Winning Ways for Your Visualization Plays

Mark Grundland
Functional Elegance

Mark Grundland

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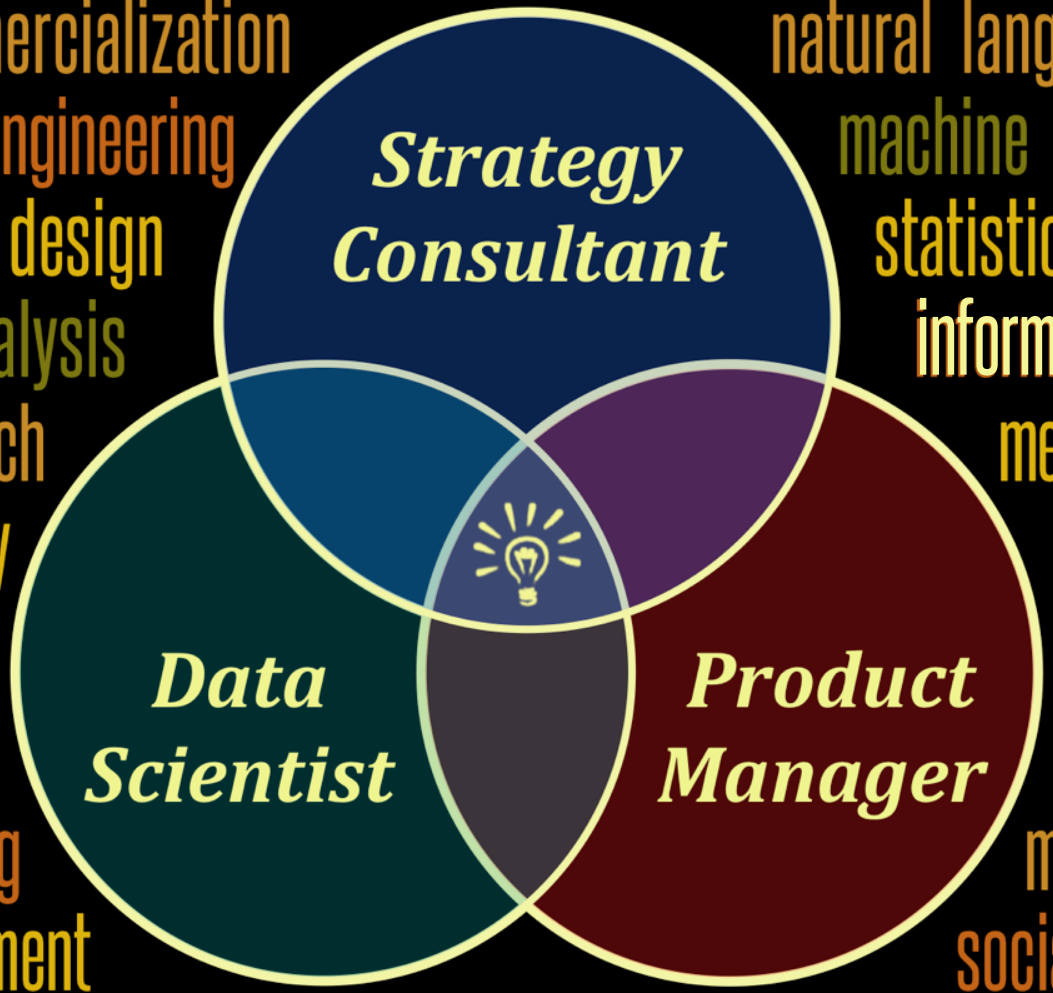
consultancy entrepreneurship research analysis design development
innovation commercialization
natural language processing
software system engineering
machine learning methods
user experience design
statistical model design
requirements analysis
information visualization
technology research
medical data analysis
business strategy
image processing
market analysis
computer vision
prototype design
online marketing
startup fundraising
mobile applications
business development
social media analytics
markets customers strategy insight data technology opportunity



Visualization is old as art but it is just getting started

"I am here"

Hand cloud

invented 35,000 B.C.

http://en.wikipedia.org/wiki/Cueva_de_las_Manos
http://kristybuddeneducation.com/2012/07/ and http://www.tagxedo.com/app.html

Visualization is old as art but it is just getting started

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Hand cloud

invented 35,000 B.C.

"I blog here"

Word cloud

invented 1992 A.D.

http://en.wikipedia.org/wiki/Cueva_de_las_Manos
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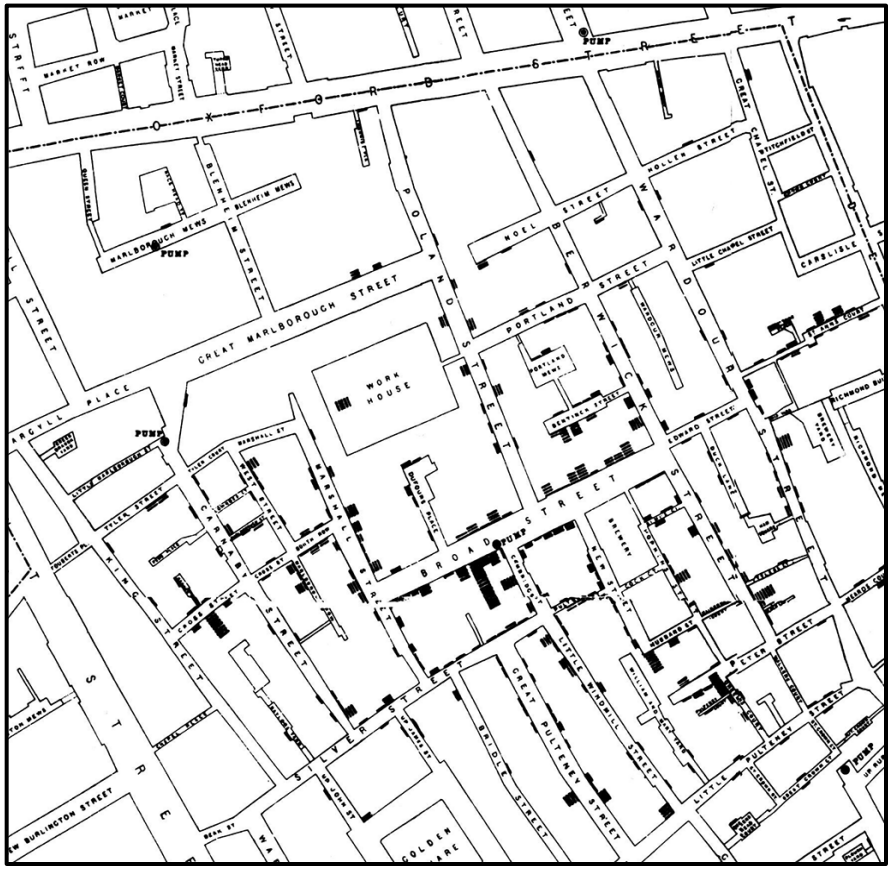
Seeing the pattern in the data can change how we view our world

Modern epidemiology started with plotting dots on a map.



http://en.wikipedia.org/wiki/1854_Broad_Street_cholera_outbreak

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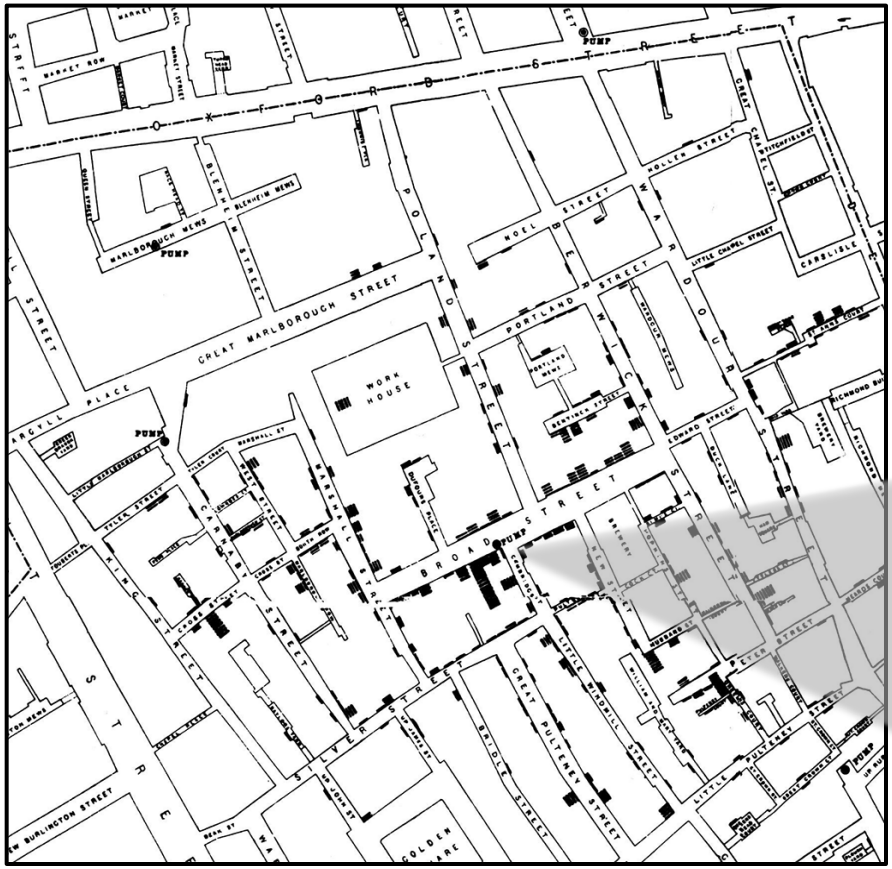
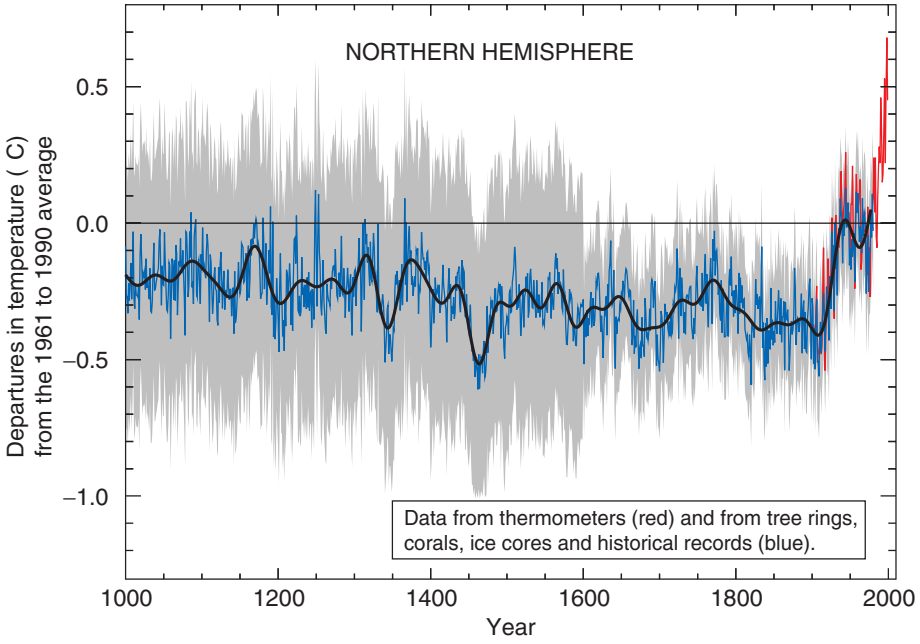


In 1854, a cholera outbreak in Soho killed over 600 people. John Snow plotted the locations of the deaths to show that they were clustered around the neighborhood water pump.

http://en.wikipedia.org/wiki/1854_Broad_Street_cholera_outbreak

Communicating data effectively can change what we do with our world

Hockey stick graph was arguably the most controversial chart in science: our future depends on how we read it.



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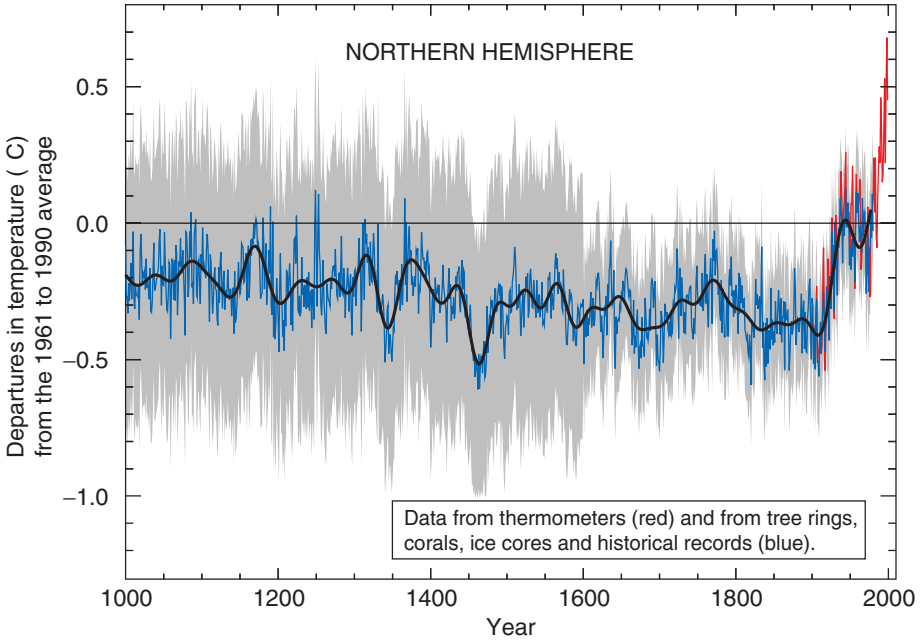
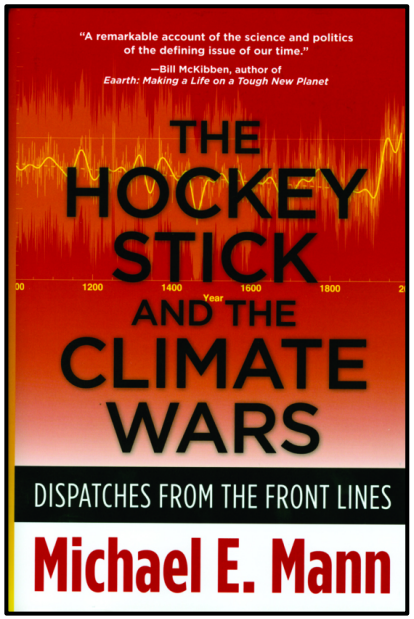
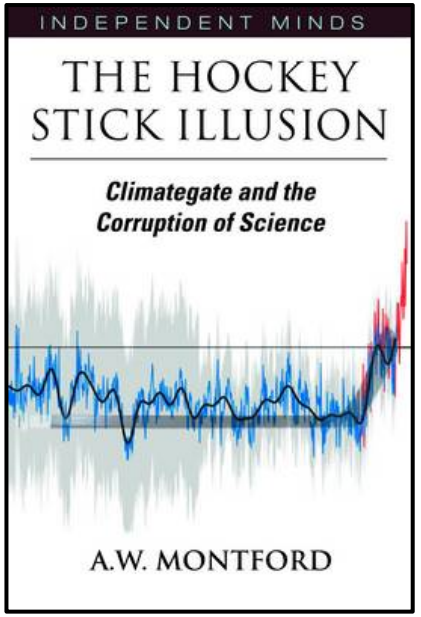


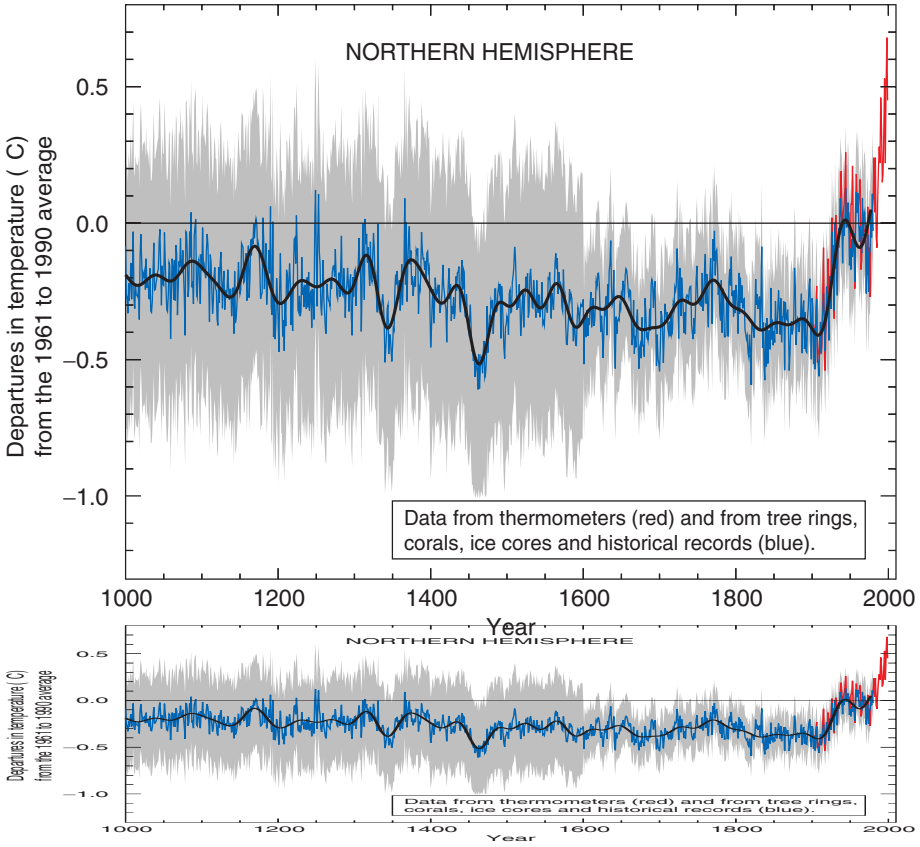


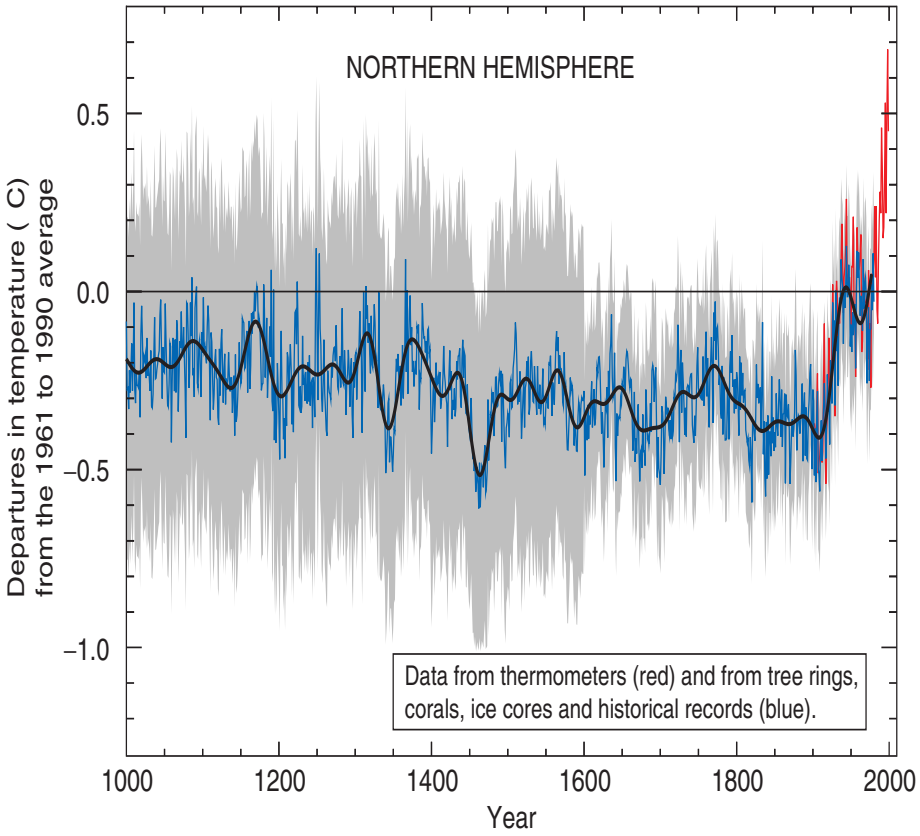


http://www.ipcc.ch/pdf/climate-changes-2001/synthesis-syr/english/summary-policymakers.pdf
http://www.amazon.com/dp/023115254X/ and http://www.amazon.com/dp/1906768358/

How can we display our data without distorting the truth?

Hockey stick graph was arguably the most controversial chart in science: our future depends on how we read it.





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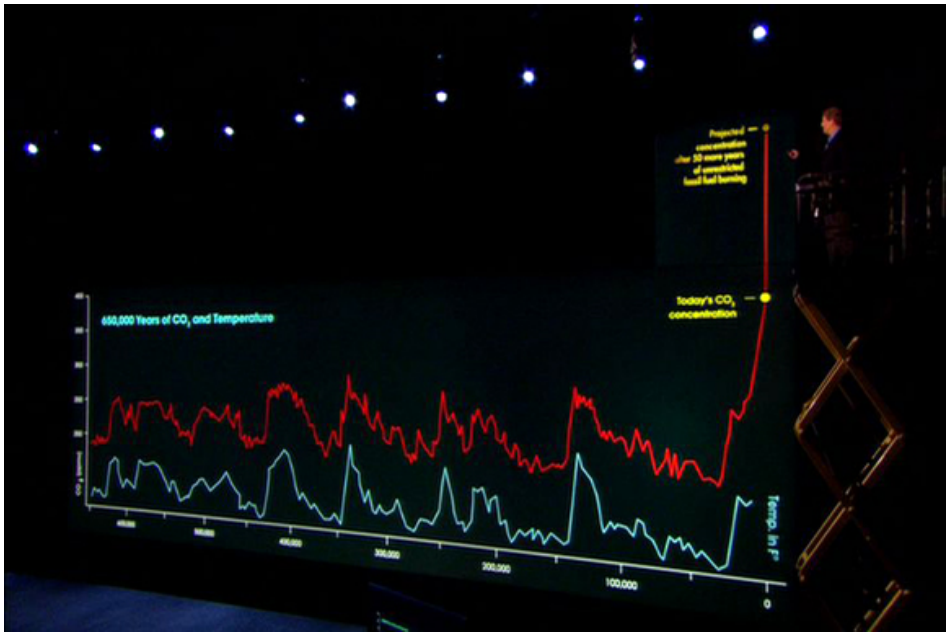
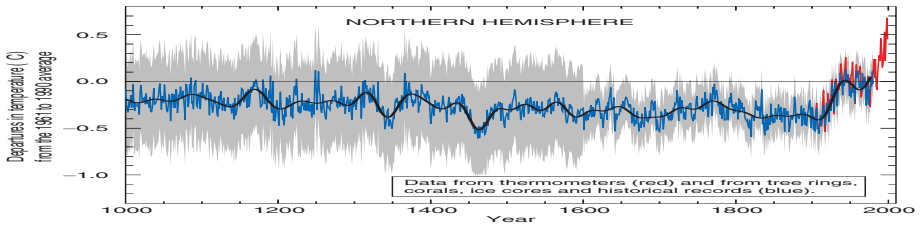
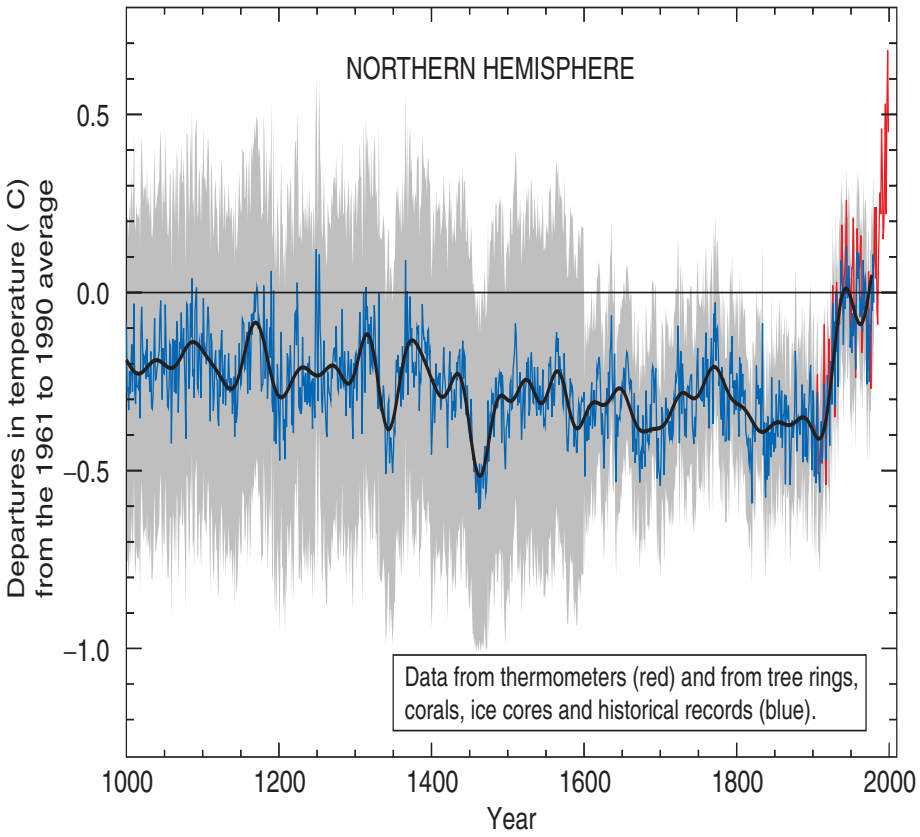
How can we display our data without distorting the truth?

The visualization design decisions we make affect which interpretations of the data are facilitated or impeded.







http://www.takepart.com/an-inconvenient-truth/film
http://www.ipcc.ch/pdf/climate-changes-2001/synthesis-syr/english/summary-policymakers.pdf

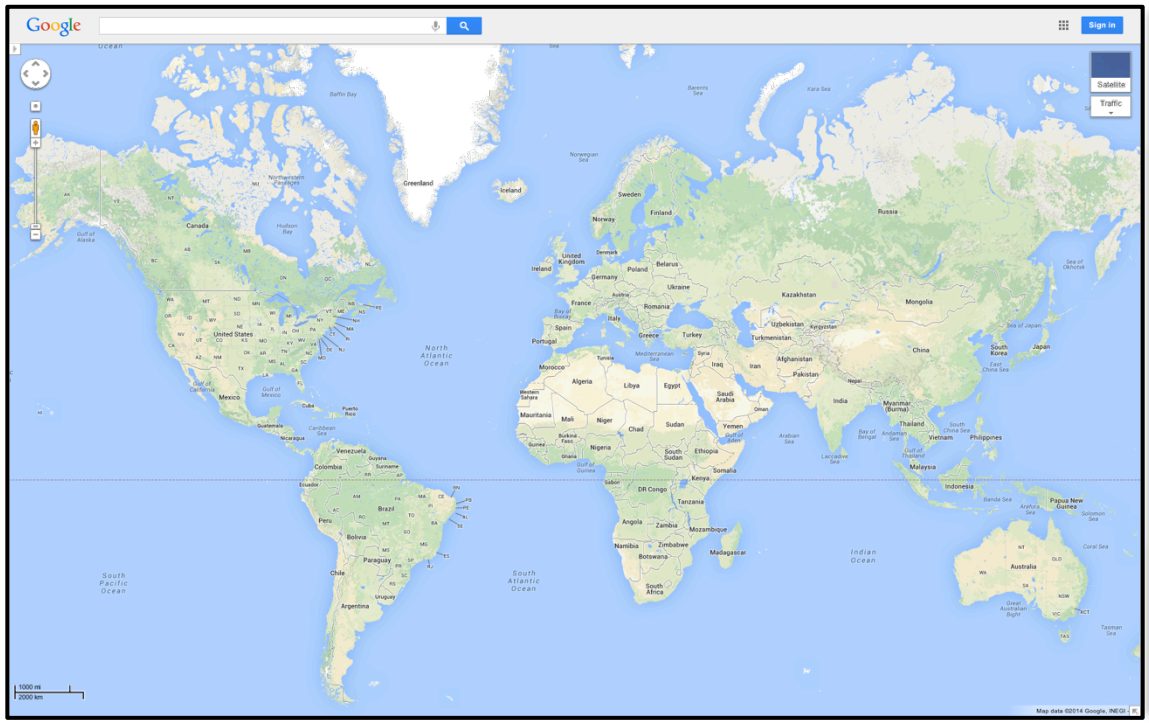
How can we select the aspect ratio?

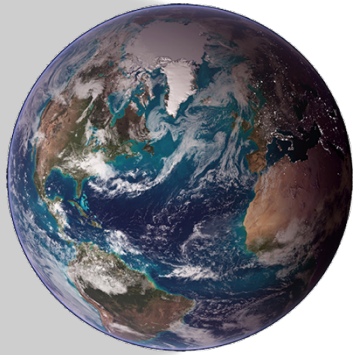
- Use 1:1 … **Why?** It is fair and square.
- Use 3:2 … **Why?** It is wider than taller, like a landscape photo.
- Use the golden ratio…
  Why? It is a most pleasing proportion found in nature and art.
- Make the average slope of all line segments 45º…
  Why? It is perceptually optimal for orientation discrimination.
- Minimize arc length, keeping area under the plot constant…
  Why? It is short, sweet, and mathematically optimal.
- Take the screen size or the widow size as given…
  Why? It fits, so obviously this must be what the user wants.
- Depends on the situation…
  Why? It depends on the story the user is meant to believe.

http://vis.berkeley.edu/papers/banking/2006-Banking-InfoVis.pdf and http://vis.stanford.edu/papers/arclength-banking
http://www.manorpress.co.uk/printing%20info.html

How can we select the map projection?

Representing the Earth on a flat map must in some way distort distances, directions, angles, shapes, and/or areas.





Mercator Projection

Preserves angles but not areas

http://maps.google.com/
http://earthobservatory.nasa.gov/Features/10thAnniversary/top10.php

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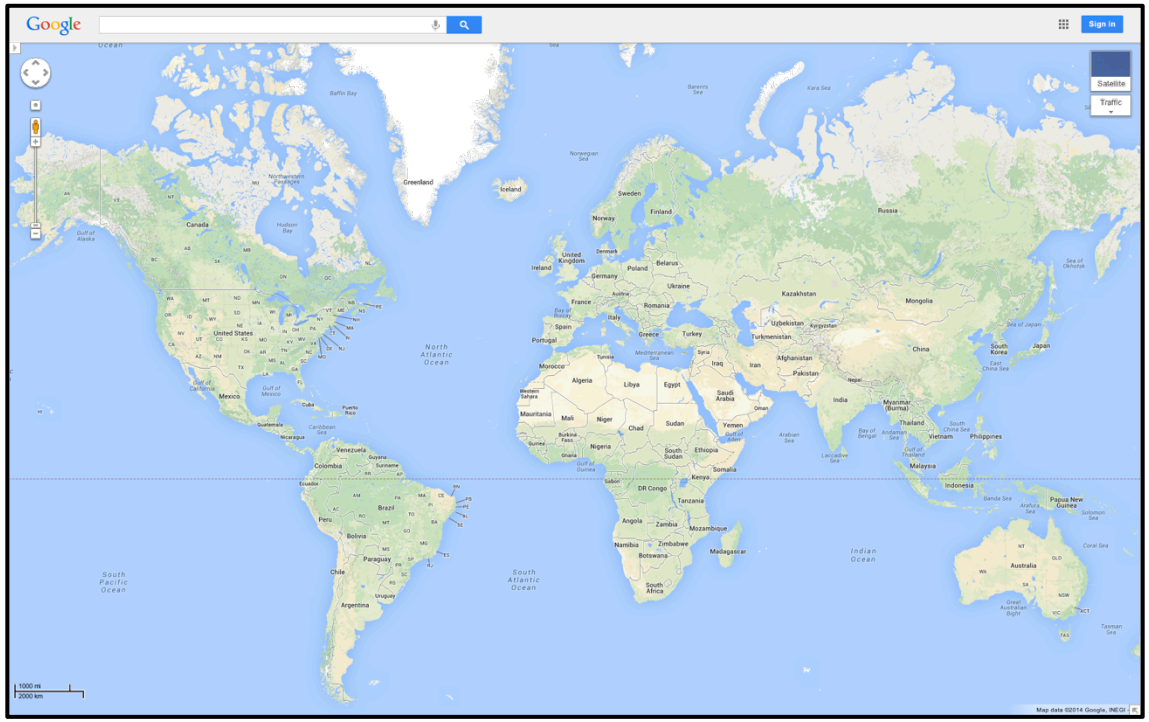

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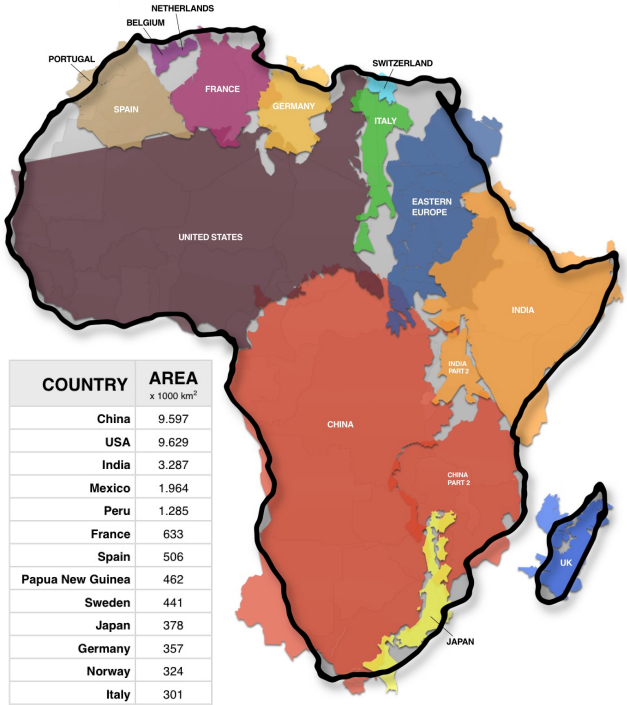

COUNTRY	AREA x 1000 km²
China	9.597
USA	9.629
India	3.287
Mexico	1.964
Peru	1.285
France	633
Spain	506
Papua New Guinea	462
Sweden	441
Japan	378
Germany	357
Norway	324
Italy	301
New Zealand	270
United Kingdom	243
Nepal	147
Bangladesh	144
Greece	132
TOTAL	30.102
AFRICA	30.221

http://maps.google.com/
http://cdn.static-economist.com/sites/default/files/true-size-of-africa.jpg

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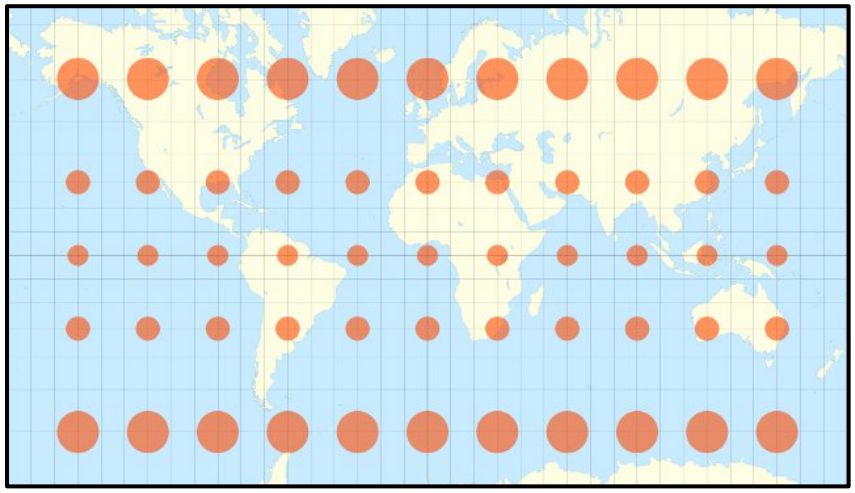
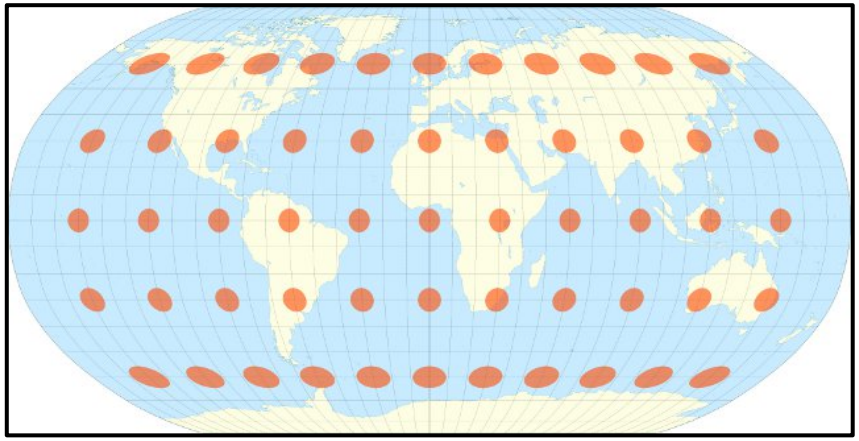
Representing the Earth on a flat map must in some way distort distances, directions, angles, shapes, and/or areas.

- Tissot indicatrix measures geometric distortion by showing how circles on the globe appear as ellipses on the map.



Mercator Projection
Preserves angles
but not areas



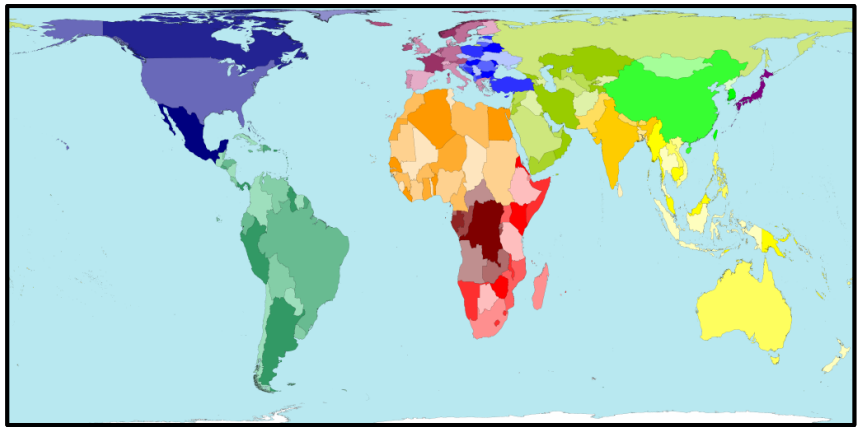
Robinson Projection
Nearly preserves areas
but not angles

http://wordpress.mrreid.org/2011/06/07/tissots-indicatrix/
http://www.progonos.com/furuti/MapProj/Normal/TOC/cartTOC.html

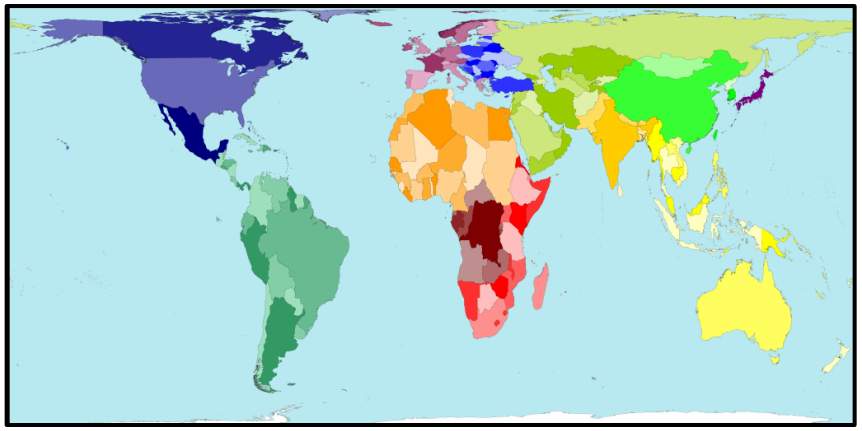
How can we select the map projection?

Representing the Earth on a flat map must in some way distort distances, directions, angles, shapes, and/or areas.

- Cartograms distort the size and shape of regions in order to make their area proportional to a given variable of interest.
- Computed using density diffusion or cellular automata.



Land Mass
Equal area cartogram



Land Mass
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http://www.worldmapper.org/
http://arxiv.org/pdf/physics/0401102v1.pdf

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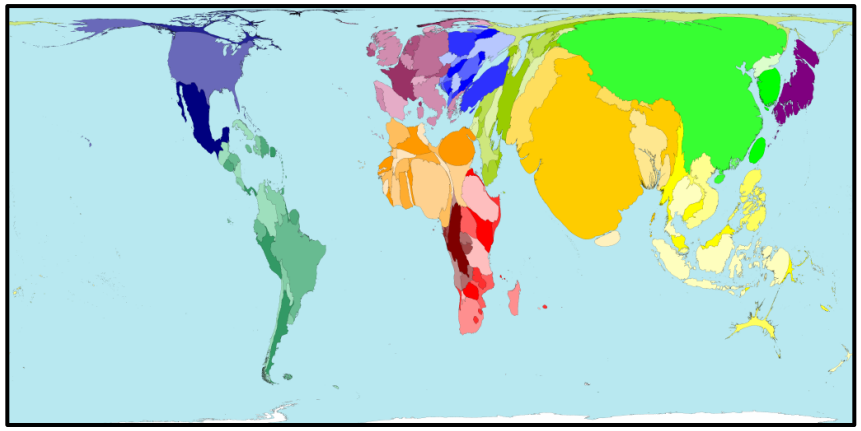
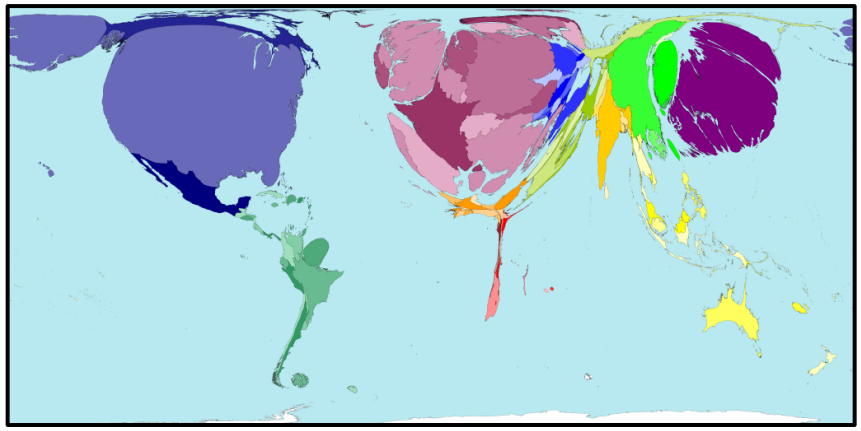


Population
Equal area cartogram



GDP Wealth
Equal area cartogram

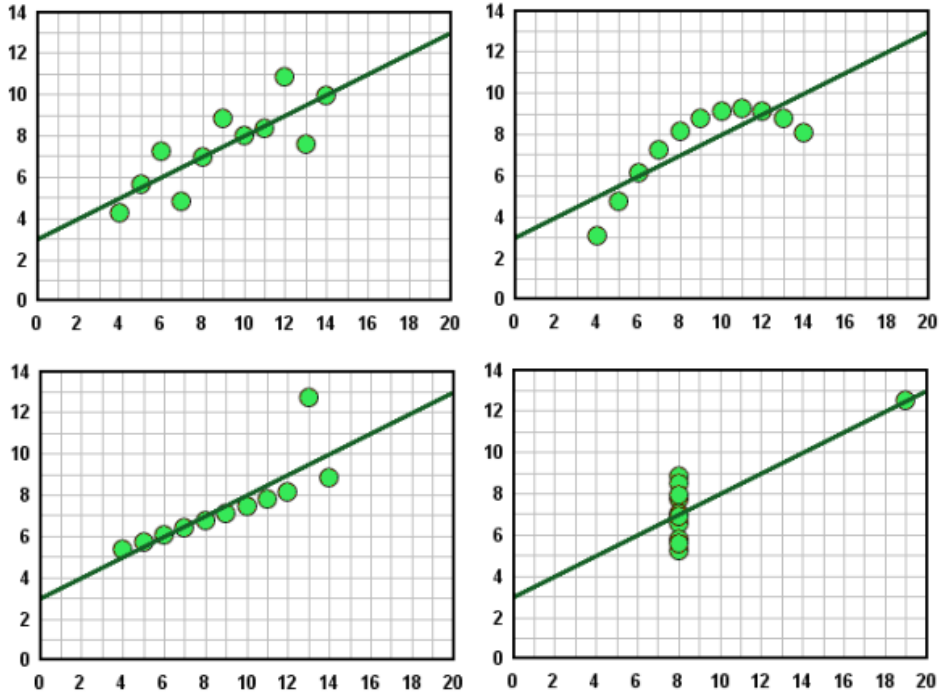
http://www.worldmapper.org/
http://arxiv.org/pdf/physics/0401102v1.pdf

Why do we visually represent values?

Though data is easily summarized by numbers, information is best communicated by patterns.

Same pattern ≠ Same statistics

Same means μ, variances σ^2, correlation R^2, and regression



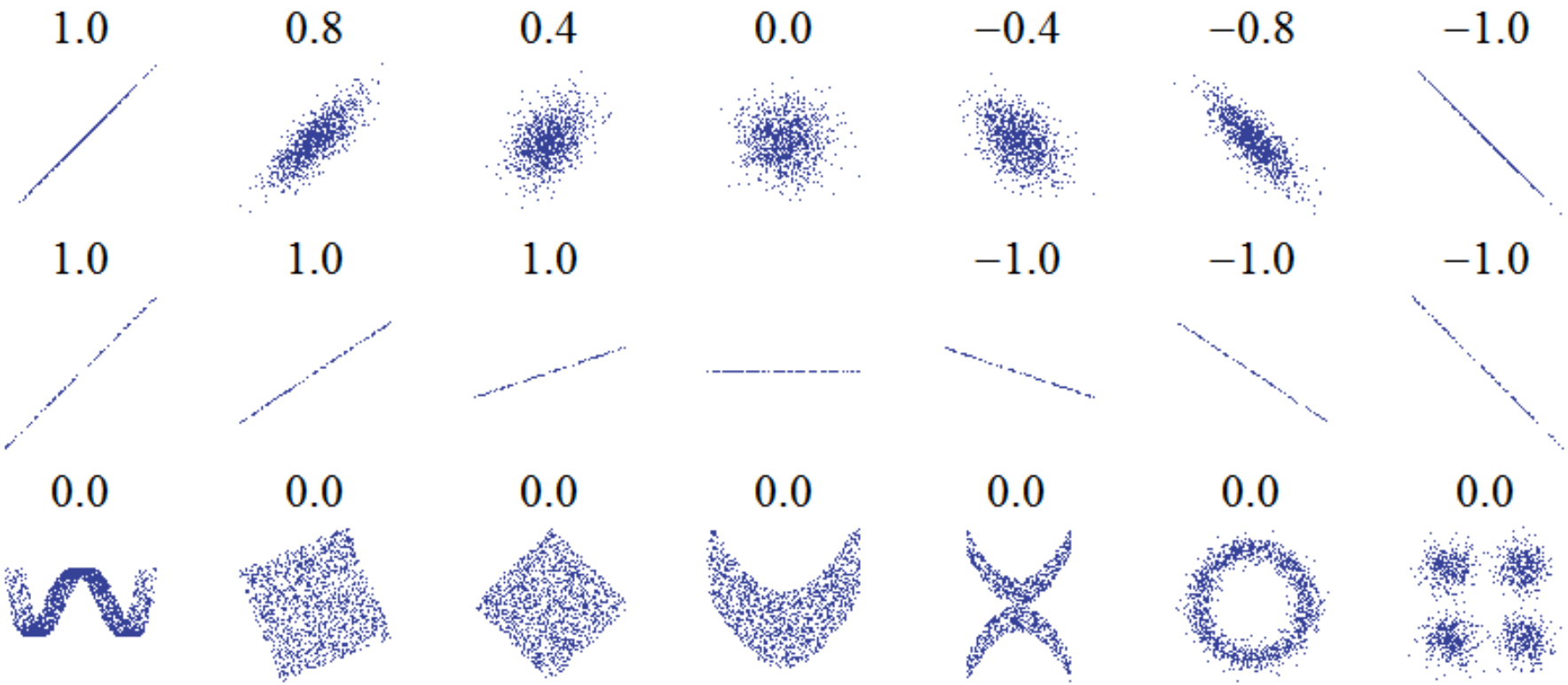
http://en.wikipedia.org/wiki/Anscombe%27s_quartet
http://tradersonline-mag.com/01_ezine/01_traders/en/2011/08/index.html#/18/zoomed

Image Credit: Michael Taylor

Why do we visually represent values?

Though data is easily summarized by numbers, information is best communicated by patterns.

Same relationship ≠ Same correlation

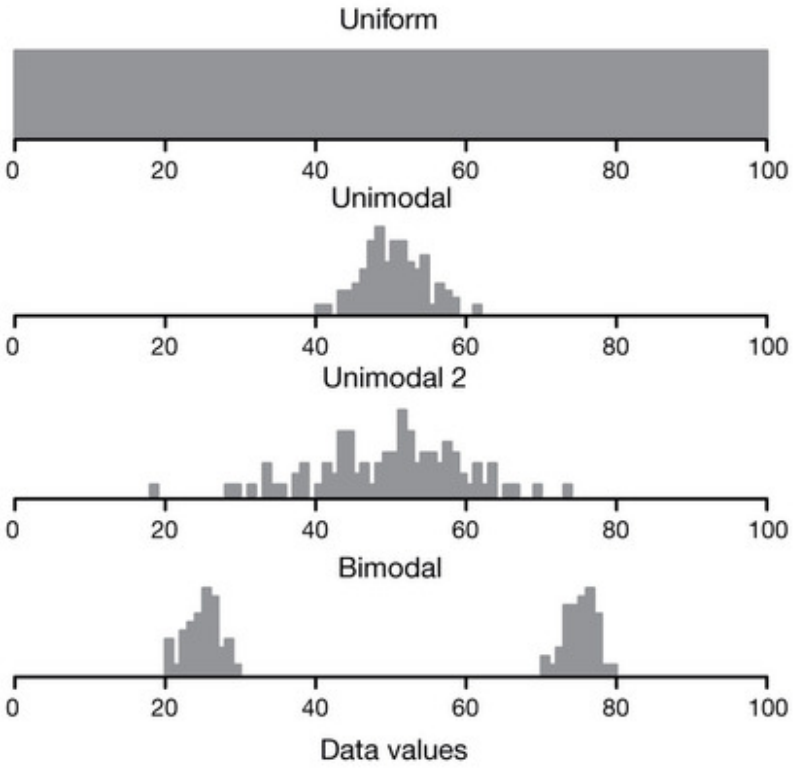


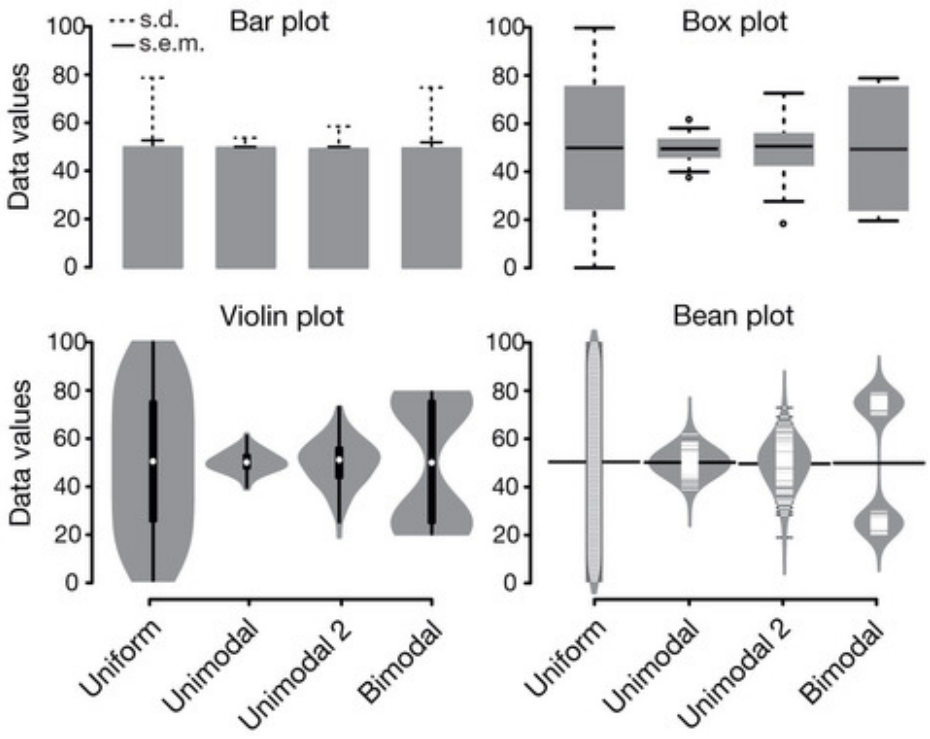
http://en.wikipedia.org/wiki/File:Correlation_examples.png#filelinks
http://stats.stackexchange.com/questions/119835/correlation-between-a-nominal-iv-and-a-continuous-dv-variable

Why do we visually represent values?

Though data is easily summarized by numbers, information is best communicated by patterns.

Visualizing the data ≠ Visualizing the statistics





http://www.nature.com/nmeth/journal/v11/n2/full/nmeth.2811.html
http://flowingdata.com/2012/05/15/how-to-visualize-and-compare-distributions/

How can we visually represent values?

Numeric values express absolute magnitudes but visual perception makes relative judgments.

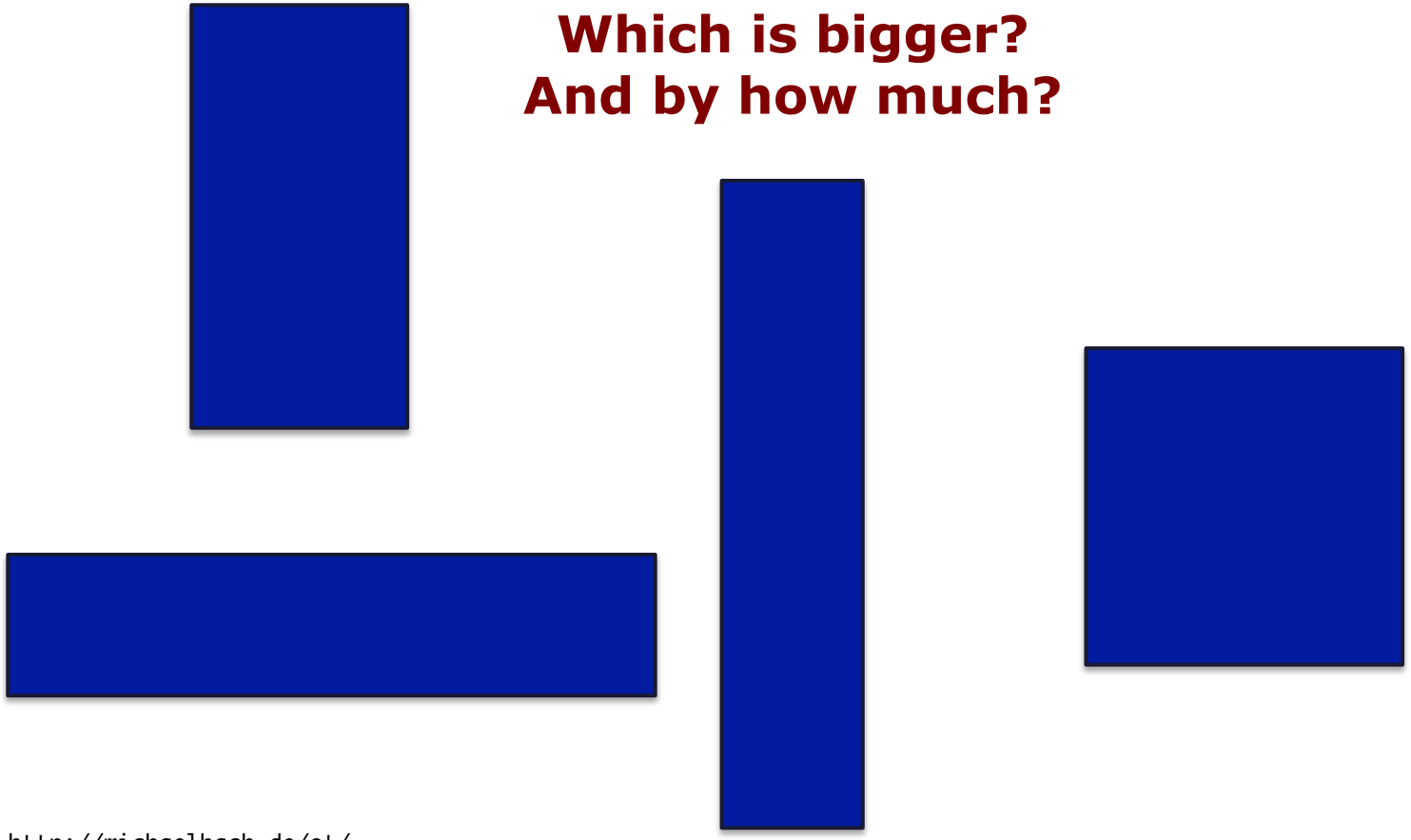
- Position
- Shape
- Length
- Orientation
- Area and volume
- Hue, saturation, brightness
- Texture and transparency
- Alignment and proximity
- Containment and connection
- Labels and glyphs
- Motion and flicker

http://www2.parc.com/istl/projects/uir/publications/items/UIR-1986-02-Mackinlay-TOG-Automati
http://visualfunhouse.com/altered_reality/14-perfect-shot-photography-illusions.html

How can we visually represent values?

Numeric values express absolute magnitudes but visual perception makes relative judgments, not very well.

Which is bigger?
And by how much?



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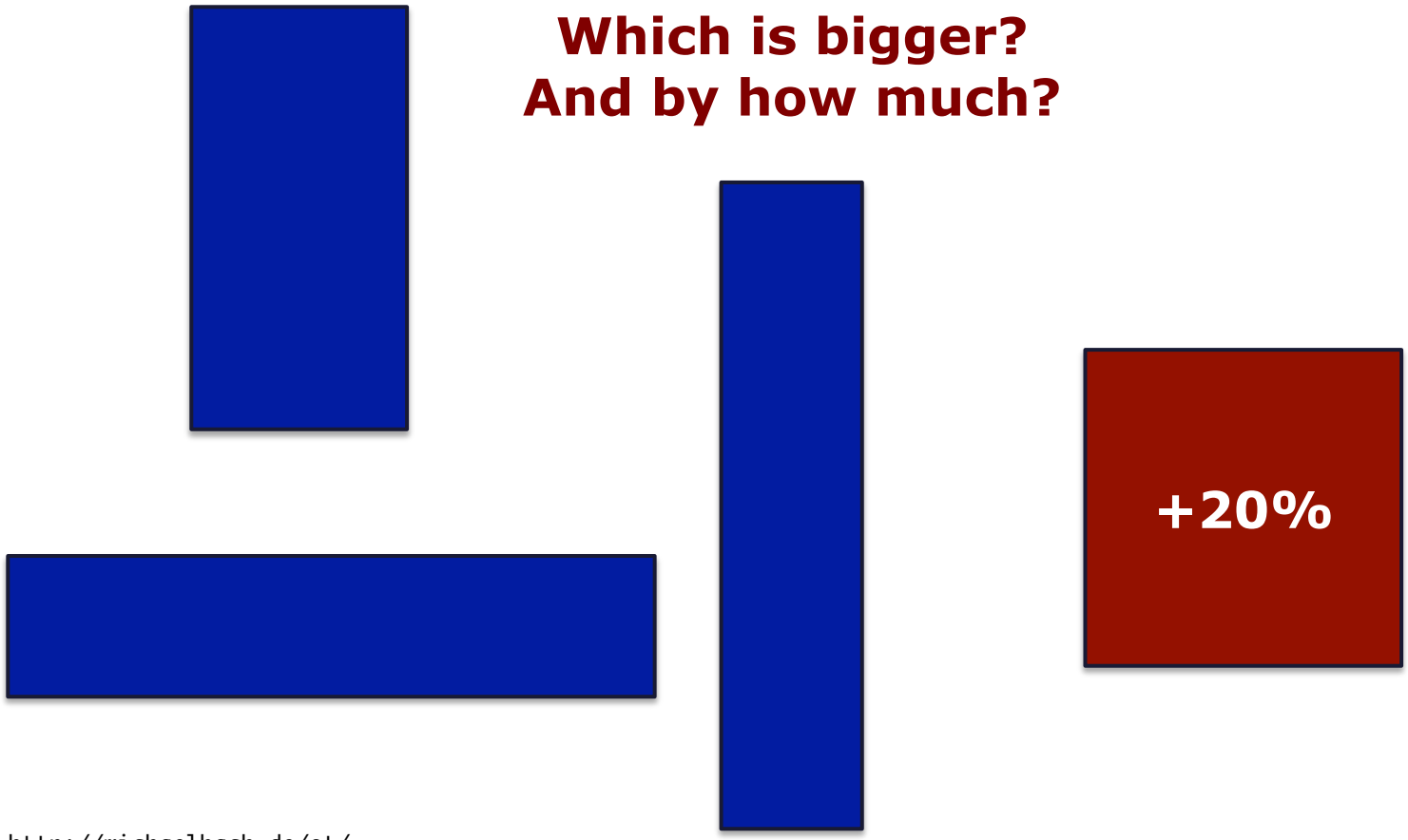

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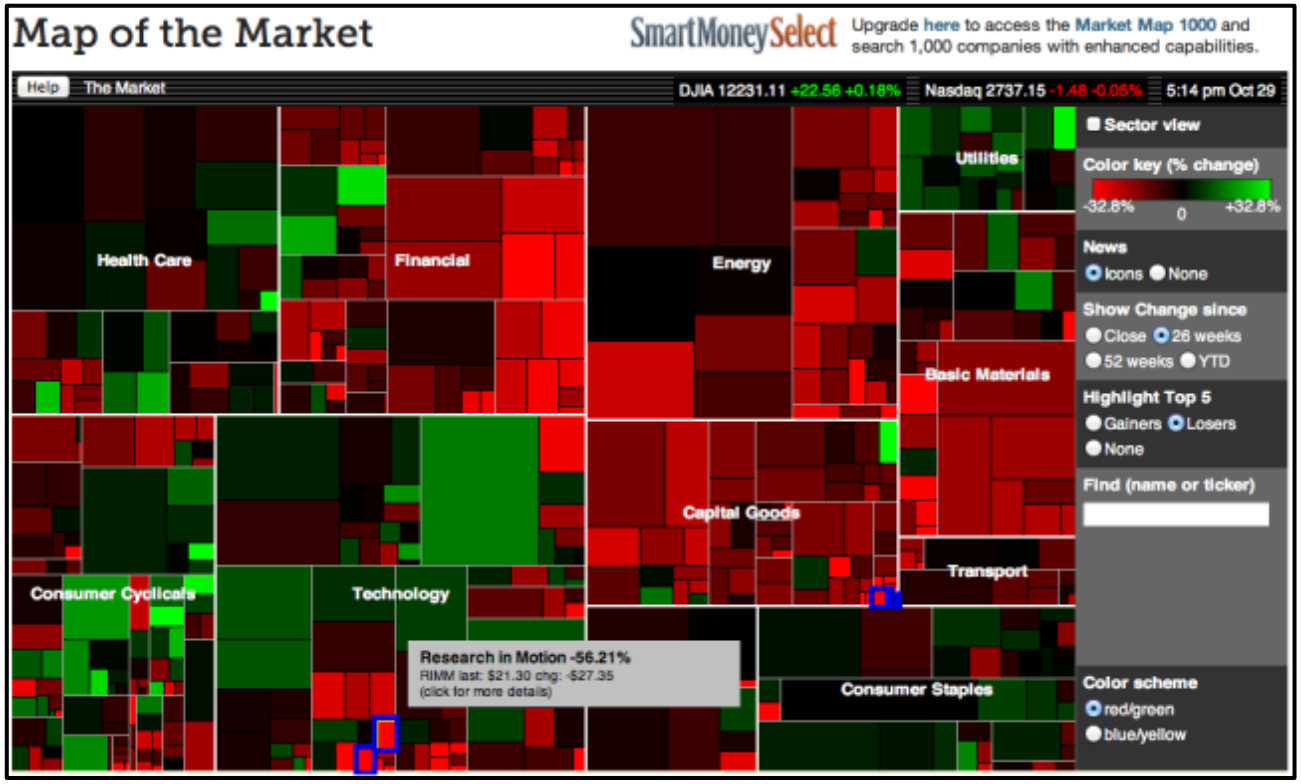
Equity Market Heat Map



http://www.marketwatch.com/tools/stockresearch/marketmap

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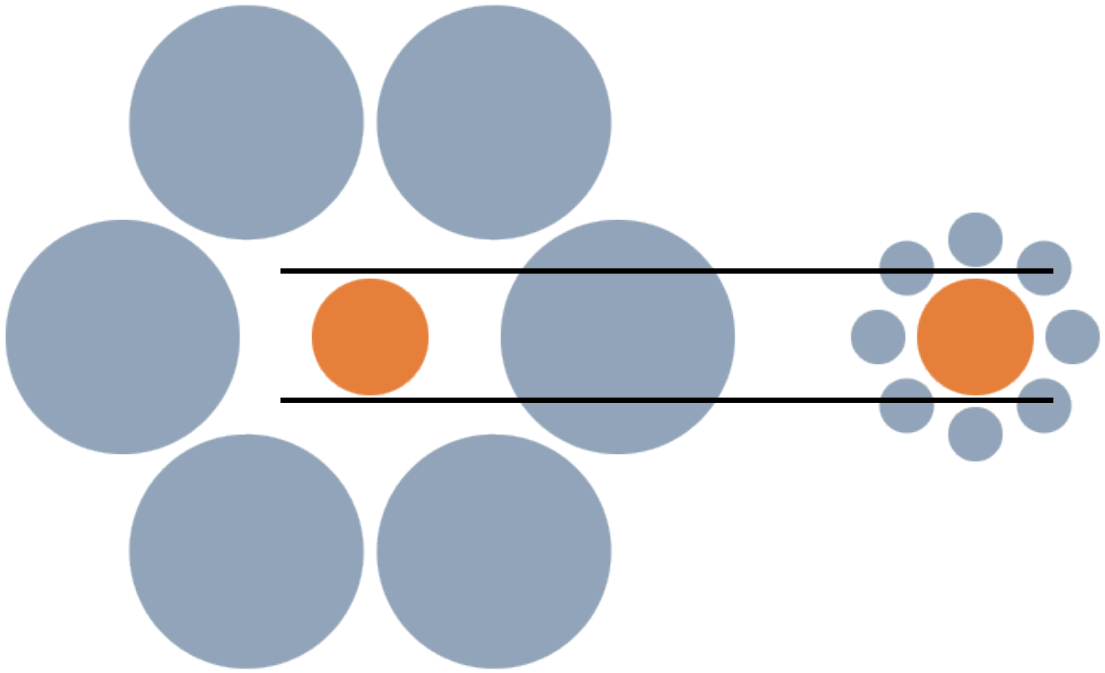

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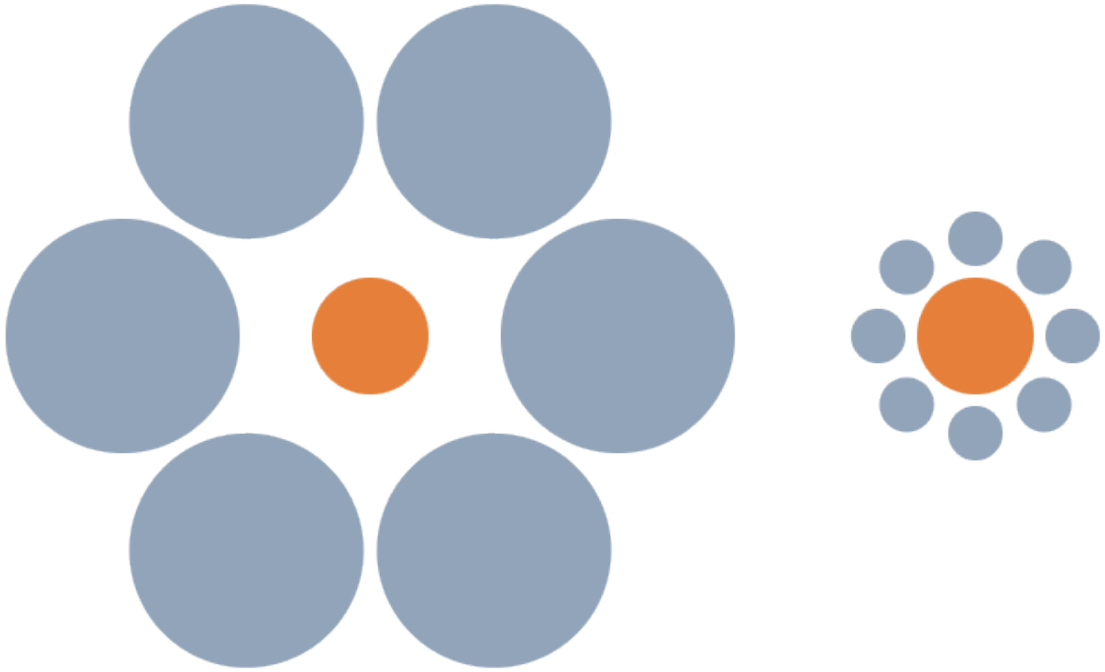

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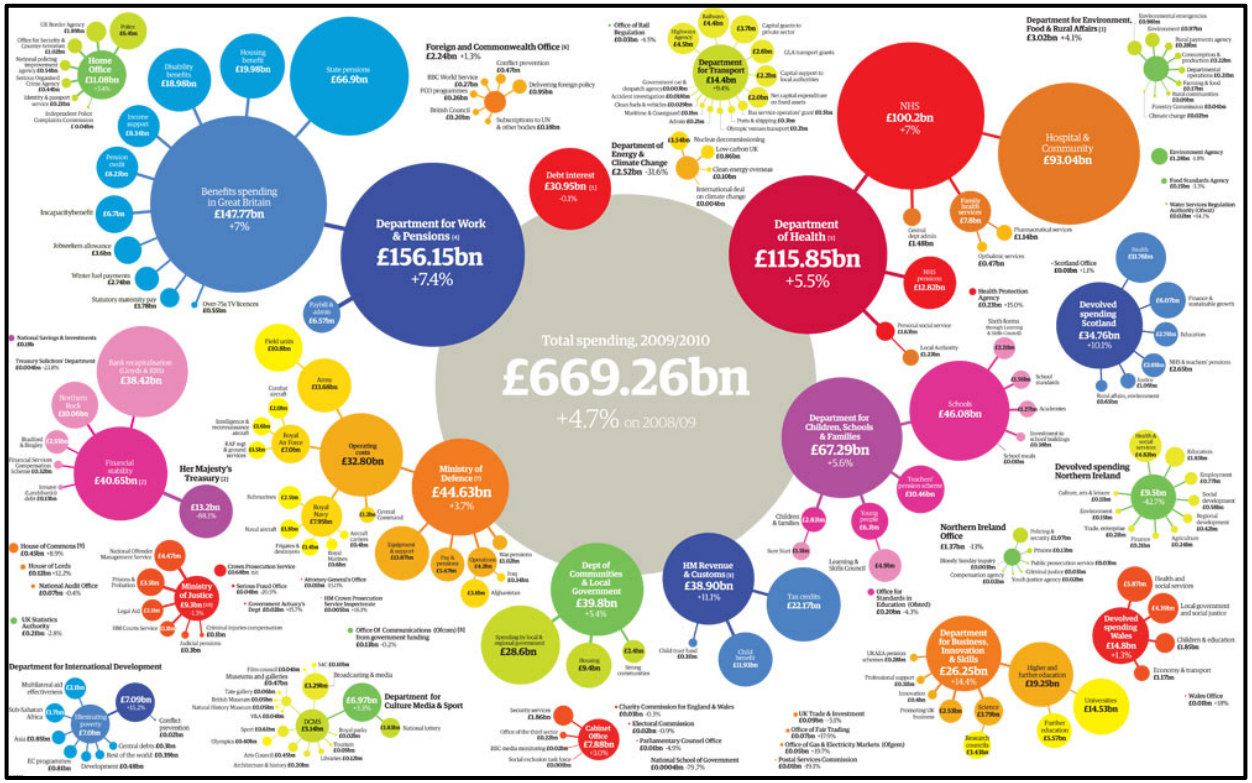
UK Government Spending Bubble Chart



http://www.theguardian.com/news/datablog/2010/oct/18/government-spending-department-2009-10

How can we visually represent values?

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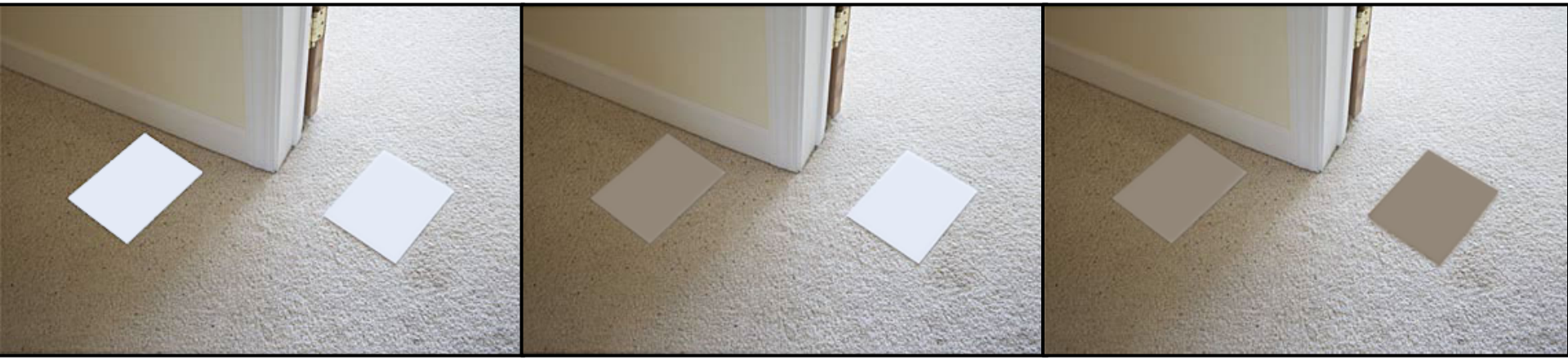
Which is brighter?
And by how much?



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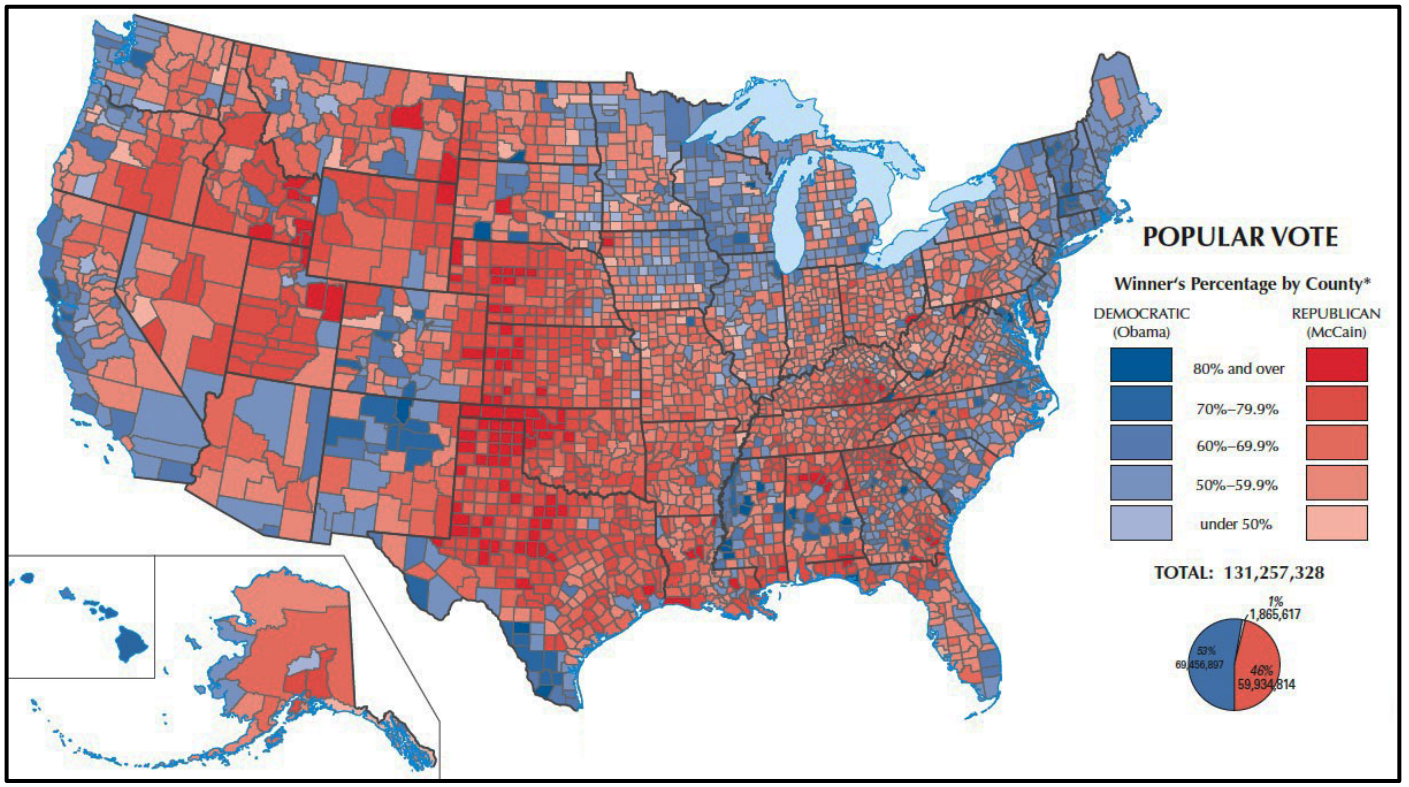
US Presidential Election Map



http://bsumaps.blogspot.co.uk/2012/11/cartographic-election-resources.html

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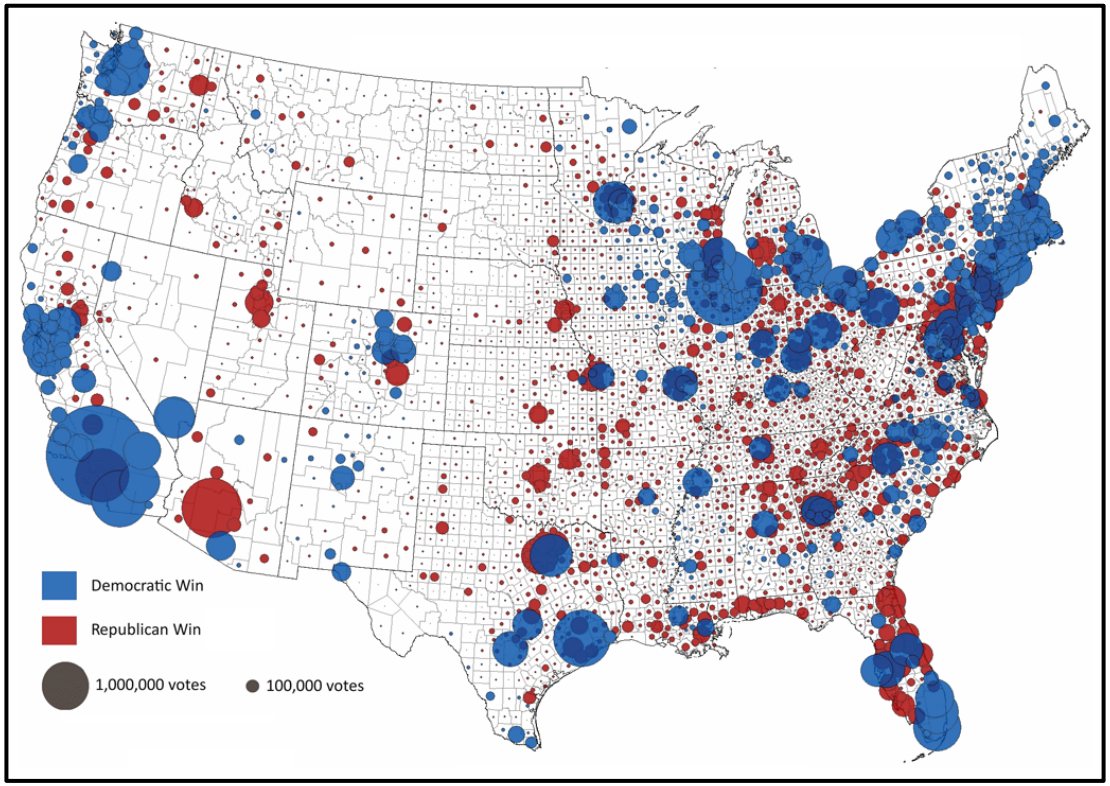
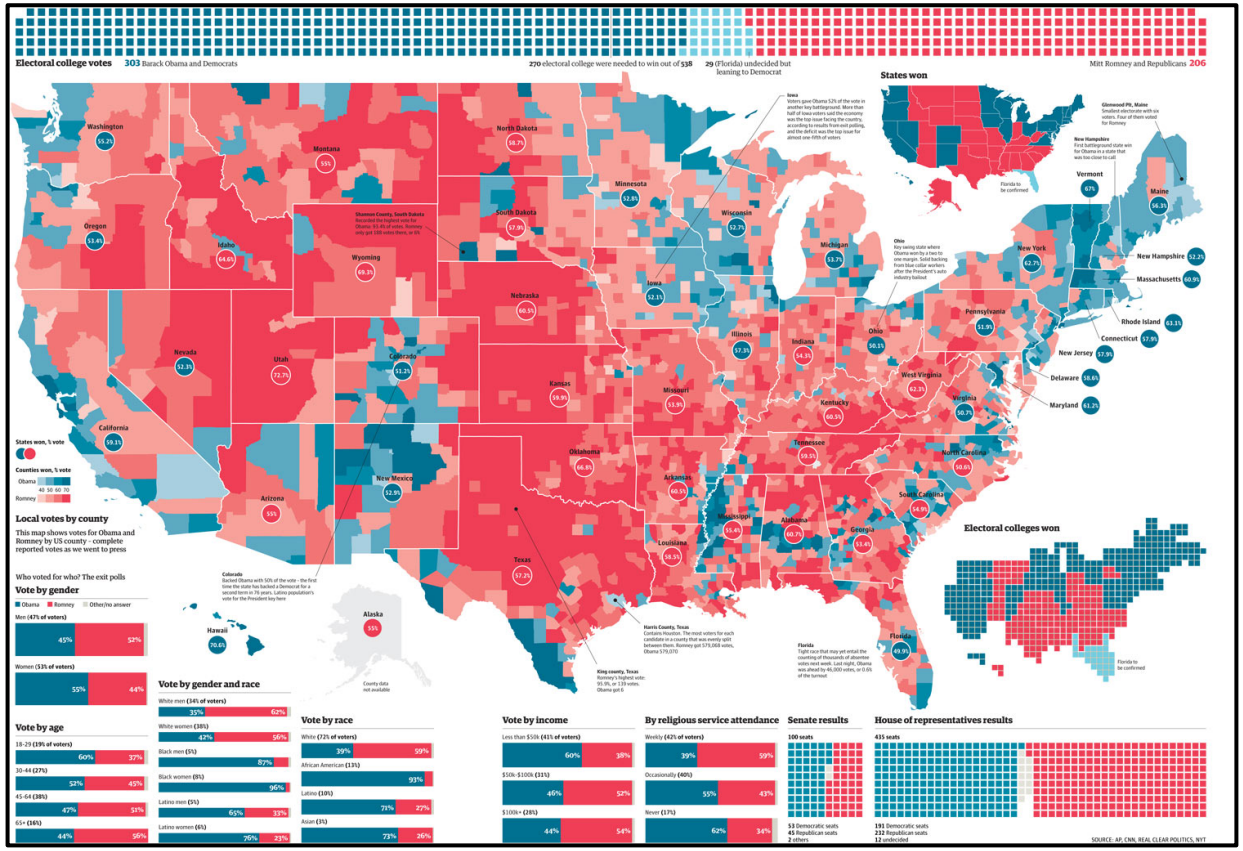


http://statchatva.org/2013/01/14/lower-turnout-in-2012-makes-the-case-for-political-realignment-in-2008/

How can we visually represent values?

Help users by labeling data and adding trend indicators.

US Presidential Election Map



http://www.theguardian.com/news/datablog/2012/nov/07/us-elections-2012-results-map

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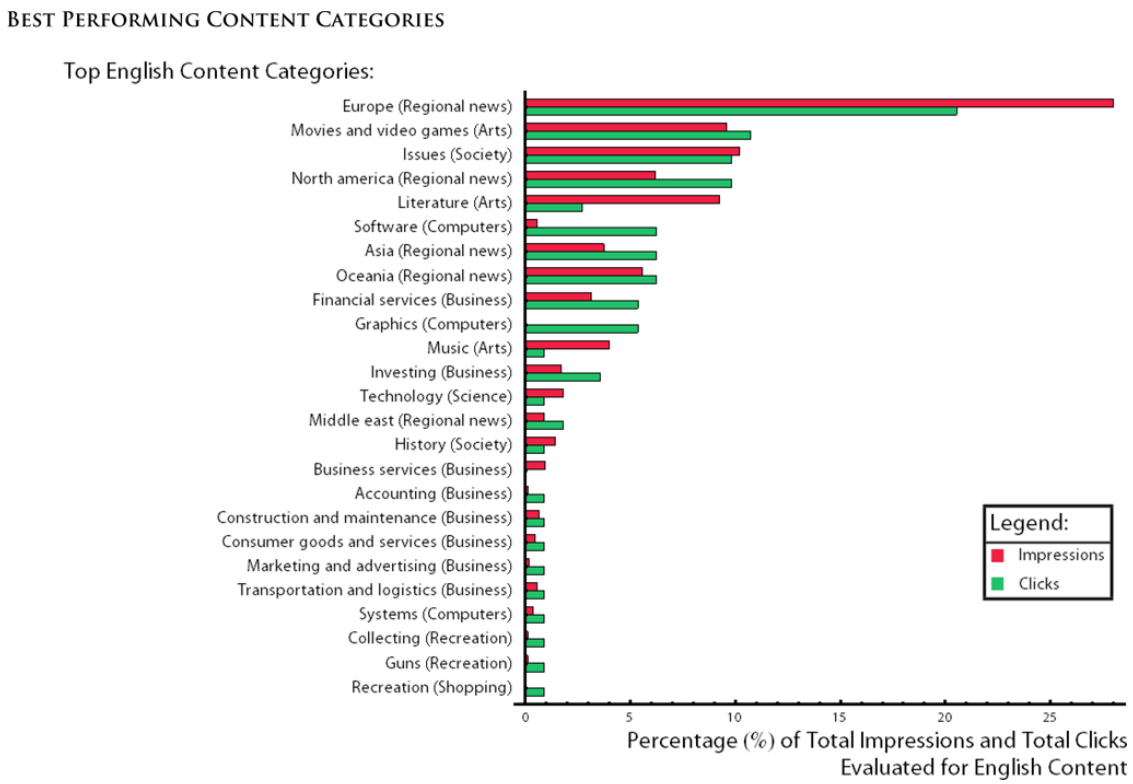
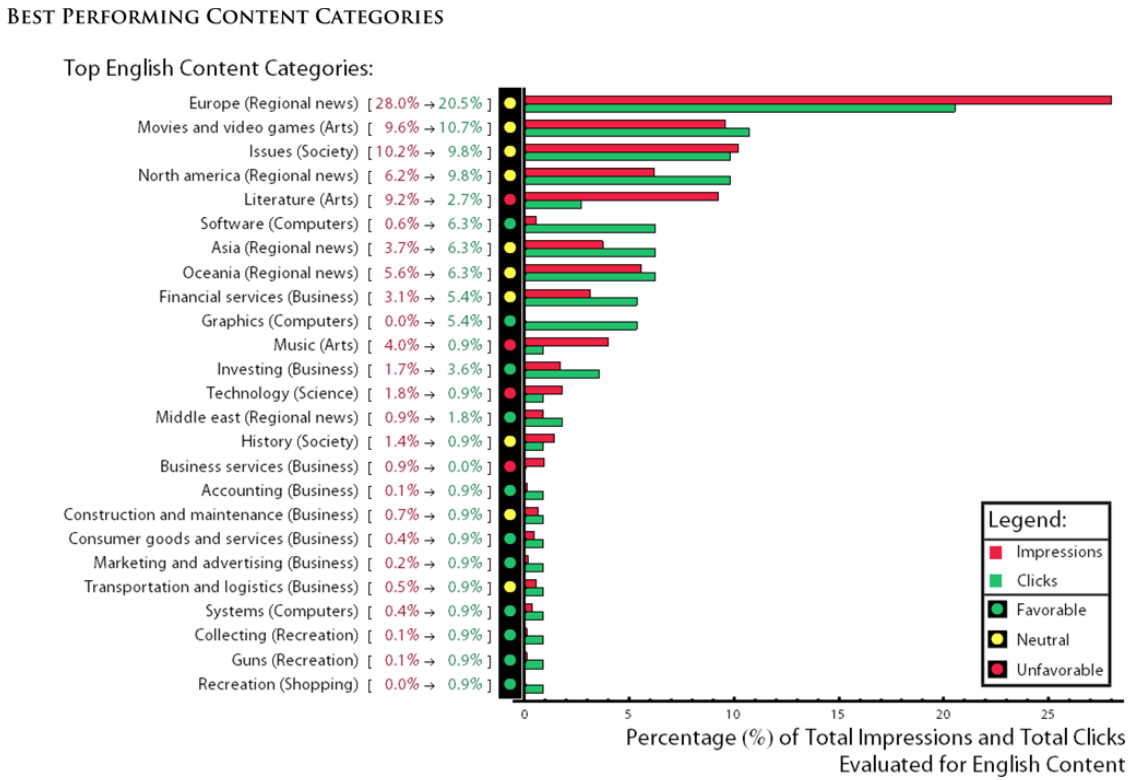
Online Ad Campaign Performance Bar Chart



How can we visually represent values?

Help users by labeling data and adding trend indicators.

Online Ad Campaign Performance
Traffic Light Bar Chart

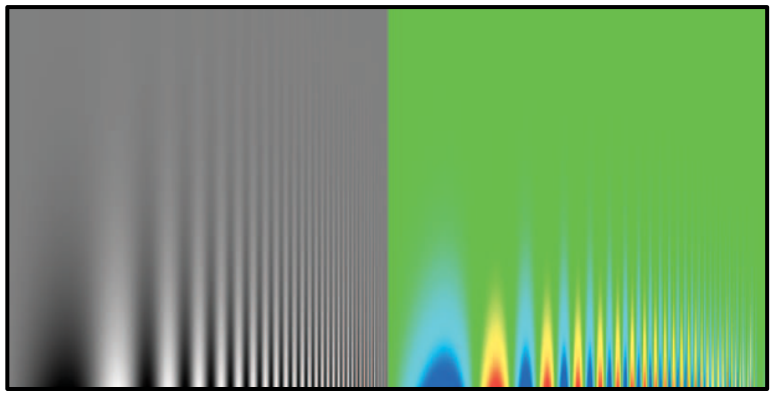


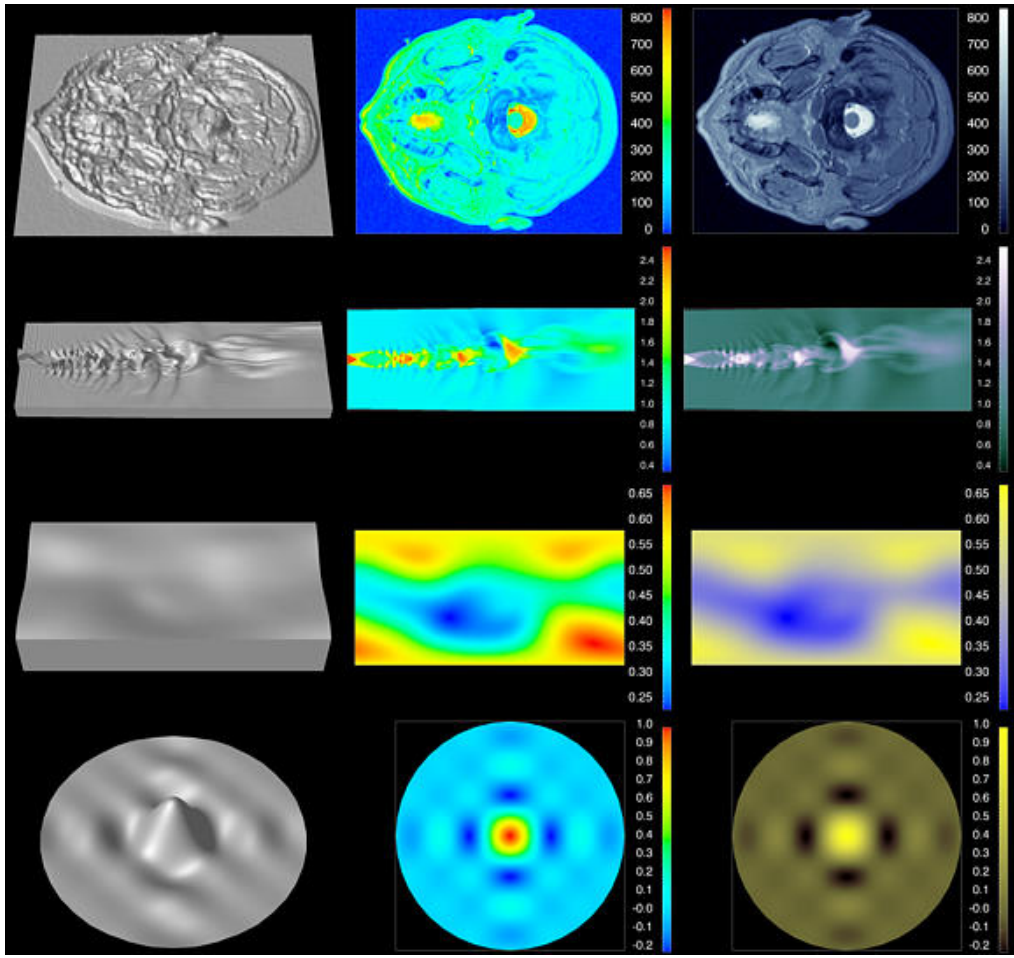
How can we visually represent values?

Perceptually uniform color gradients for continuous values.

Avoid rainbow color maps:

- Hue order is not obvious.
- Hue changes make edges.
- Yellows make highlights.
- Detail is harder to see.
- Eyes are more sensitive to brightness than hues.





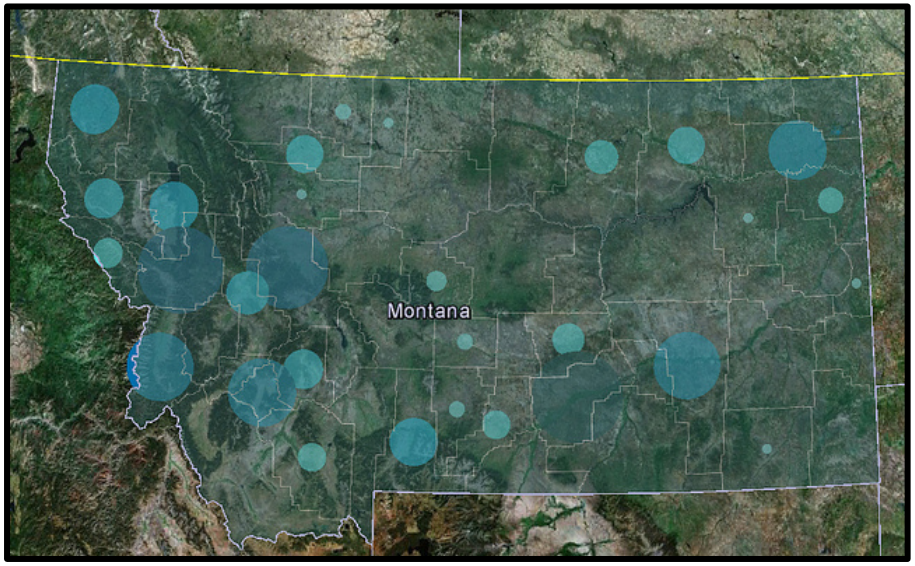
http://blog.visual.ly/rainbow-color-scales/
http://researchweb.watson.ibm.com/people/l/lloydt/color/color.HTM

How can we visually represent values?

Use transparency to overlay information layers.

- Normally transparent layers are composited using linear interpolation, an averaging operation that reduces variation.
- Blending by linear interpolation can result in reduced contrast, dull colors, detail loss, and a lack of selective emphasis.

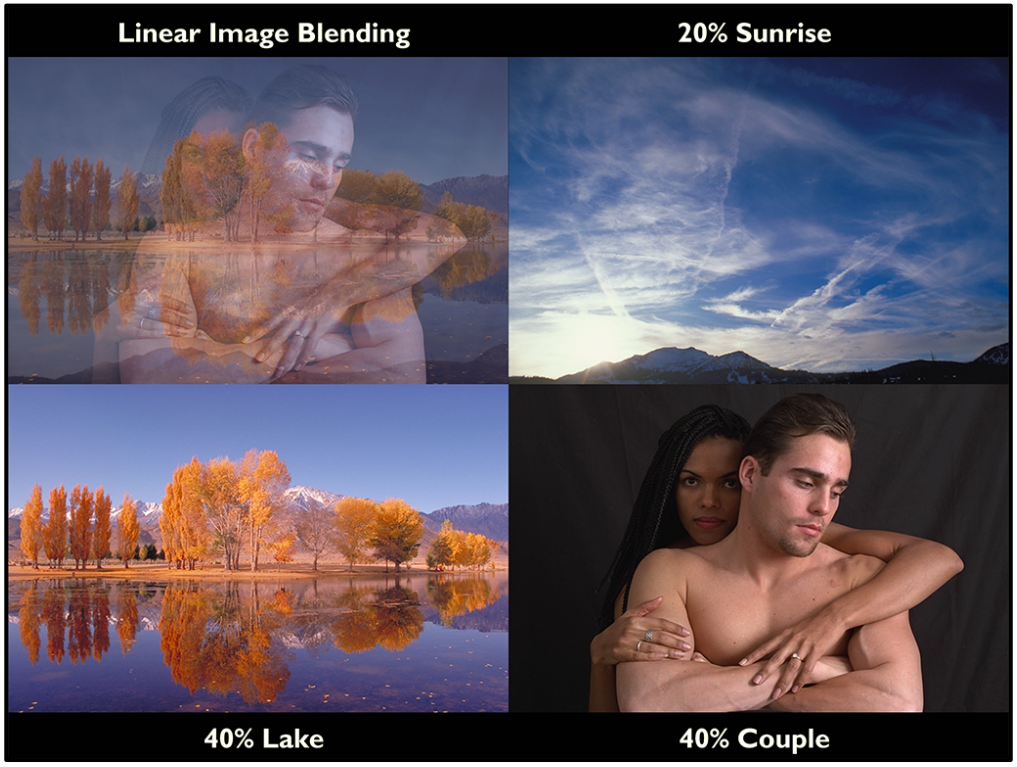
Satellite Map Overlay



How can we visually represent values?

Use transparency to overlay information layers.

- Apply image blending operators that are designed to produce composite images that preserve key visual characteristics of their components: contrast, color, detail, and salience.



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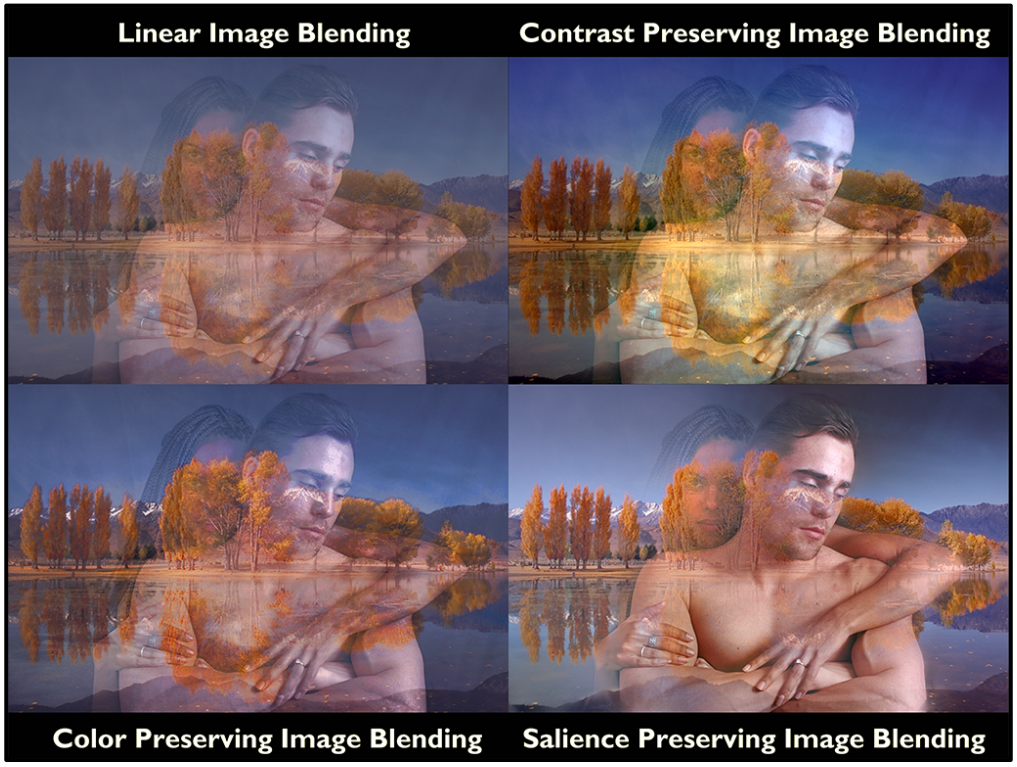


How can we visually represent values?

Use transparency to overlay information layers.

- Render the arc of each node connection in order of decreasing length using a color gradient that emphasizes short links.

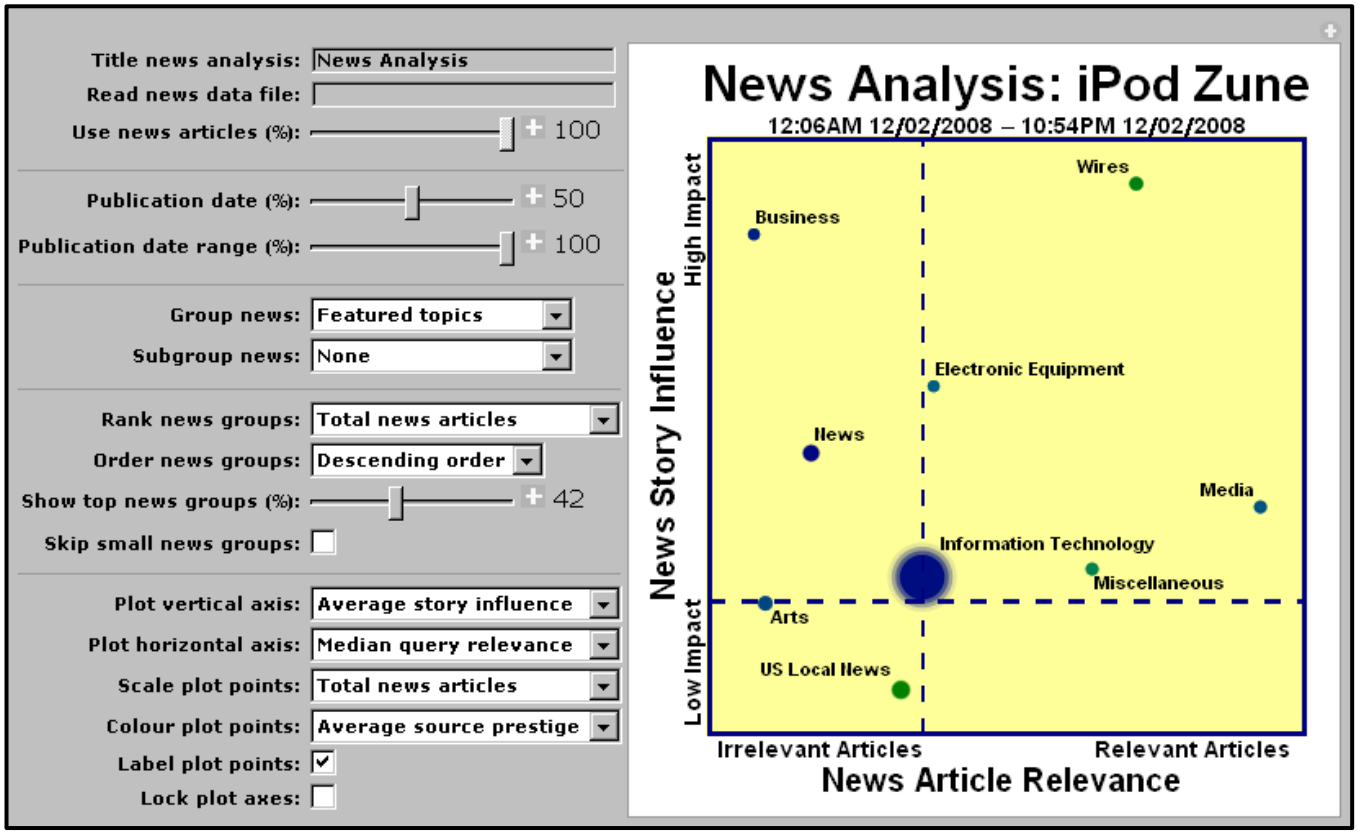
Facebook Friend Connection Map

http://paulbutler.org/archives/visualizing-facebook-friends/

How can we visually represent values?

Familiar visual metaphors make interpretation easier.

SnapShot News Analysis Tool



http://www.grapeshot.co.uk/snapshot/snapshot.html
http://www.FunctionalElegance.com

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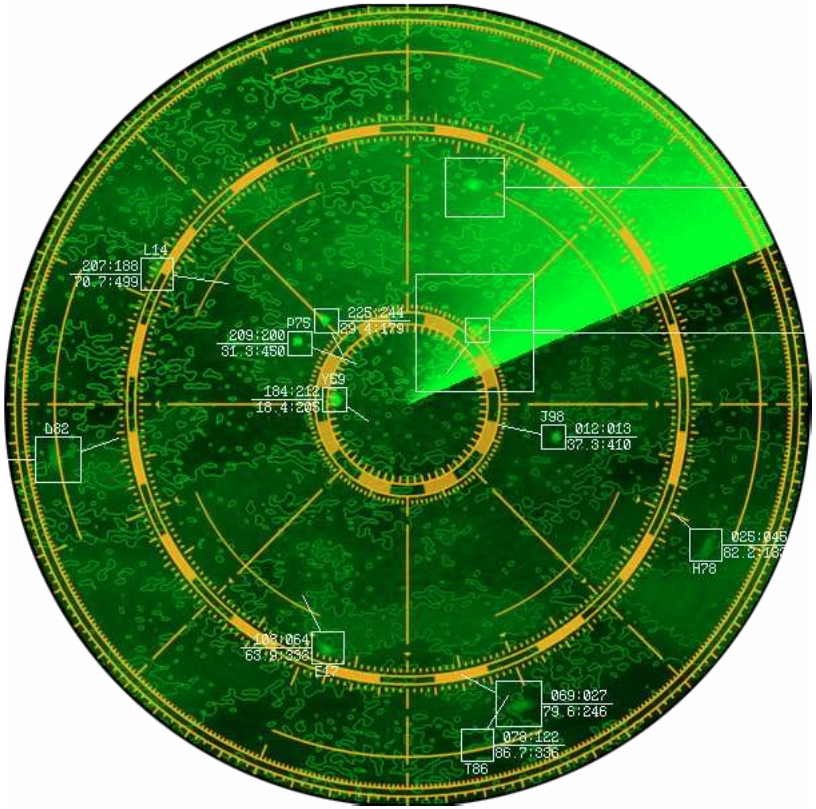
SnapShot News Radar



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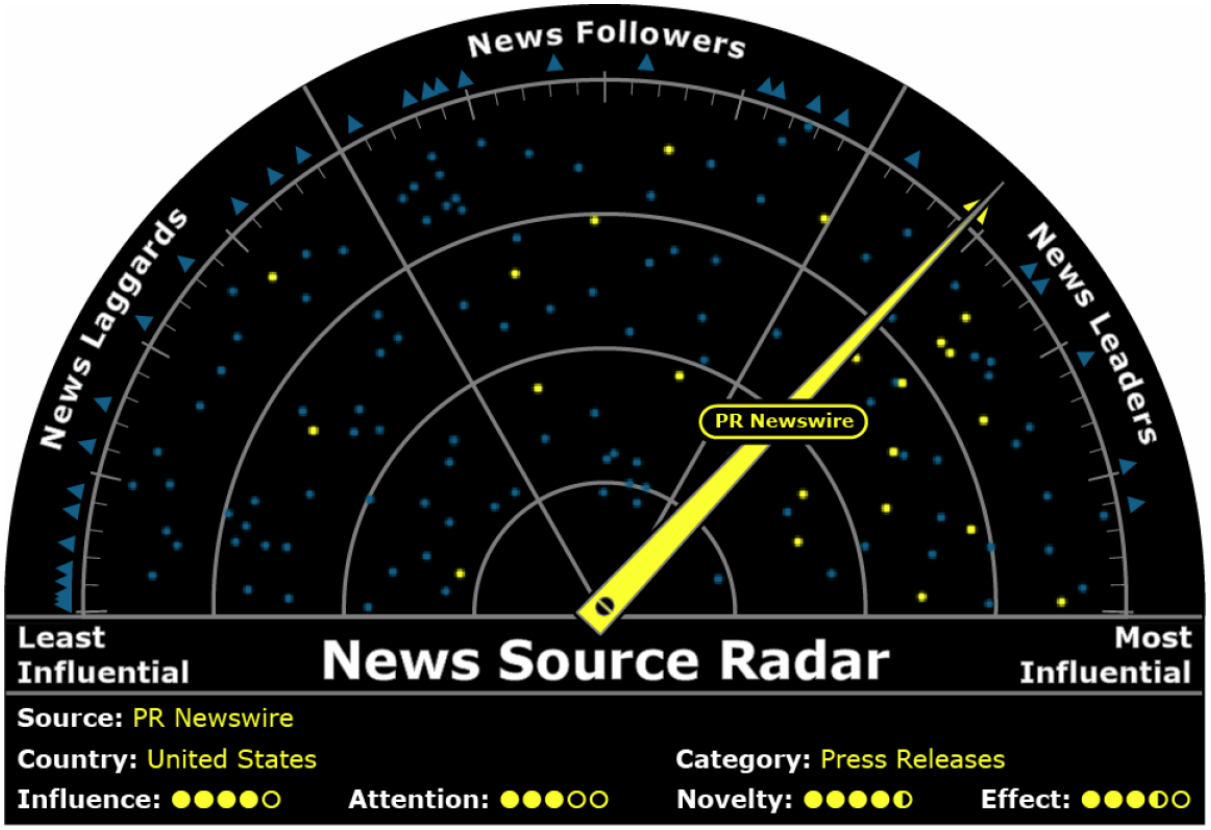

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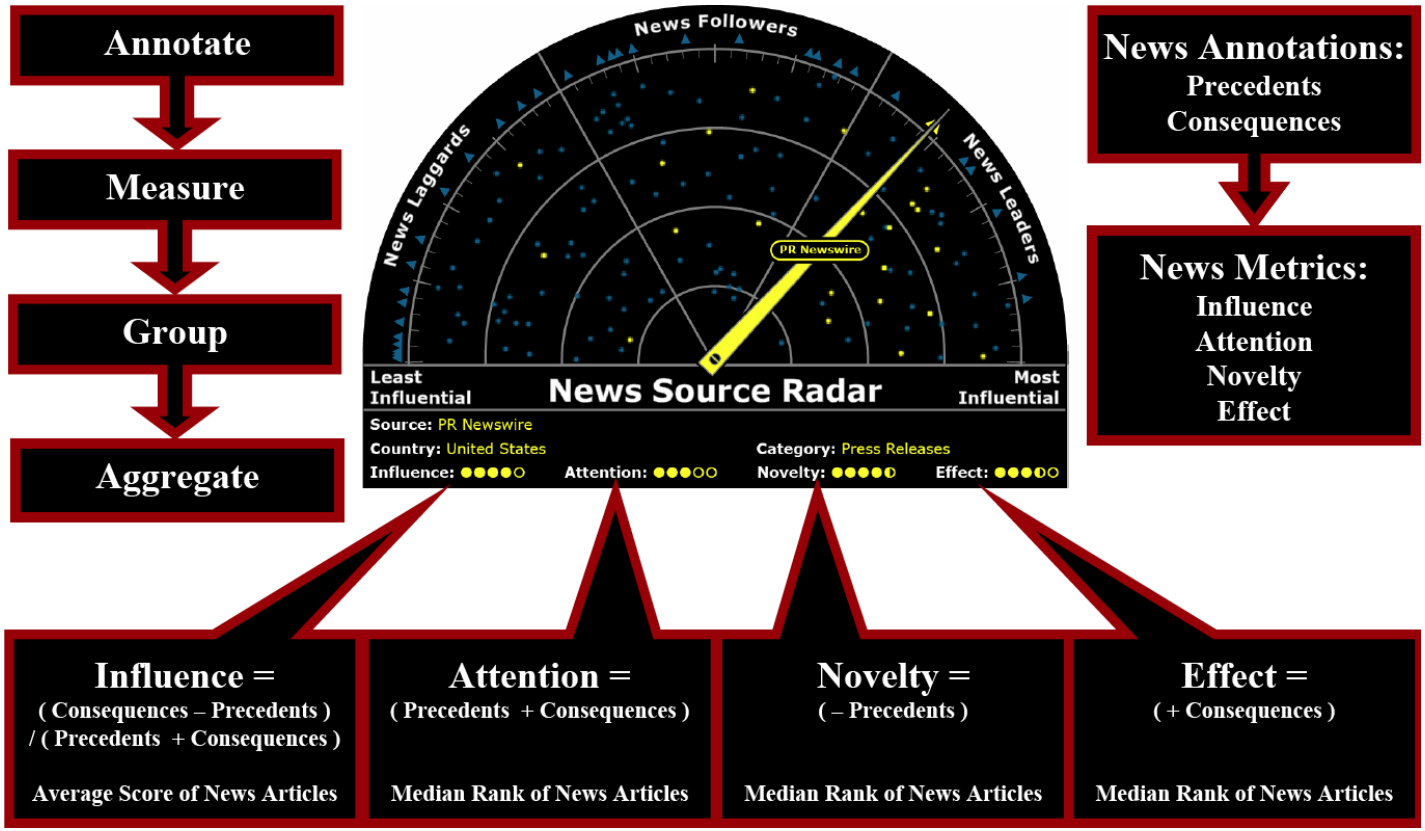


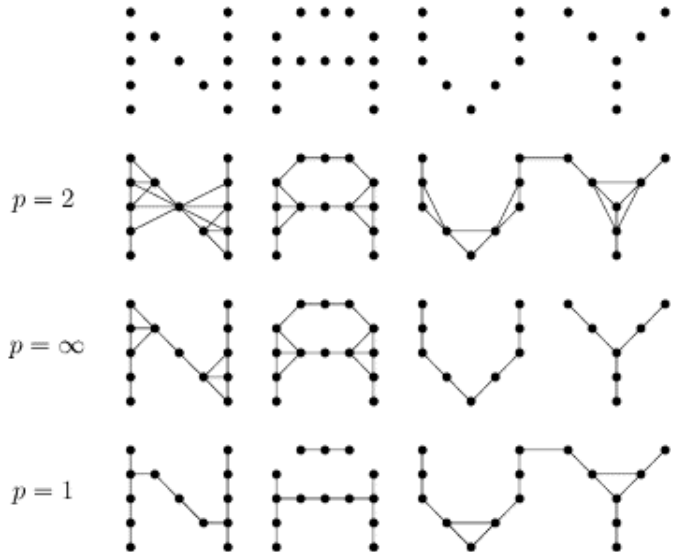
http://www.grapeshot.co.uk/snapshot/snapshot.html
http://www.FunctionalElegance.com

How can we visually represent connections?

Use proximity to find connections in a cloud of points.

- Take a sphere of influence around each point, with radius equal to its nearest neighbor distance, and connect every pair of points whose spheres of influence intersect.

Sphere of Influence Graphs
Work in R^n for any L_p Metric



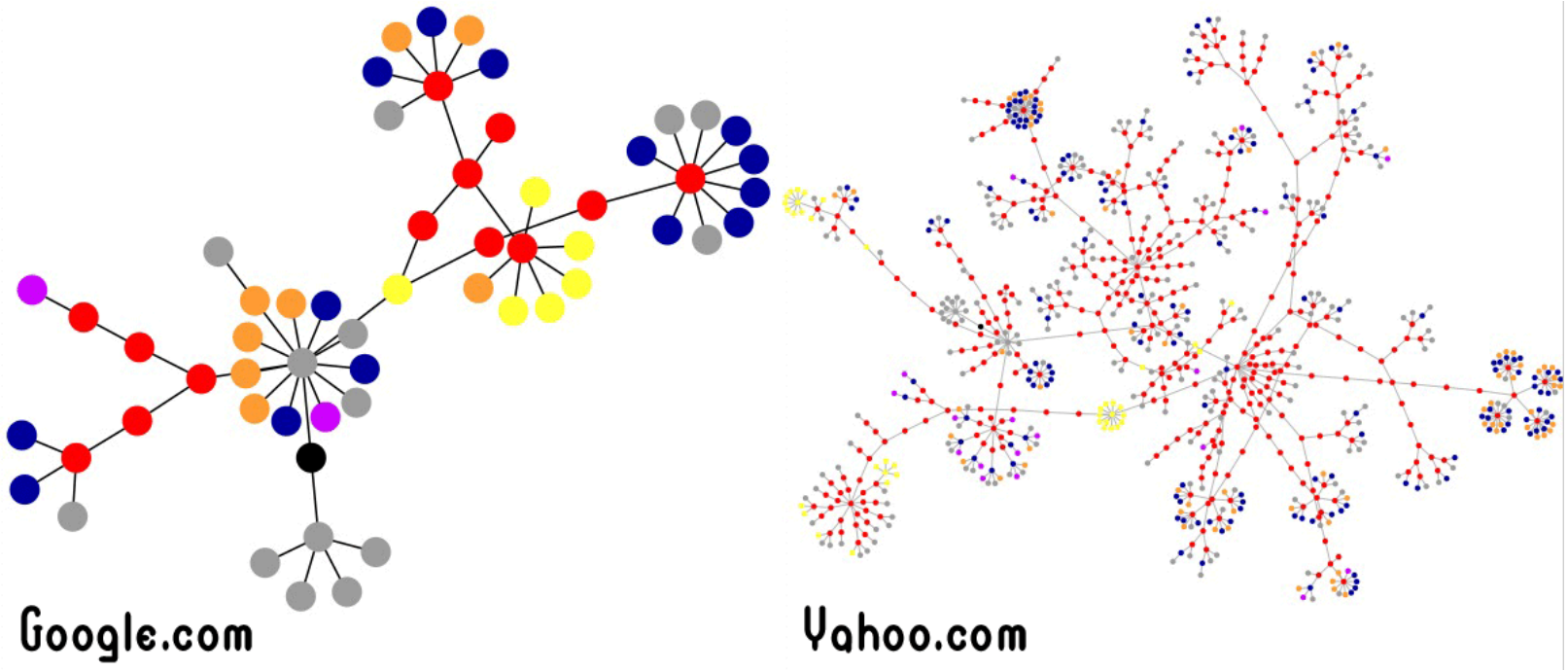
http://dx.doi.org/10.1016/S0166-218X(02)00246-9

How can we visually represent connections?

Use tree drawing to see patterns in hierarchical data.

- Coloring each node according to its data type reveals the structure of expression trees, such as XML, JSON, and HTML.

Website Home Pages as HTML Trees



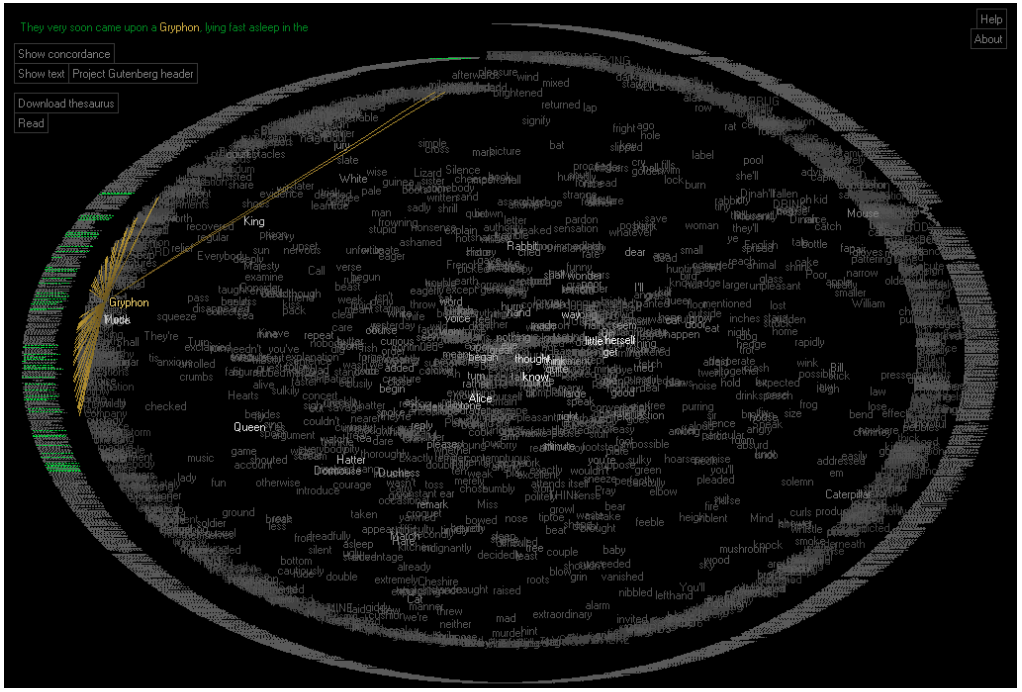
http://www.generatorx.no/20060528/websites-as-graphs/
http://www.flickr.com/photos/davezilla/155045024/

How can we visually represent connections?

Use word clouds that place their terms meaningfully.

- TextArc writes the sentences of a text along a circular arc and places each term according to its average position in the text.

"Alice in Wonderland" TextArc



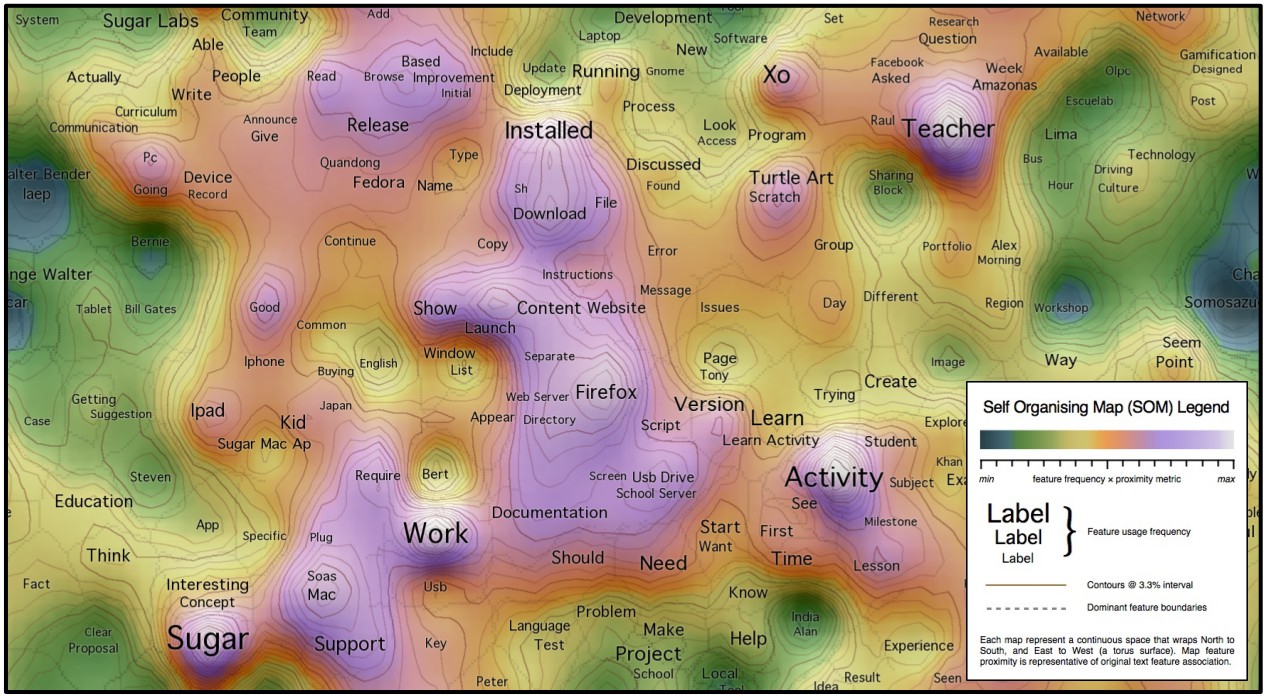
http://www.textarc.org/
http://www.nytimes.com/2002/04/15/arts/15ARTS.html

How can we visually represent connections?

Use word clouds that place their terms meaningfully.

- Self-organizing maps (SOM) are neural networks, which can create knowledge maps that cluster closely associated topics.

Self-organizing Map of a Mailing List



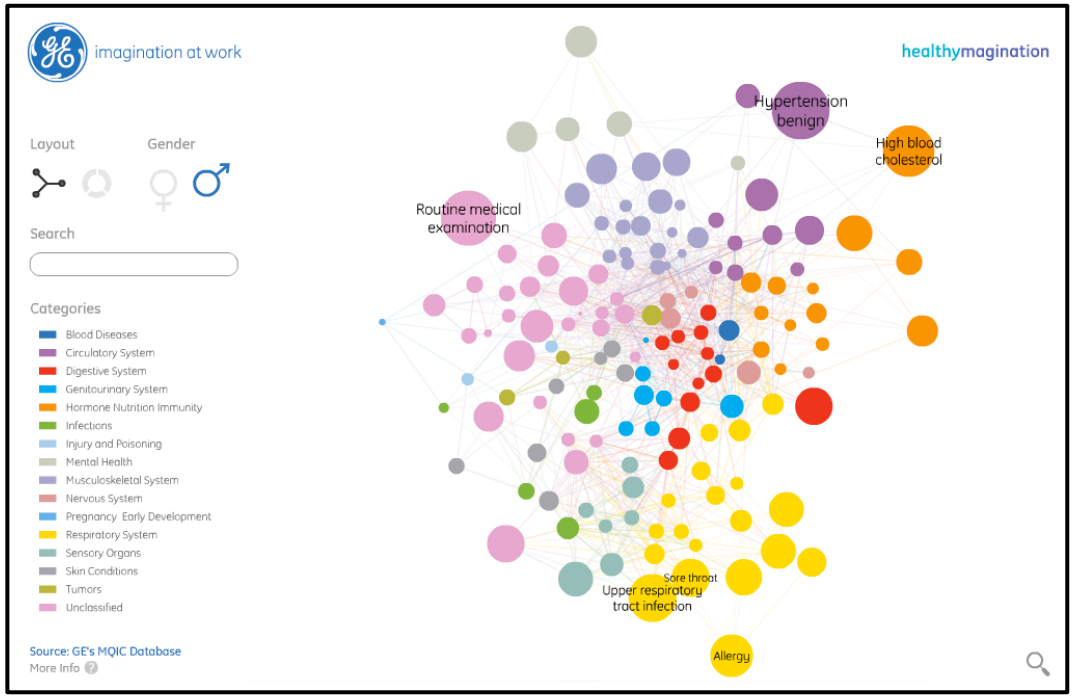
http://dx.doi.org/10.1371/journal.pone.0058779
http://wiki.sugarlabs.org/go/Sugar_Labs/SOM

How can we visually represent connections?

Use graph drawing tools to see how data is connected.

- Graph drawing algorithms, such as simulated annealing or spring systems, make it easier to follow how data is related.

Graph Drawing of Medical Knowledge



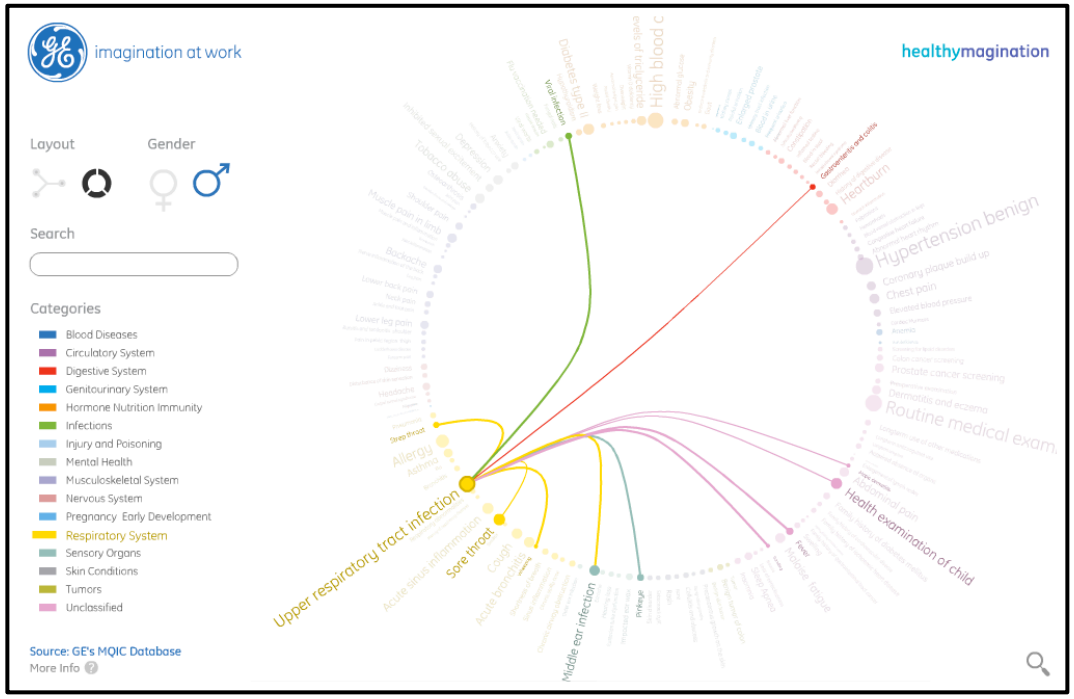
http://cs.brown.edu/~rt/gdhandbook/
http://visualization.geblogs.com/visualization/network/

How can we visually represent connections?

Use graph drawing tools to see how data is connected.

- Hierarchical edge bundles group connections belonging to related nodes, which can be placed radially along a circle.

Graph Drawing of Medical Knowledge

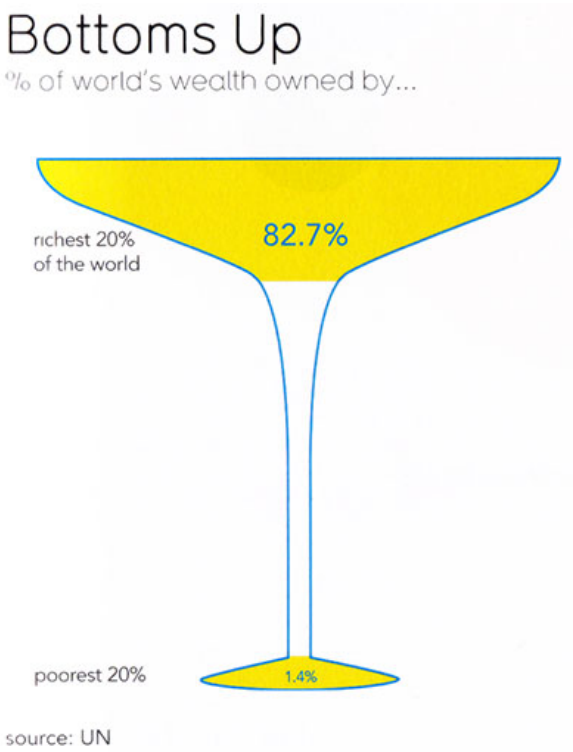


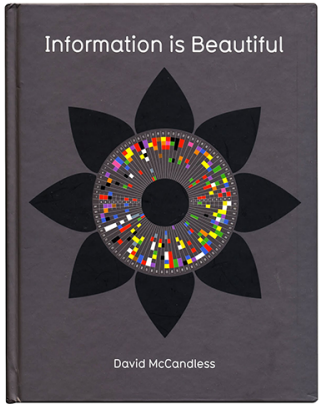
http://www.win.tue.nl/~dholten/papers/bundles_infovis.pdf
http://visualization.geblogs.com/visualization/network/

What is effective visualization design?

Communicating the message that makes a difference means more than just plotting the data.

Global Income Inequality





https://www.amazon.co.uk/Information-Beautiful-David-McCandless/dp/0007294662
http://hdr.undp.org/sites/default/files/reports/221/hdr_1992_en_complete_nostats.pdf

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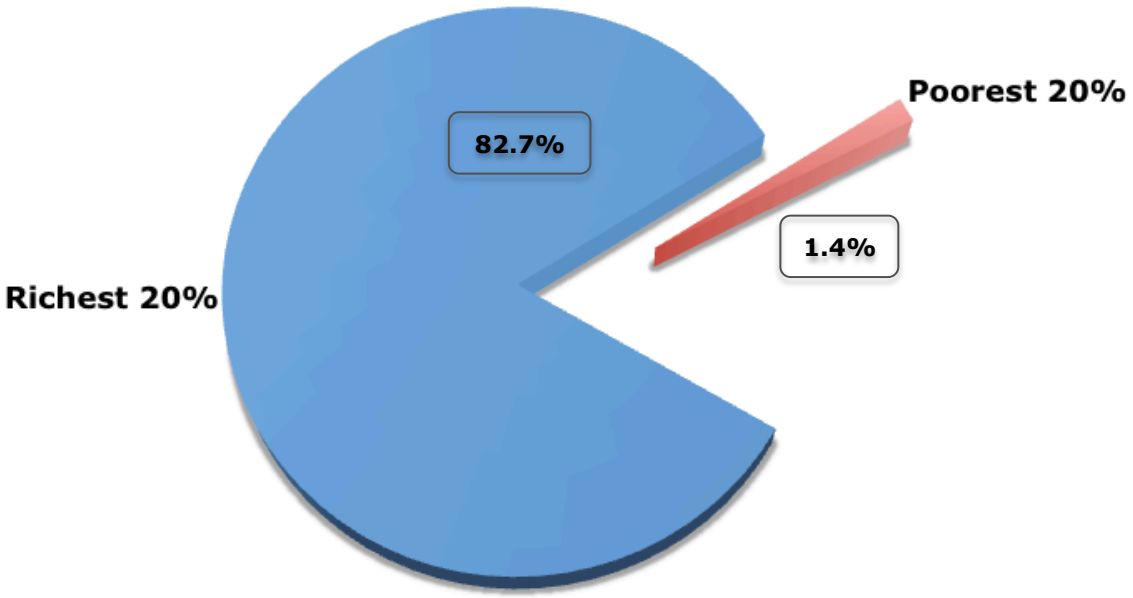

Share of Global Income Going to
the Richest 20% and Poorest 20% of the World's Population

https://www.office.com/
http://hdr.undp.org/sites/default/files/reports/221/hdr_1992_en_complete_nostats.pdf

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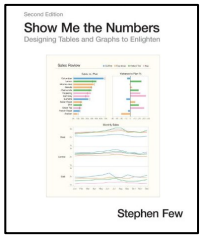

https://www.amazon.co.uk/Show-Me-Numbers-Stephen-Few/dp/0970601972
http://hdr.undp.org/sites/default/files/reports/221/hdr_1992_en_complete_nostats.pdf

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Global Income Inequality

THE HUFFINGTON POST

https://www.huffingtonpost.co.uk/entry/hunger-photo-series_n_6297410
http://hdr.undp.org/sites/default/files/reports/221/hdr_1992_en_complete_nostats.pdf

Artwork by Roman Cieslewicz

**The richest 20%
own more than 80%
of the world's income.**

**The poorest 20%
own less than 2%
of the world's income.**

Is that right?

What is the secret to great information visualization design?

Start with the user, not the data and not the graphic.

- What will this allow you to do that you can't do now?
- What difference can you observe in your business?
- What value do you expect that this will add to your business?
- What will this let your customers do that they can't do now?
- What difference can your customers observe in their business?
- What value can your customers expect that this will add?
- How does this fit in with your other strategic plans?
- How will you know that this has been a success?
- How will you build on this success?
- So what?

What does the future hold for information visualization?

In an information economy, there is no shortage of information; only understanding is in short supply.

- Will interactive charts become more common as letting people play with the data drives engagement?
- Will subtly animated infographics become more common as graphic designers compete for attention?
- Will augmented reality glasses superimpose an information visualization layer on our everyday lives?
- Will cheap displays make ambient visualization ubiquitous?
- Will virtual reality and gesture interfaces have an impact?

Let me know!

Mark@FunctionalElegance.com

Online information visualization resources

Thank you for making this presentation possible!

Visualization Galleries:

- **Tree Visualizations (Hans-Jörg Schulz):** http://vcg.informatik.uni-rostock.de/~hs162/treeposter/poster.html
- **Time Series Visualizations (Christian Tominski & Wolfgang Aigner):** http://survey.timeviz.net/
- **Visual Complexity (Manuel Lima):** http://www.visualcomplexity.com/vc/
- **D3 JavaScript Visualization Library:** https://github.com/mbostock/d3/wiki/Gallery
- **WebdesignerDepot.com Examples (Cameron Chapman):** http://bit.ly/1nYR89L

Visualization Courses:

- **University of Utah (Miriah Meyer):** http://www.sci.utah.edu/~miriah/cs6964/
- **University of British Columbia (Tamara Munzner):** http://www.cs.ubc.ca/~tmm/courses/533-09/
- **University of California Berkeley (Michael Porath):** http://blogs.ischool.berkeley.edu/i247s13/
- **University of Washington (Jeffrey Heer):** https://courses.cs.washington.edu/courses/cse512/14wi/
- **Georgia Institute of Technology (John Stasko):** http://www.cc.gatech.edu/~stasko/7450/syllabus.html

Visualization Tutorials:

- **Storytelling with Data (Jonathan Corum):** http://style.org/tapestry/
- **Visualization Analysis and Design (Tamara Munzner):** http://www.cs.ubc.ca/~tmm/courses/533-11/book/
- **Principles of Information Visualization (Jessie Kennedy):** http://mkweb.bcgsc.ca/vizbi/2012/
- **Information Visualization for Knowledge Discovery (Ben Shneiderman):** http://bit.ly/1cw3oa2
- **Data Visualization Best Practices (Jen Underwood):** http://www.slideshare.net/idigdata/
- **Data Visualization (Jan Willem Tulp):** http://www.slideshare.net/janwillemtulp/
- **Information Visualization Primer (Xavier Tricoche):** https://www.cs.purdue.edu/homes/cs530/new/slides/Infovis.pdf
- **Visual Techniques for Exploring Databases (Daniel A. Keim):** http://www.dbs.informatik.uni-muenchen.de/~daniel/KDD97.pdf

Visualization Sites:

- **Perceptual Edge (Stephen Few):** http://www.perceptualedge.com/
- **Envisioning Information (Edward Tufte):** http://www.edwardtufte.com/tufte/
- **Information is Beautiful (David McCandless):** http://www.informationisbeautiful.net/
- **Information Aesthetics (Andrew Vande Moere):** http://infosthetics.com/
- **Flowing Data (Nathan Yau):** http://flowingdata.com/learning/