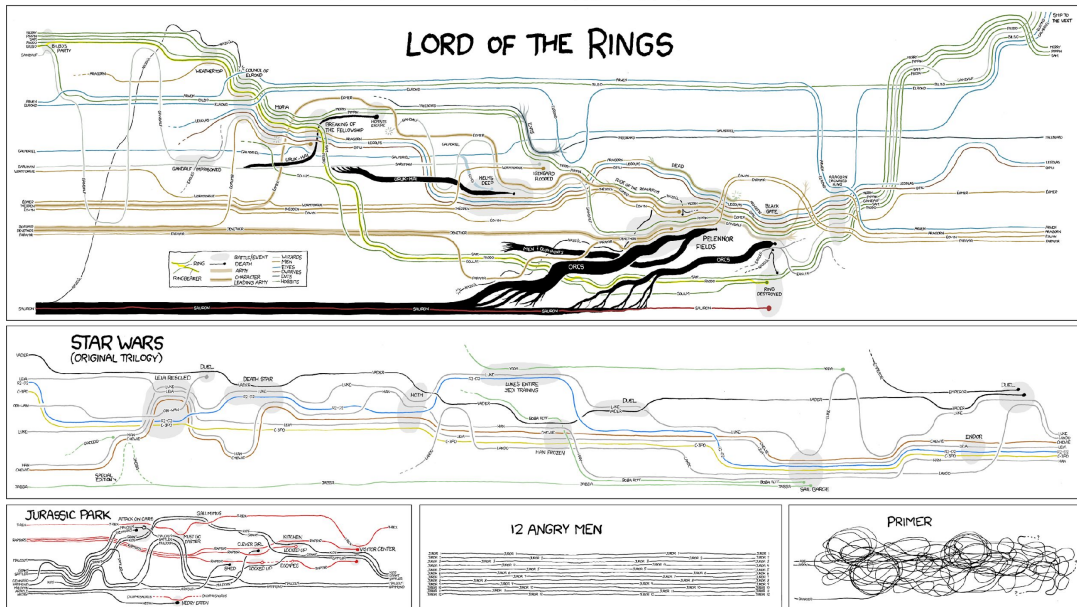


Figurative Map of the successive losses in men of the French Army in the Russian campaign 1812-1813. Charles Joseph Minard, 1869.

The numbers of men present are represented by the widths of the colored zones at a rate of one millimeter for every ten thousand men; they are further written across the zones. The red designates the men who enter Russia, the black those who leave it. — The information which has served to draw up the map has been extracted from the works of M.M. Thiers, de Ségur, de Fezensac, de Chambray and the unpublished diary of Jacob, the pharmacist of the Army since October 28th.

In order to better judge with the eye the diminution of the army, I have assumed that the troops of Prince Jérôme and of Marshal Davout, who had been detached at Minsk and Mogilev and have rejoined near Orsha and Vitebsk, had always marched with the army.

THESE CHARTS SHOW MOVIE CHARACTER INTERACTIONS.
 THE HORIZONTAL AXIS IS TIME. THE VERTICAL GROUPING OF THE
 LINES INDICATES WHICH CHARACTERS ARE TOGETHER AT A GIVEN TIME.

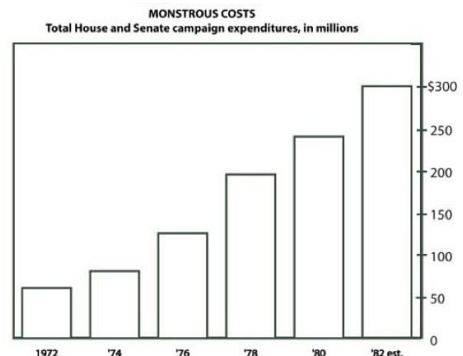
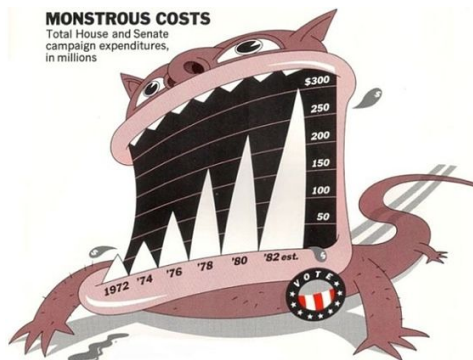


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Reading for Today

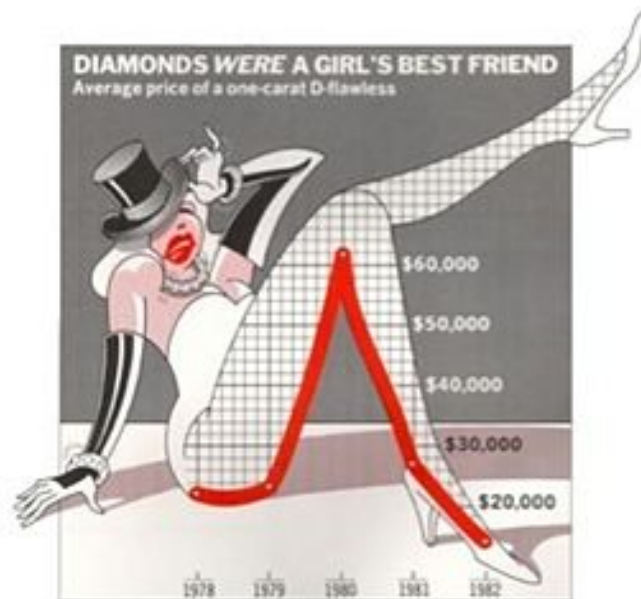
- “Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts”, Bateman et al., CHI 2010.



- Article discussed here:
<http://eagereyes.org/criticism/chart-junk-considered-useful-after-all>

What is “Chart Junk”?

- Extraneous elements in a chart or visualization
- Does not represent data
- Data-to-ink ratio (aim to convey more data with less ink)
- According to Edward Tufte: It's not just unnecessary, it's harmful (distracting)
- According to Nigel Holmes: Visualization should engage the reader's interest



Nigel Holmes

Study Design

“Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts” Bateman, Mandryk, Gutwin, Genest, McDine, & Brooks, CHI 2010

- Compare embellished charts to plain ones
- Measured:
 - interpretation accuracy *was no worse for embellished charts*
 - long-term recall (2-3 weeks later) *was better for embellished charts, topic & details of the chart were more memorable*
- Prior work:
 - Higher data-to-ink → faster response & greater accuracy [Gilan & Richman]
 - Other work shows a somewhat weak correlation between data-to-ink and interpretability or aesthetics
- Author's caution:
 - Not an endorsement of chart junk
 - Embellishments can lead to bias!

- Relatively small sample pool
 - 10 tested with ~5 min recall
 - 10 tested with 2-3 week recall
- Found no difference in time to read & describe embellished vs. non-embellished
- Participants preferred the embellished charts and found them more attractive

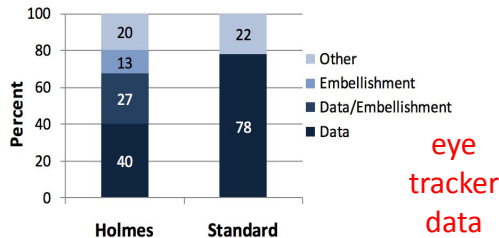


Figure 9. Percentage of on-screen time spent looking at different chart elements for Holmes and Plain charts.

eye
tracker
data

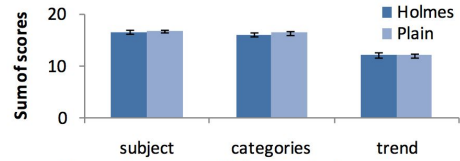


Figure 4. Means \pm SE for description scores.

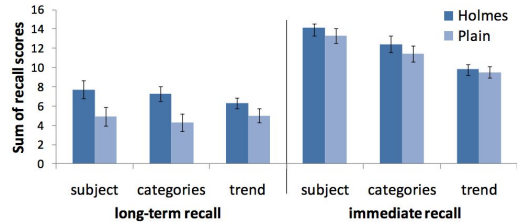


Figure 5. Means \pm SE for recall scores for long-term and immediate recall.

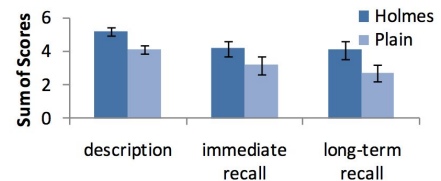


Figure 6. Means \pm SE for sum of value message scores.

- Viewing time was unlimited for this study
 - Participants ended up spending the ~same amount of time on embellished vs. non-embellished
 - Effect of limiting time *not measured*
- Chart junk for these examples was tightly coupled with subject & details of chart
 - Quote from Holmes: "I think [Tufte] missed the point of much that I was trying to do: TIME magazine charts were aimed at lay readers, not unintelligent ones, but busy ones. I knew they'd get the point quicker if they were somehow attracted to the graphic."
- What about charts from paper on last slide? What was their point? How good is your recall? Will your recall them in 2-3 weeks? Why didn't the authors use embellishment?

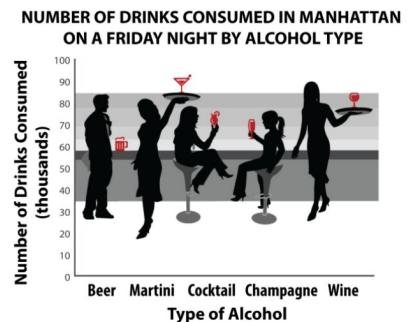
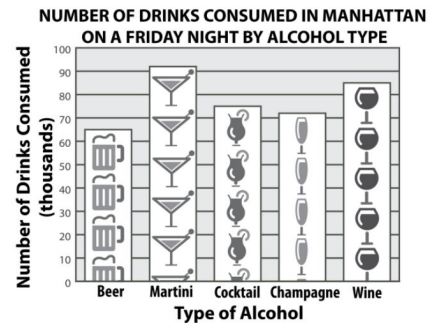


Figure 10. Less extreme visual imagery in charts.

Today

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- Graph Drawing Preview: Terminology & Goals (15 min)
- Readings for Tuesday: Graph Drawing

Pair Worksheet (~20 minutes)

- Meet new people
 - Work with someone you did not know before this class
 - Work with a different partner every time
- 1 worksheet per team of 2
 - Sketch & brainstorm on the page
 - (I’ll scan & upload to Submittly for your review)
- Use color! Be creative!

Homework 2: Time-Based Datasets

- Team of 2
- Obtain an interesting time-based dataset
 - Should be collectable* from online sources, and
 - Require a modest effort to prepare*
- Use Microsoft Excel or Google Sheets or LibreOffice Calc
 - Create a variety (one of each?!) of the charts following the guidelines from "Eenie, Meenie, Minie, Moe: Selecting the Right Graph for Your Message"
 - Excellent labels and captions for each
- Upload your assignment to Submittity by Thursday @ 11:59pm
And post two of the charts on the forum

Tools for Scraping Data from the Web

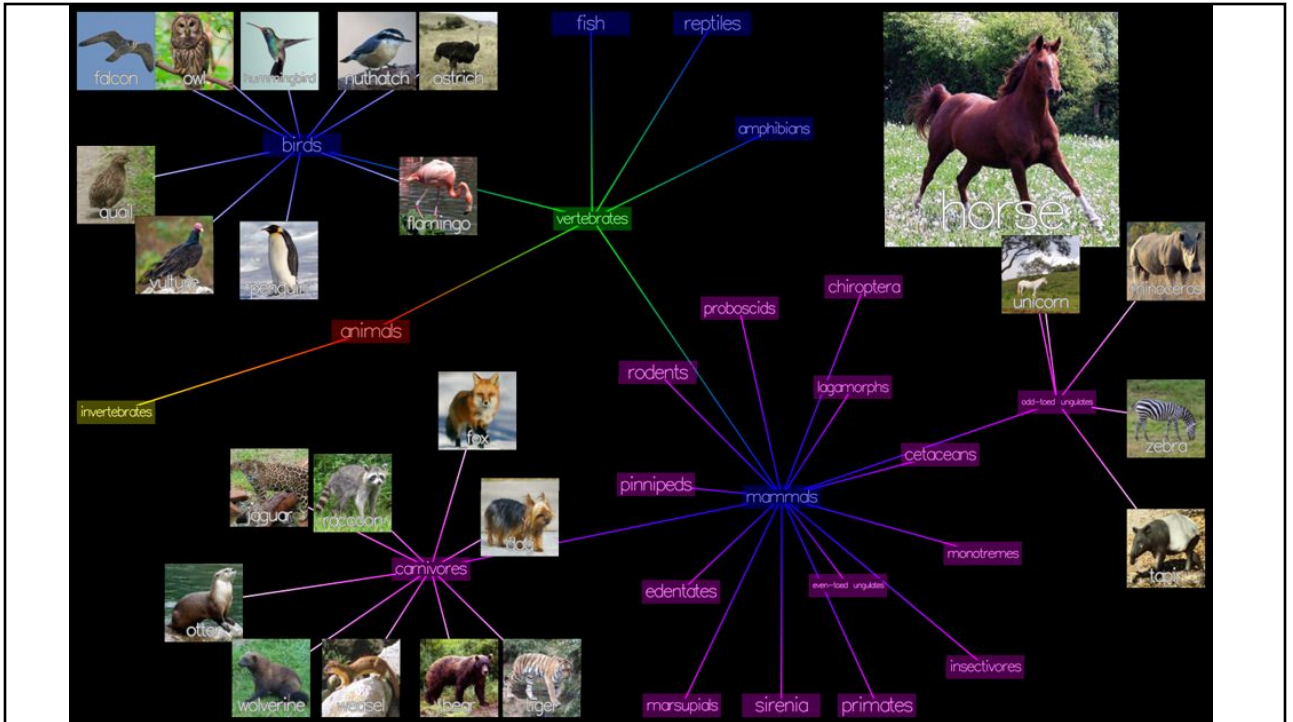
- copy-paste
- wget
- grep / sed / awk / sort / uniq
- Favorite programming language to parse/strip out unnecessary html formatting
- Save as .csv (comma separated value) files to upload to Excel / Google Sheets
- Python has lots of packages for parsing (e.g., json format)
- Selenium for automated browsing of websites

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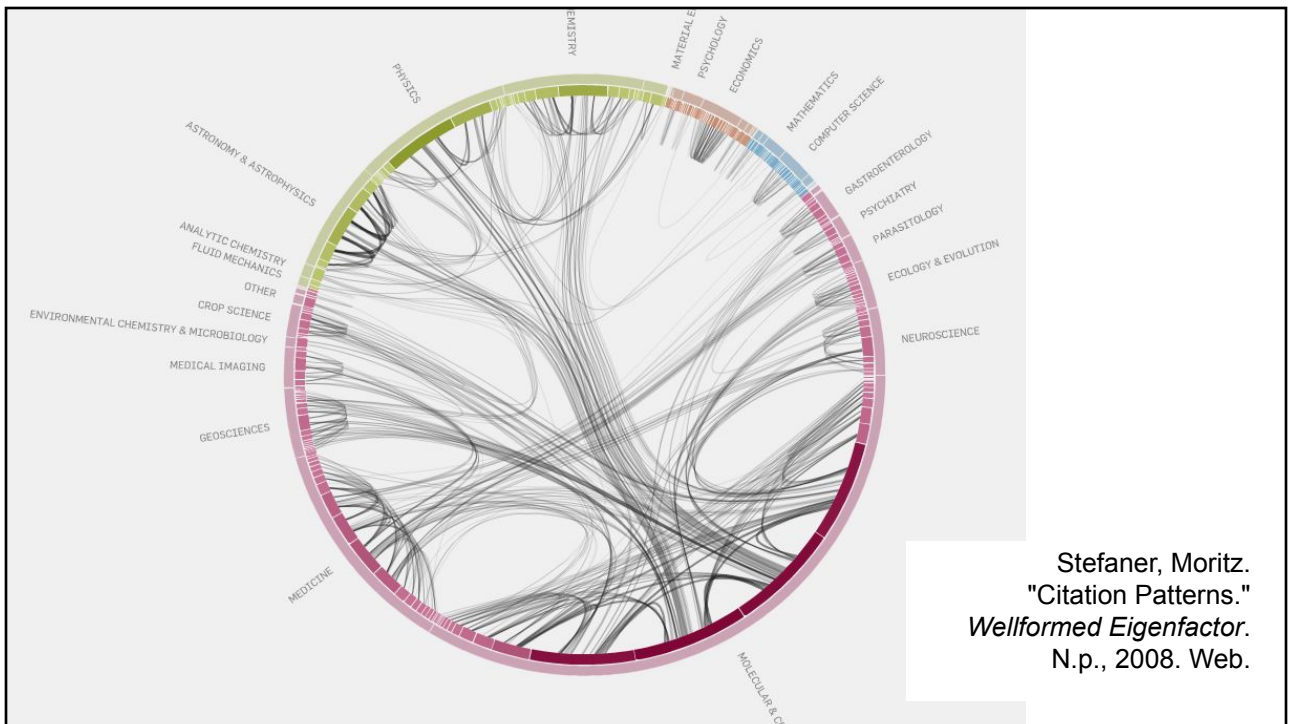
Graph Terminology I

- Directed vs. Undirected Edges
- Tree (no cycles) vs. Graph (cycles allowed)
 - Cycle: A path along edges through the graph starting & ending at the same vertex.
 - Cycle Variants: closed walk, simple cycle, directed cycle, ...
- Valence (a.k.a. Degree) of a Vertex:
of edges incident on the vertex
- Regular: Each vertex has same valence,
a 3-regular graph is also called cubic



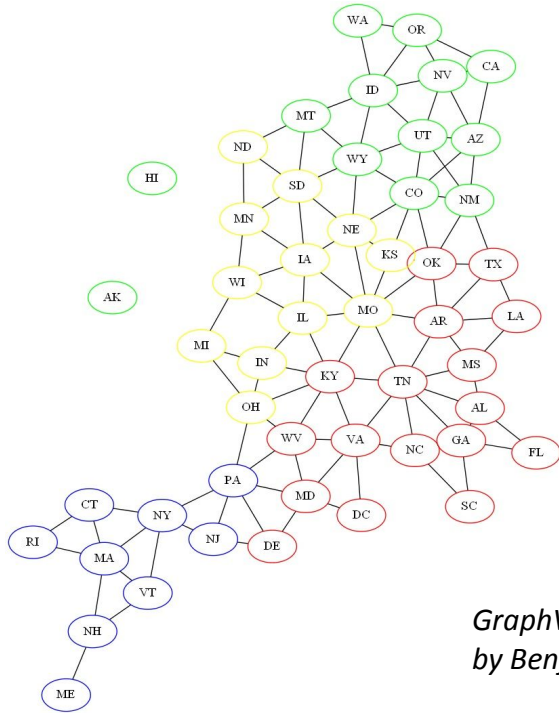
Graph Terminology II

- Polygon: 2D flat or on a sphere, with straight or great circle edges
- Polyhedron: 3D solid formed by flat faces
- Polytope: flat sides in any dimension
- Bipartite: vertices can be split into two groups, A & B. No edge connects a vertex in A to another vertex in A. Same for B.
- Clique – subset of vertices in an undirected graph with an edge connecting every pair of vertices in the subset.

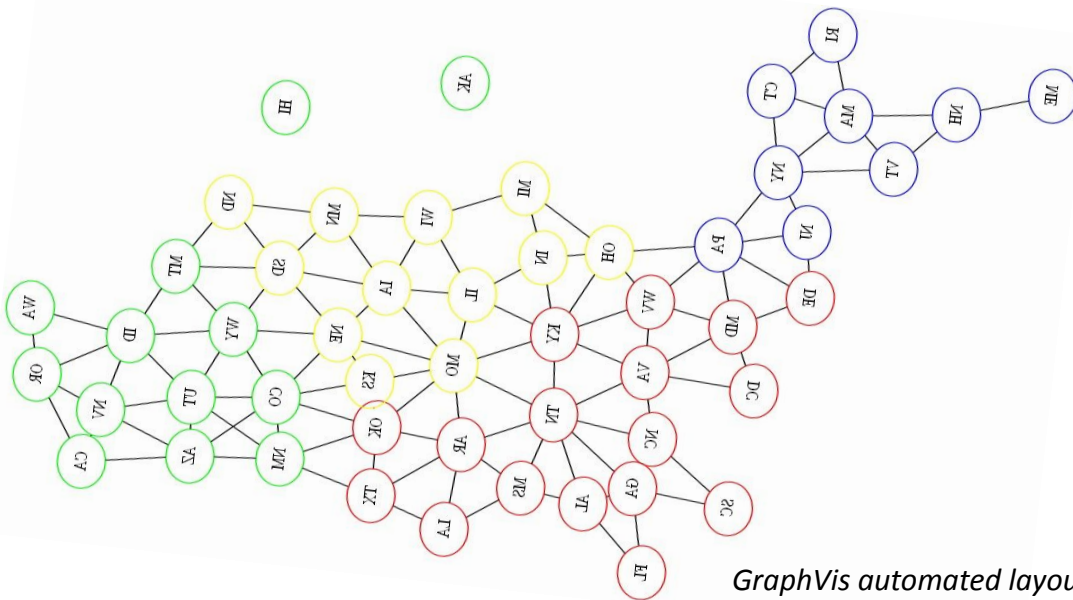


Graph Terminology III

- Upward Drawing (of a tree) – no child is drawn with vertically above (higher y value than) its parent.
- Plane Graph – A 2D drawing of the graph where no edges cross (touching at the endpoint vertices they share is ok)
- Planar Graph – A graph for which a Plane Graph exists.
- Euler's Theorem for planar graphs:
 For a plane graph with n vertices, m edges
 and f faces, we have $n - m + f = 2$.



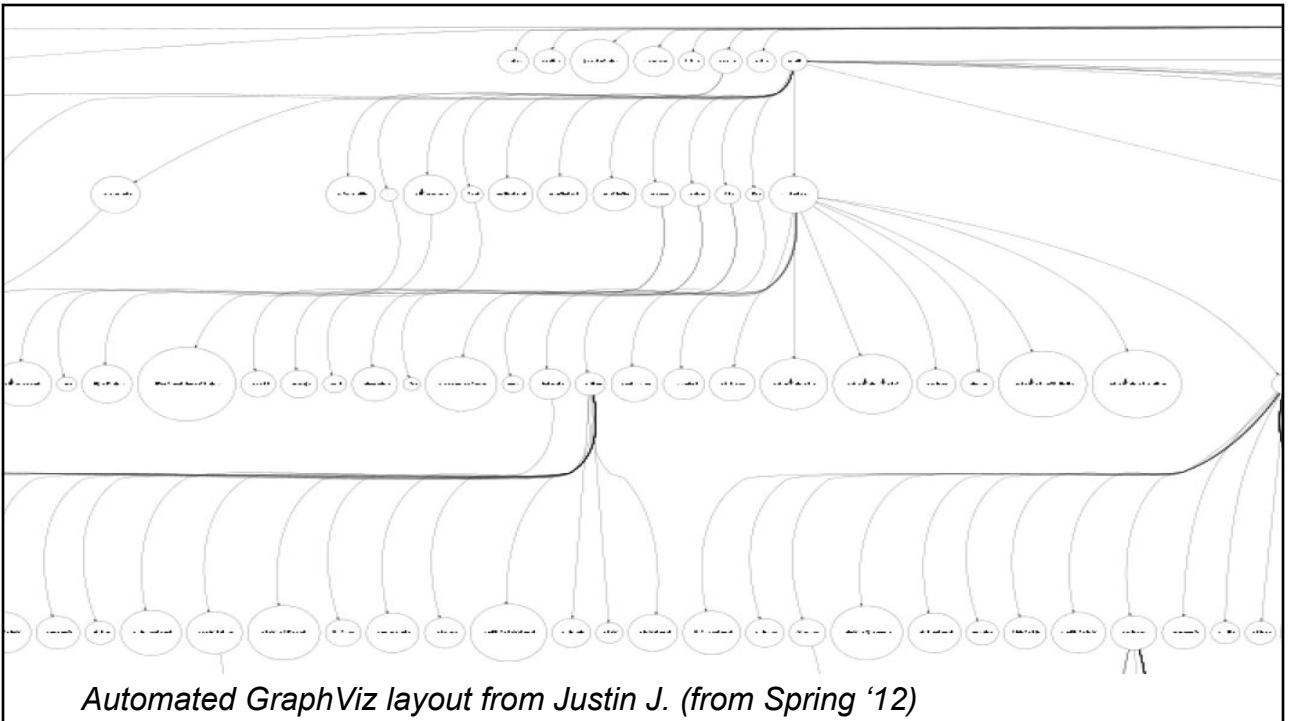
*GraphVis automated layout
by Benjamin B. (from Spring '12)*



*GraphVis automated layout
by Benjamin B. (from Spring '12)*

Graph Drawing Goals

- Automated!
- Can read all of the labels
- Can follow the line and see exactly which 2 vertices it connects
- Aesthetically pleasing
- Layout should display as much symmetry as possible
- Crossing free or minimal-crossing layout
- All edge lengths are approximately equal
- Even vertex distribution
- Distance between nodes in final layout should be as close as possible to “graph distance” (# of edges on shortest path between those nodes)



Graph Drawing Questions

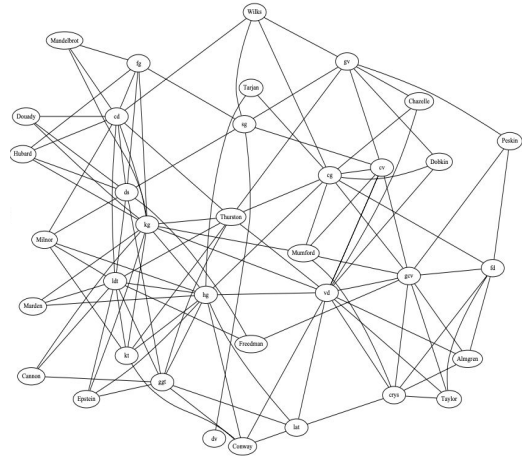
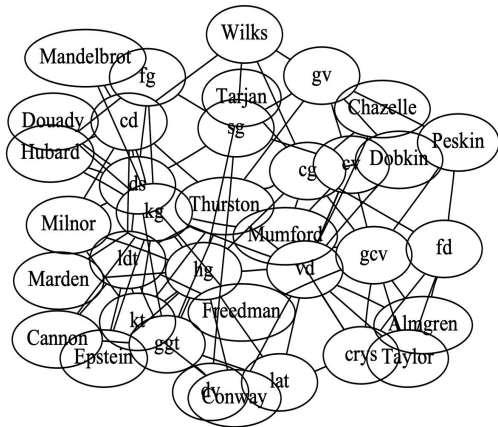
- What is the metric of success for each of our goals?
- Can we guarantee to find a solution? The optimal or best solution?
- Can we use randomness? Does it help?
- How expensive/slow are the different algorithms to draw graphs?
- How does it scale with more nodes/edges?
 - Does it lose effectiveness in meeting our goals?
 - How is the running time affected?
- How do we label the nodes/edges with color/words/images?

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Reading for Tuesday (*pick one*)

“Improved force-directed layouts”,
Gansner and North, Graph Drawing, 1999.



Reading for Tuesday (*pick one*)

“A Technique for Drawing
Directed Graphs” Gansner,
Koutsofios, North, & Vo, IEEE
Trans. on Software
Engineering, 1993.

