

Varieties of information visualization

Michael Friendly
Psych 6135

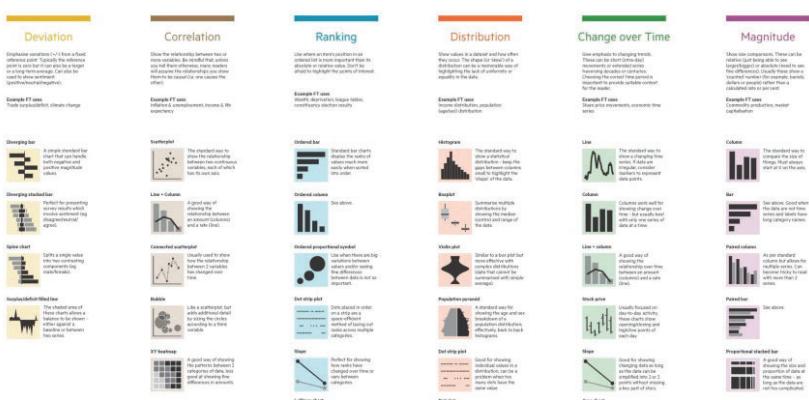


<https://friendly.github.io/6135>

@datvisFriendly

Classify by: ???

For purposes of “What kind of graph should I use?” usually most useful to think:
“What do I want to show?”

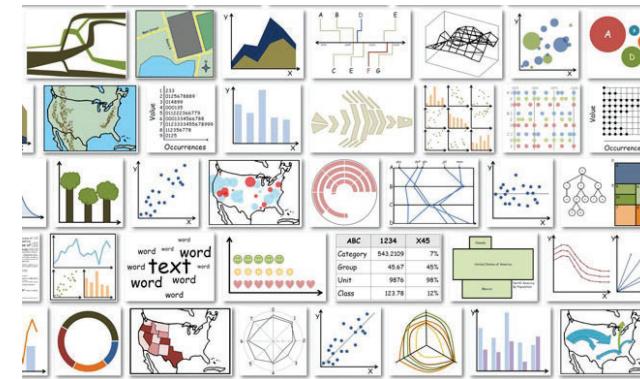


Financial Times, Chart Doctor, <https://github.com/ft-interactive/chart-doctor>

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So many types

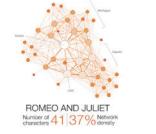
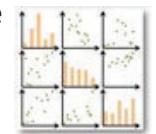
There are so many kinds of charts, diagrams, graphs, maps
What are their features?
What tasks are they good for? – Accuracy or speed of judgment? Memorability?



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Topics, by graph type

- Statistical data graphs
 - 1D: dotplot, boxplot, violin plot
 - 1.5D: time-series plot, density plot, bar chart, pie chart
 - 2D: scatterplot, ridgeline plot
 - 3D: contour plot, 3D scatterplot, surface plot
- Thematic maps
 - Choropleth map
 - Anamorphic map
 - Flow maps
- Network & tree visualization
- Animation & interactive graphics



ROMEON AND JULIET

Number of characters 4137% density

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What are dimensions

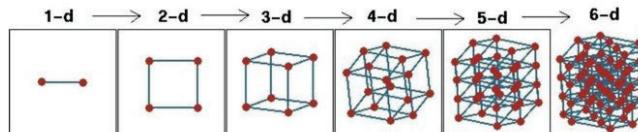


Fig credit: Di Cook [@visnut](#)

1 D
1.5 D
2 D
3 D
 n D ?

Data graphs can be classified by the number of variables, dimensions shown in a given graph

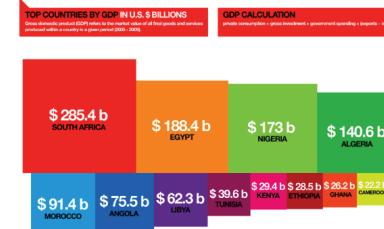
Data graphs

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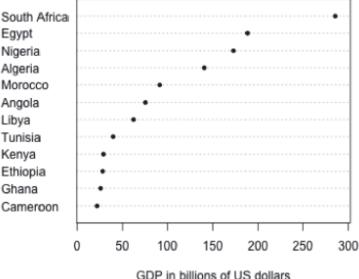
1D: Infographic vs. Data graphic

The same data can be shown in different forms, for different purposes

African Countries by GDP



African Countries by GDP



One might argue that this infographic has greater impact in showing the relative size of GDP

One might argue that this statistical graph makes comparisons easier

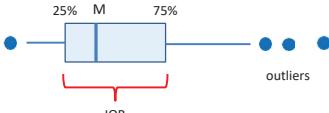
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1.5D: Dotplots & boxplots

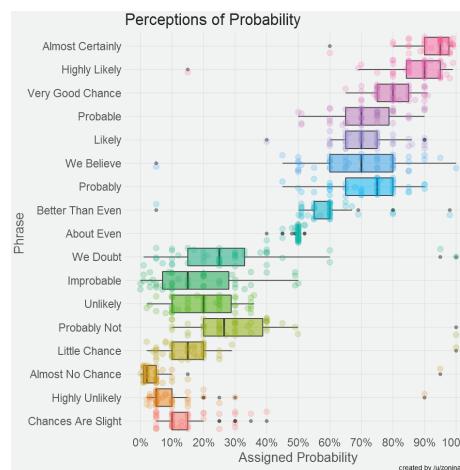
What number do you give to a probability phrase?

Boxplots summarize the important characteristics of a univariate data distribution:

- center (median)
- spread (IQR)
- shape (symmetric? skewed?)
- outliers?



This example overlays the boxplot with a jittered dotplot, so we can also see the individual observations



This visualization made the longlist for the 2015 Kantar Information is beautiful award. Data & R code:
<https://github.com/zonination/perceptions>

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1.5D: Density ridgeline plots

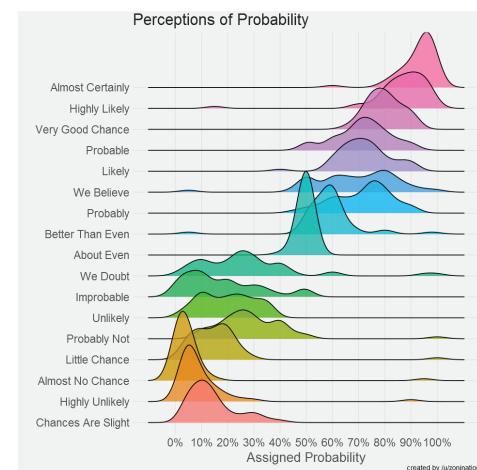
Another possible 1D display is a **density estimate**—a statistically smoothed histogram.

For comparing a set of them, a ridgeline plot stacks them vertically to create the impression of a mountain range.

As in the boxplot version, this uses:

- a progressive scale of colors
- transparent colors to handle overlap

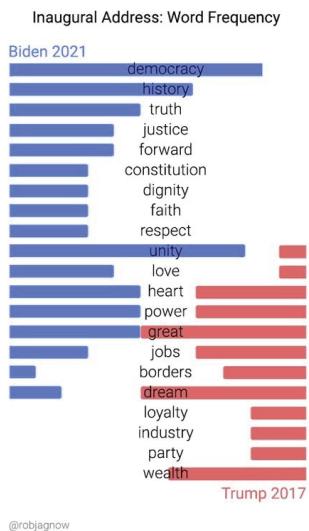
Q: What features stand out here?



Software note: These figures are drawn with R, using ggplot2 and the ggridges package. See:
<https://cran.r-project.org/web/packages/ggridges/vignettes/introduction.html>

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1.5D: Text bar charts



- Text can be analyzed as data also, most often in frequency counts.
- This chart uses a novel design to compare the most frequent words by Biden (2021) & Trump (2017) in their inaugural addresses.
- The contrast is striking!
 - democracy, unity vs. great, dream

From:
https://www.reddit.com/r/dataisbeautiful/comments/l7k0f0/us_inauguration_address_word_frequency_biden_vs/

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1.5D: Time series line graphs

William Playfair (1786), *The Commercial and Political Atlas*, invented the time series line graph as a way to show data on England's trade with other countries

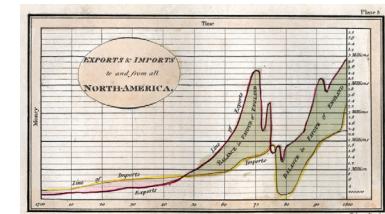
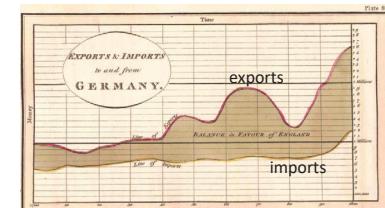
One curve for imports, one for exports

The **balance of trade** could be seen as the difference between the curves

Trade with Germany was consistently in favor of England

With North America, the balance changed back and forth over time

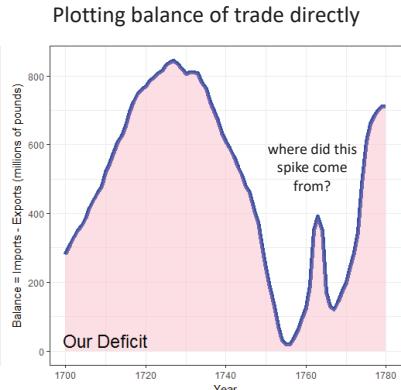
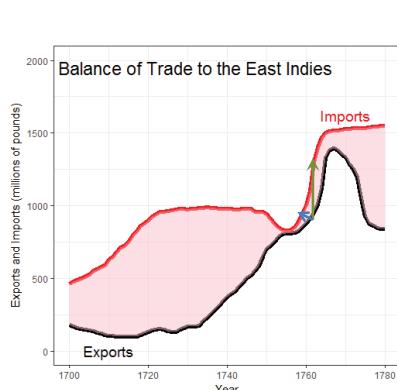
Economic 'history' could now be visualized and explained



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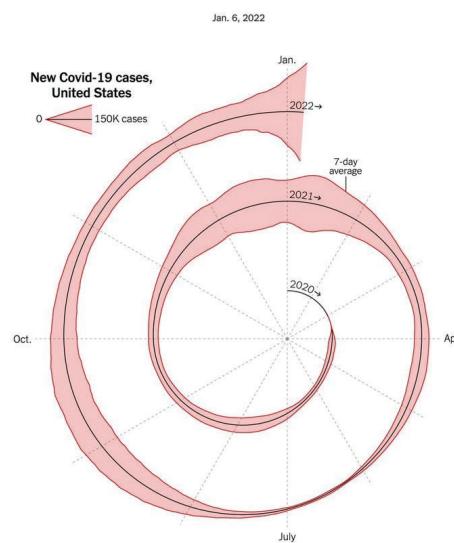
Psychology: Distances between curves

What Playfair didn't know is that judgments of **distance** between curves are **biased**. We tend to see the **perpendicular** distance rather than the **vertical** distance



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The New York Times



1.5 D COVID spiral graph

This graph shows a 1.5 D time series of COVID-19 cases over the entire span of the pandemic

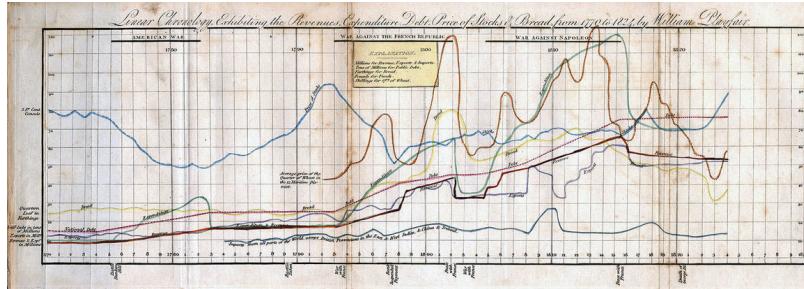
It is wrapped into a spiral to compare months over years.

Does this work for you, or is it too weird?

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Multiple time series graphs

Things get messy when there are many series to be compared
To be fair, this was designed as [timeline of history](#)—a visual story of economics. It was Playfair's last graph. History shown as a [strip-chart recording](#) (e.g., EKG)

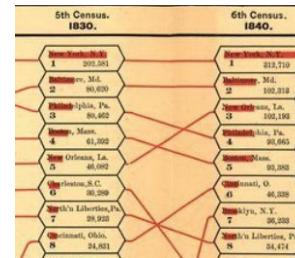


Playfair, W. (1824) *Chronology of Public Events and Remarkable Occurrences*.

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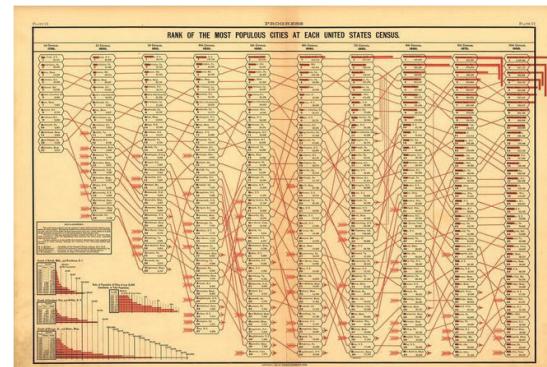
Parallel ranked list charts

Another solution for multiple time series is to chart the [ranks](#) of observations and connect them with lines to show changes in relative position.



Slopes of lines reflect change in rank

Red bars try to show the numbers



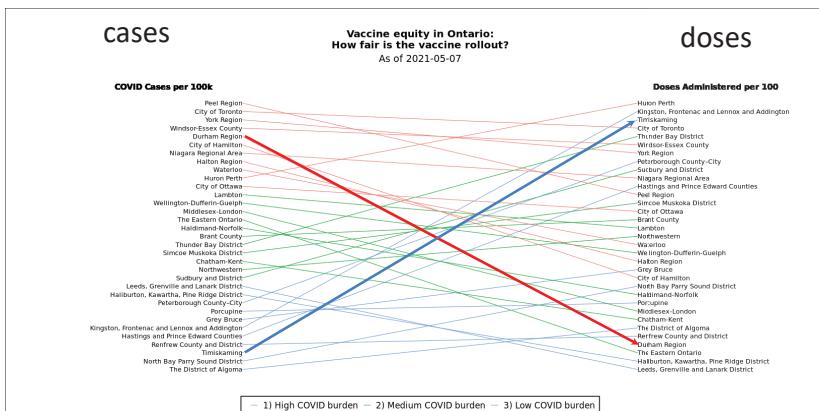
From: *Statistical Atlas of the United States (1880)*

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COVID: Cases vs. Doses

Vaccine equity → all lines should be ≈ flat

Which health regions stand out?
How could this graph be better?



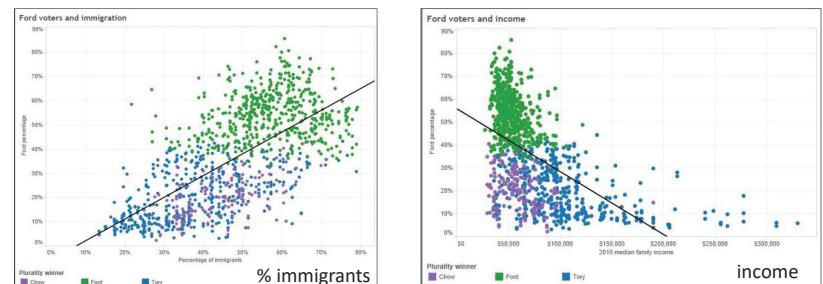
Graphic by Matthew Dubins, @MDubins

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2D: Scatterplots: Ford Nation



Who voted for Rob Ford in the 2014 Toronto mayoral election?



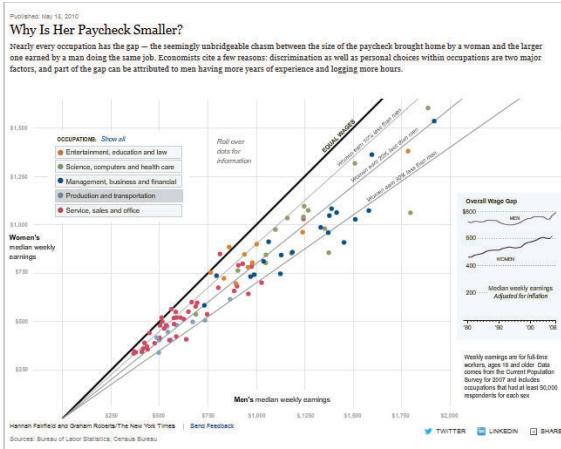
These simple scatterplots by data journalist Patrick Cain use simple enhancements:

- Color, for candidate (Chow, Ford, Tory)
- Overall regression line

Source: <https://globalnews.ca/news/1652571/ford-nation-2014-15-things-demographics-tell-us-about-toronto-voters/>

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Scatterplots: Wage gap



How to compare salaries of men & women in different occupations?

The NYT chose to plot median salaries for women against those for men, in different occupational groups

The 45° line represents wage parity
Other lines show 10, 20, 30% less for women

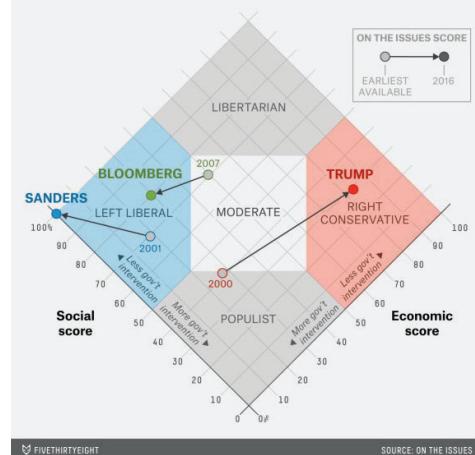
How else to show this?

Alberto Cairo, *The Truthful Art*, Fig 9.19, from:
http://www.nytimes.com/interactive/2009/03/01/business/20090301_WageGap.html

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Scatterplots: InfoVis

Candidates abandoning the middle ground
Earliest available and current OnTheIssues score for Bernie Sanders, Donald Trump and Michael Bloomberg



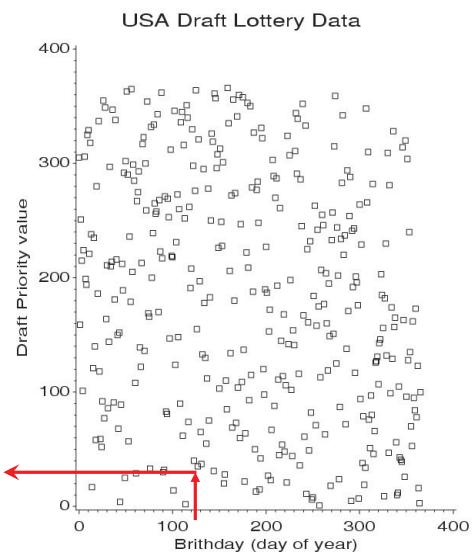
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Scatterplots: Annotations enhance perception

Data from the US draft lottery, 1970

- Birth dates were drawn at random to assign a “draft priority value” (1=bad)
- Can you see any pattern or trend?

This is an example of data with a weak signal and a lot of noise

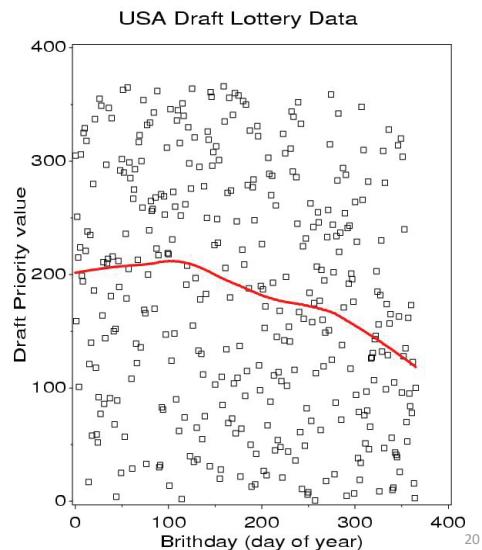


Scatterplots: Smoothing enhances perception

Drawing a smooth curve shows a systematic decrease toward the end of the year.

- The smooth curve is fit by **loess**, a form of non-parametric regression.

Visual explanation:



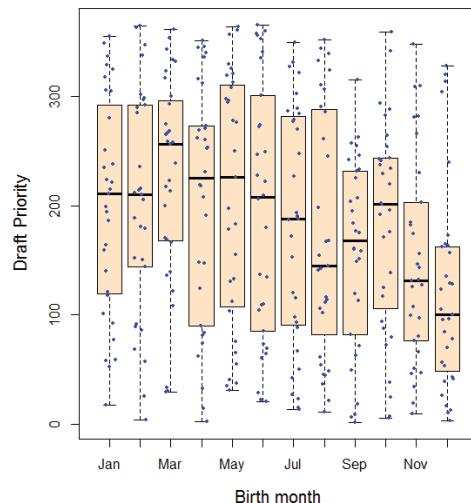
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Smoothing by grouping and summarization

Another form of smoothing is to make one variable discrete & show a graphical summary – here a boxplot

The decrease in later months becomes apparent

Perception: the boxplots form the foreground; the jittered points show the data



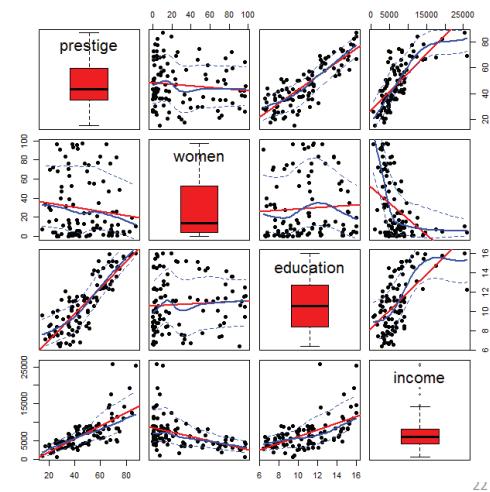
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Scatterplot matrices

A scatterplot matrix shows the bivariate relation between all pairs of variables. Seeing these all together is more useful than a collection of separate plots.

How does occupational prestige depend on %women, education and income?

The individual plots are enhanced with linear regression lines and non-parametric smoothes to show non-linearity



This figure uses scatterplotMatrix() in the [car](#) package. There are many options.

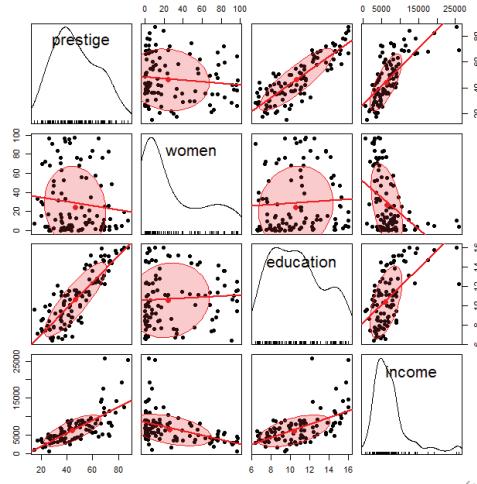
Scatterplot matrices

Density plots are often more useful for showing the shapes of distributions

- women: bimodal
- income: highly skewed

A data ellipse gives a visual summary of the direction and strength of the relationship

Again, graphical annotation provides aids for interpretation.



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Larger data sets

Scatterplot matrices hold up reasonably well with a larger number of variables

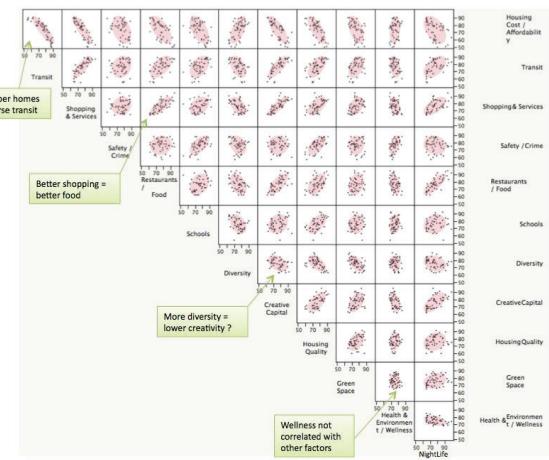
Where to live in NYC?

This SPM shows 12 variables on ~60 neighborhoods

The data ellipses provide a visual summary

I call this visual thinning – reducing details in a larger picture

In an interactive display we can zoom in/out



From: http://junkcharts.typepad.com/junk_charts/2010/06/the-scatterplot-matrix-a-great-tool.html

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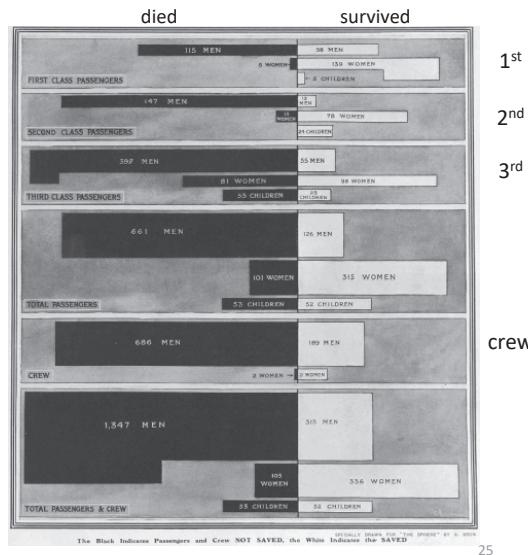
Categorical data

This remarkable chart shows survival on the *Titanic*, by Class for passengers and Gender and Age.

It was drawn by G. Bron, a graphic artist, and published in *The Sphere*, one month after the *Titanic* sank.

It uses back-to-back bar charts, with area ~ frequency

See our web page:
<http://datavis.ca/papers/titanic/>



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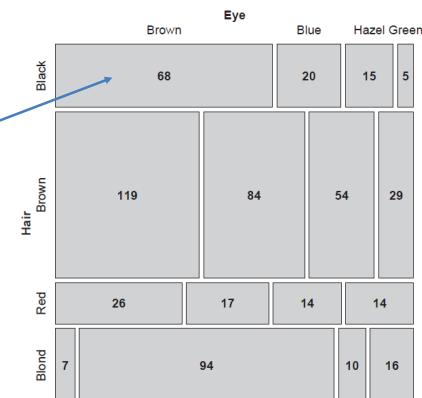
Categorical data: Mosaic plots

Similar to a grouped bar chart
 Shows a frequency table with tiles,
 area ~ frequency

```
> data(HairEyeColor)
> HEC <- margin.table(HairEyeColor, 1:2)
> HEC
   Eye
Hair  Brown  Blue Hazel Green
Black   68    20   15    5
Brown  119    84   54   29
Red    26    17   14   14
Blond   7    94   10   16
> chisq.test(HEC)

Pearson's Chi-squared test

data: HEC
X-squared = 140, df = 9, p-value <2e-16
```



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Mosaic plots

Shade each tile in relation to the contribution to the Pearson χ^2 statistic

$$\chi^2 = \sum r_{ij}^2 = \sum \frac{(o_{ij} - e_{ij})^2}{e_{ij}}$$

```
> round(residuals(chisq.test(HEC)), 2)
   Eye
Hair  Brown  Blue Hazel Green
Black   4.4   -3.1   -0.5   -2
Brown  1.2   -1.9   1.4   -0.3
Red    -0.1   -1.7   0.9   2.3
Blond  -5.9     7   -2.2   0.6
```

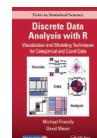


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Mosaic plots extend readily to 3-way + tables

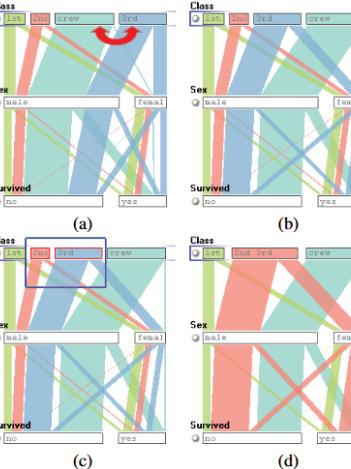
They are intimately connected with loglinear models

See: Friendly & Meyer (2016), Discrete Data Analysis with R



Parallel Sets

Titanic data: Who survived?



From: Kosara et al. (2006), https://kosara.net/papers/2006/Kosara_TVCG_2006.pdf

Parallel sets use **parallel coordinate** axes to show the relations among categorical variables.

The frequencies of one variable (Class) are sub-divided according to the joint frequencies in the next (Sex) and shown by the width of the connecting line.

The ParSets application is interactive:

- categories can be reordered (a, b)
- categories can be grouped (c, d)

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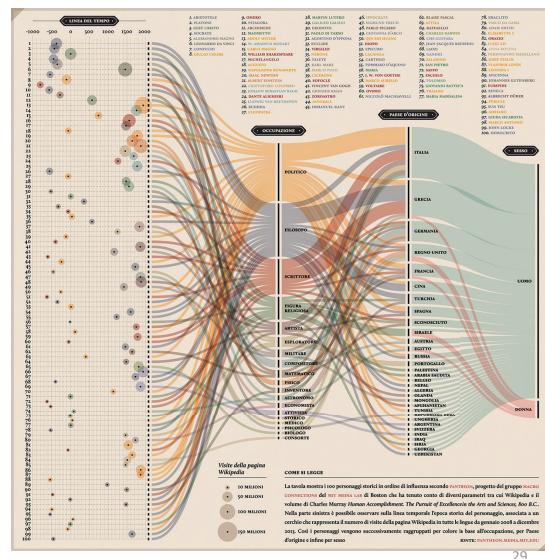
Sankey diagram

Pantheon, by Valerio Pellegrini

Visualizing the 100 most influential figures in History (Wikipedia visits)

Columns show occupation,
country of origin and
gender

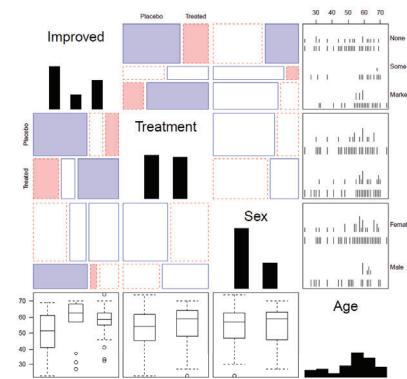
Flow lines link individuals to the column variables, width ~ influence



Generalized pairs plots

Generalized pairs plots from the [gpairs](#) package handle both categorical (**C**) and quantitative (**Q**) variables in sensible ways.

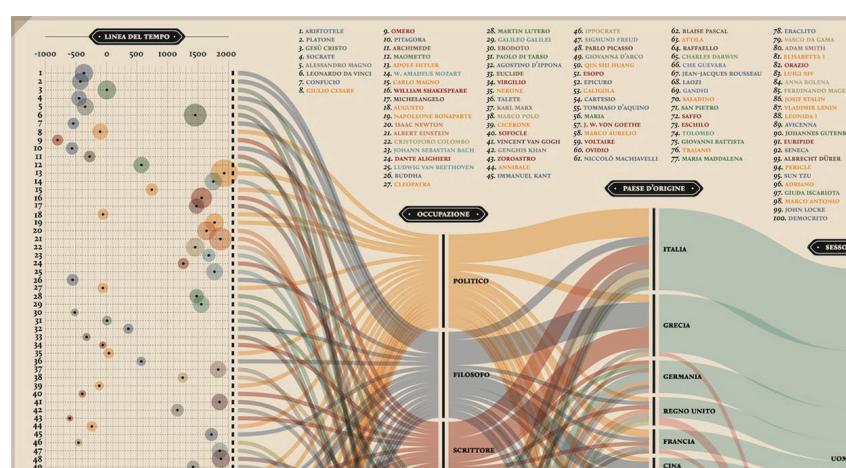
x	y	plot
Q	Q	scatterplot
C	Q	boxplot
Q	C	barcode
C	C	mosaic



```
library(gpairs)
data(Arthritis)
gpairs(Arthritis[, c(5, 2:5)], ...)
```

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Sankey diagram



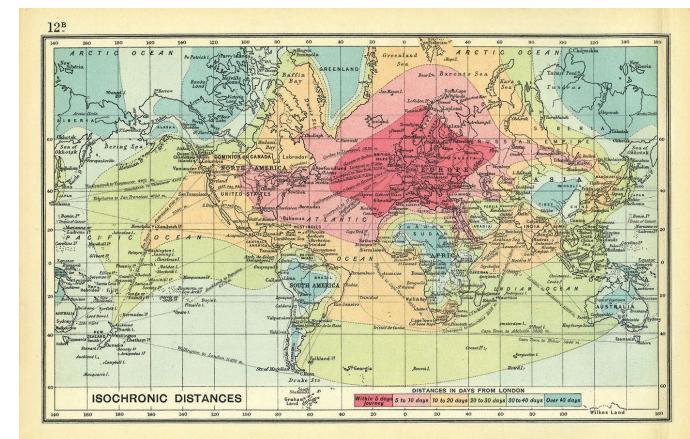
Multiple dimensions of the most influential people in history

From: <http://visualoop.com/blog/83382/pantheon-by-valerio-pellegrini>

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3D: Iso-contour maps

Early attempts to show 3D data used **contours of equal value** on a map
The data was actually very thin; the contours the result of imaginative smoothing

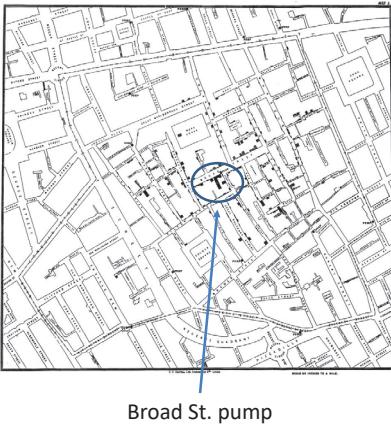


Francis Galton, *Isochronic chart of travel time*, 1881

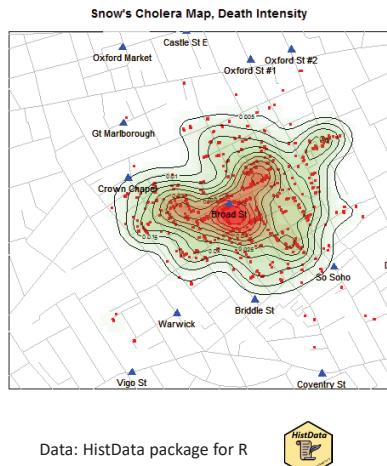
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3D: Bivariate density estimation

John Snow's map of cholera deaths in London, 1854



Modern statistical techniques can compute contours of constant density



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3D: population pyramid

Italian demographer Luigi Perozzo (1880) develops the first true 3D diagram showing the population of Sweden over years and age groups as a 3D surface

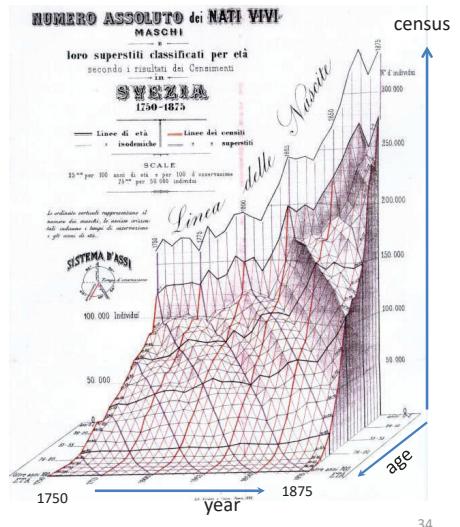
Census counts for a given **year** are shown by the red lines

Survival of a given **age** are shown by black lines

Cohorts are shown by lines down & to the right

These 3 variables are primary in demography.

A mystery here: what caused the decline at the upper right?



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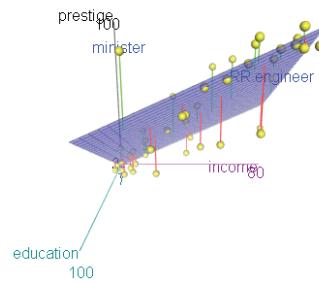
3D: scatterplot & regression surface

How does occupational prestige depend on income & education?

This plot shows the data and a fitted multiple regression surface, connecting the points to the regression plane

It is hard to see in a static view, but easier when the plot is rotated dynamically

This plot is produced in R, using the [car](#) and [rgl](#) packages



```
data("Duncan", package="car")
scatter3d(prestige ~ income + education, data=Duncan, id.n=2)
movie3d(spin3d(c(0,1,0), rpm=6), duration=6, movie="duncan-reg3d")
```

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Thematic maps & Spatial visualization

Thematic maps use a wide variety of techniques to display quantitative or qualitative variables on the geographic framework of a map

Once the domain of cartographers, these ideas are now being developed as an area of geospatial visualization and geospatial statistical methods

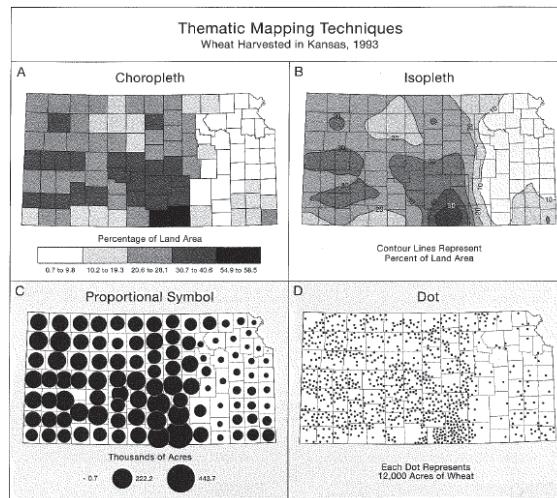
	Point	Linear	Areal	2½-D	True 3-D
Spacing	● ● ● ● ●	— — — — —			● ● ● ● ●
Size	● ● ● ● ●	— — — — —	● ● ● ● ●	● ● ● ● ●	● ● ● ● ●
Perspective Height	↑ ↑ ↑ ↑ ↑	— — — — —	— — — — —	— — — — —	None Possible
Orientation	◆ ◆ ◆ ◆ ◆	— — — — —	— — — — —	None Recommended	● ● ● ● ●
Shape	★ ★ ★ ★ ★	— — — — —	— — — — —	None Recommended	● ● ● ● ●
Arrangement	● ● ● ● ●	— — — — —	— — — — —	None Recommended	● ● ● ● ●
Lightness	○ ○ ○ ○ ○	— — — — —	— — — — —	None Recommended	● ● ● ● ●
				# dimensions	36

Thematic maps: Types

Basic types of thematic maps

Most are direct mappings of numbers to visual variables

Isopleth maps combine some analysis with display



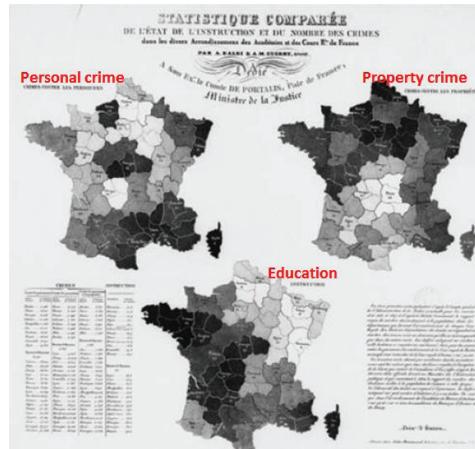
From: Slocum et al., *Thematic cartography and geographical visualization*, Fig 4.9

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Choropleth maps

Balbi & Guerry (1829)

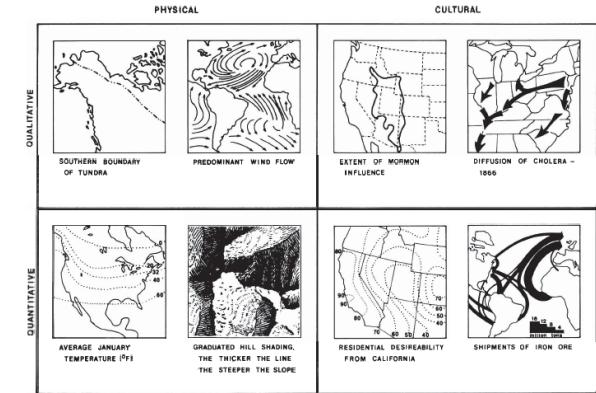
- First thematic maps of crime data
- First comparative maps ("small multiples")
- Crime against persons inversely related to crime against property
- Education: *France obscure* & *France éclairée*
- N. of France highest in education & also property crime



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Thematic maps: Theory

Alan MacEachern (1979) classifies point, line and area symbols on thematic maps according to whether they depict **quantitative** or **qualitative** phenomena, in the **physical** or **cultural** domain.

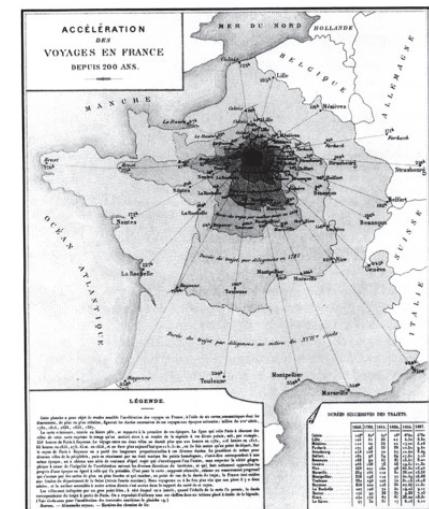


MacEachern, A. (1979). The Evolution Of Thematic Cartography / A Research Methodology and Historical Review, *The Canadian Cartographer* 16(1) June 1979, p. 17-33

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Anamorphic maps

- Anamorph:** Deforming a spatial size or shape to show a quantitative variable
- Émile Cheysson used this to show the decrease in travel time from Paris to anywhere in France over 200 years

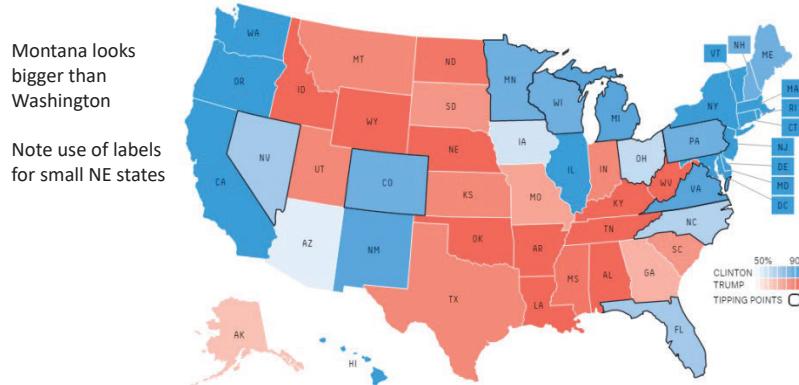


Album de Statistique Graphique, 1888, plate 8

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What's wrong with choropleth maps?

Choropleth maps are misleading because size (area) of units dominates perception. This is particularly true for maps of the US & Canada. Not so for France (why?)

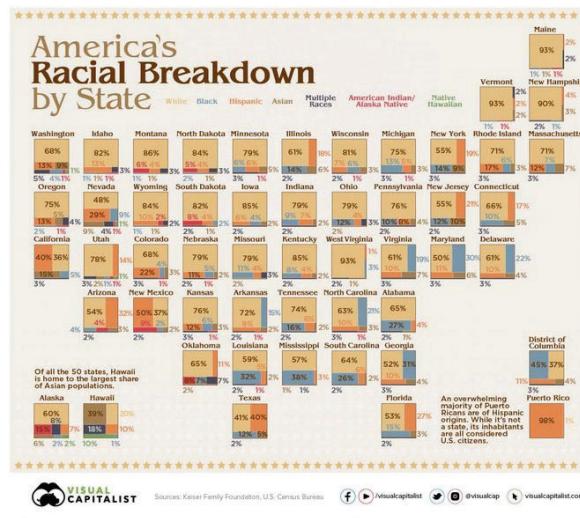


fivethirtyeight.com election predictions, Oct. 13, 2017

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Mosaic cartograms

US map provides a spatial framework for showing the distribution of categorical data



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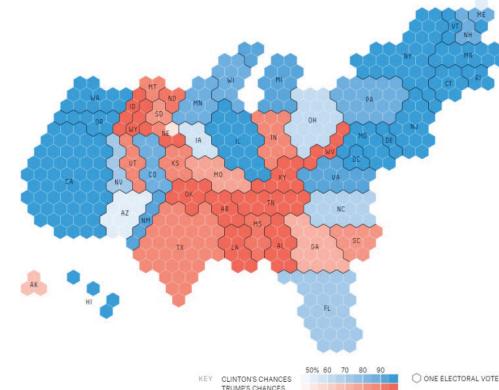
Cartogram (tilegrams)

A **tilegram** uses hexagonal tiles to make area proportional to a given variable

Here, the size of each state is made ~ number of electoral college votes

Now, it is easy to see the impact of states

Take-away: Area doesn't
vote; People do!



fivethirtyeight.com election predictions, Oct. 13, 2017

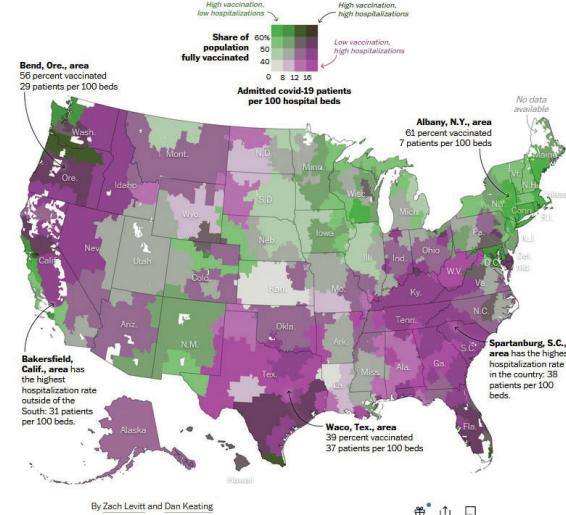
42

Bivariate maps

How to show relation between two variables on a map?

Bivariate maps combine two colors with degrees of saturation

Claim:
Regions with more vaccinations have fewer hospitalizations



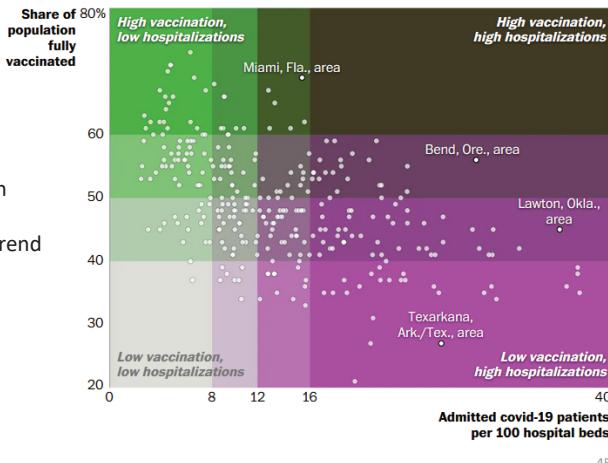
<https://www.washingtonpost.com/health/2021/09/23/covid-vaccination-hospitalization-map/>

40

Vs. a scatterplot

Distribution of vaccination and hospitalization rates

Most hospital regions with high vaccination rates have lower hospitalization rates — and places with lower vaccination rates tend to see higher rates of admitted patients.



45

This lovely scatterplot shows:

- Yes, inverse relation
- Classing of color
- Whoa: non-linear trend

Worldmapper: The world in cartograms

How to visualize social, economic, disease, ... data for geographic units?

worldmapper.com : cartograms: area ~ variable of interest (700+ maps)

WORLDMAPPER

The world as you've never seen it before

Search for a map: Go

Home Map Categories Thumbnail Index A-Z Map Index About Worldmapper Help

Worldmapper is a collection of world maps, where territories are re-sized on each map according to the subject of interest. There are 366 maps, also available as PDF posters. Use the menu above or click on a thumbnail image below to view a map.

Reference maps ...



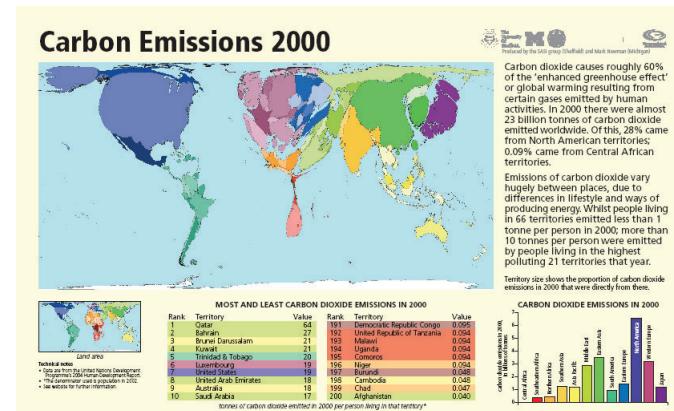
Newest maps ...



46

Worldmapper: Carbon emissions

These pages are well-designed according to data vis. Ideas: high impact graph + interpretive details & explanation



47

Worldmapper: Cholera deaths

Deaths from cholera in 2004. Territory size ~ proportion of worldwide deaths

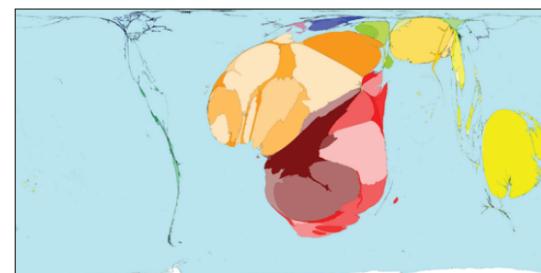
< Previous Map

Cholera Deaths

Map No. 232

[Open PDF poster](#)

[Next Map >](#)



'The cholera outbreak has continued... water provided by the tankers is not enough and they try to boost their supply from the wells which are not covered. The rain washes faeces and other pollutants into the wells.' - Pierre Kahozi, 2004

Cholera deaths result from severe dehydration caused by diarrhoea. This is treatable in 2004 the number of cholera deaths was only 2.5% of the number of cholera cases that year. Distributions of cholera cases and deaths differ due to differing availability of treatments.

In 1962, in Papua New Guinea, 36% of cholera cases, which was 464 people, died. In 2004, in the Central African Republic, 15% of cholera cases, which was 48 people, died.

In contrast, there were 73 territories where nobody died from cholera, because of good sanitation, clean water and available treatment. These territories have no area on this map.

Territory size shows the proportion of worldwide deaths from cholera that occurred there in 2004 or most recent year available.

<http://www.worldmapper.org/display.php?selected=232>

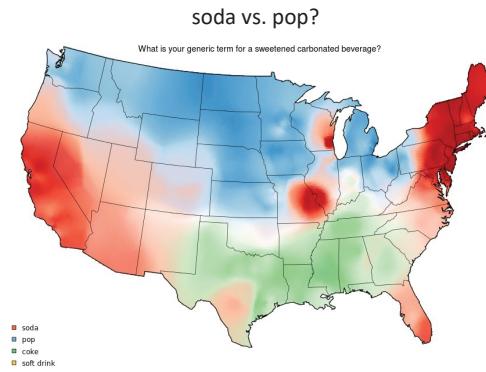
48

Spatial visualization: Analysis + maps

Linguistics: Food dialect maps— visualizing how people speak

In the *Cambridge Online Survey of World Englishes*, Bert Vaux and Marius L. Jøhndal surveyed 11,500 people to study the ways people use English words.

NC State Univ. student Joshua Katz turned the US data into shaded kernel density maps.



Take the survey: http://www.tekstlab.uio.no/cambridge_survey

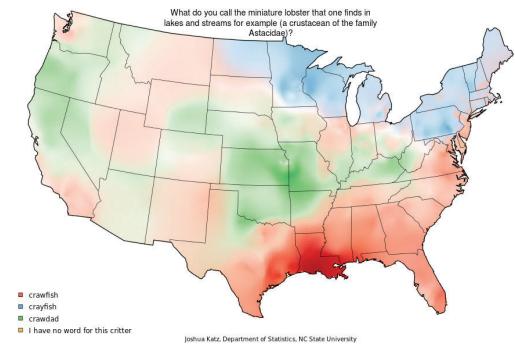
Programming in R: <http://blog.revolutionanalytics.com/2013/06/r-and-language.html>

49

Spatial visualization: Analysis + maps

Linguistics: Food dialect maps— visualizing how people speak

crawfish, crawfish, crawdad?

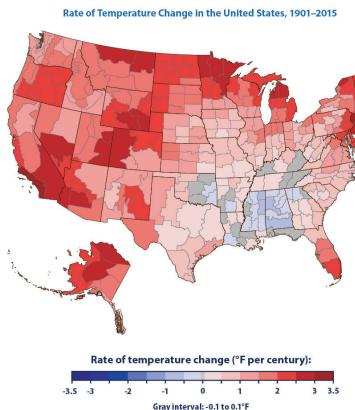


Joshua Katz, Department of Statistics, NC State University

50

Contour maps

Contour maps ignore region boundaries and estimate constant contours of a phenomenon over geographical space. This is a form of **geo-smoothing**.

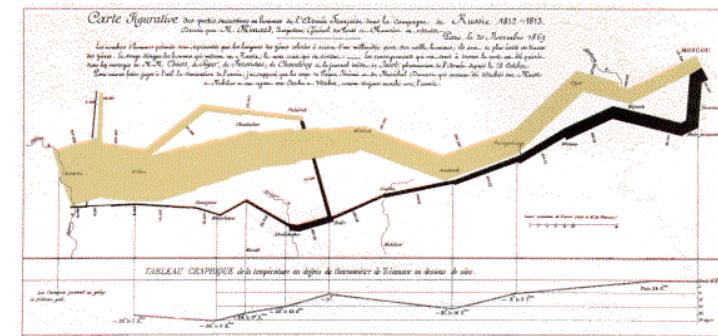


From: <https://medium.com/two-n/an-alternative-to-choropleth-contour-density-maps-in-d3-js-93e1fdbdc4e>

51

Flow maps

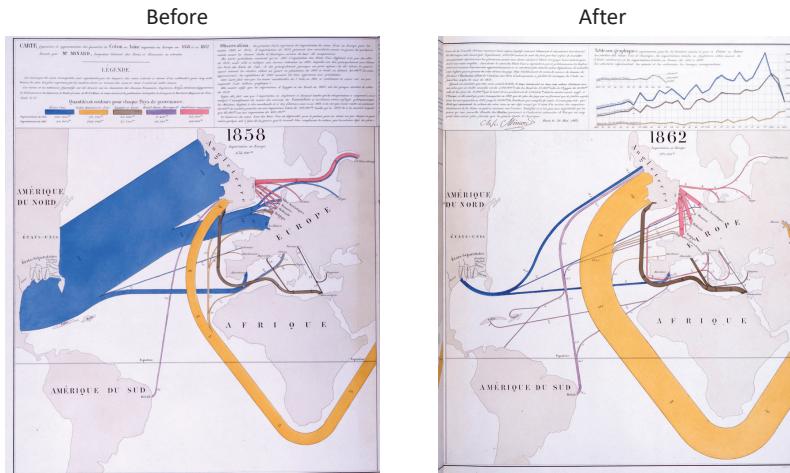
Flow maps show **movement** or **change** in a geographic framework
The master work is this image by Charles-Joseph Minard (1869)



- Marey (1878): "defies the pen of the historian in its brutal eloquence"
- Tufte (1983): "the best statistical graphic ever produced"

52

Effect of US civil war on cotton trade

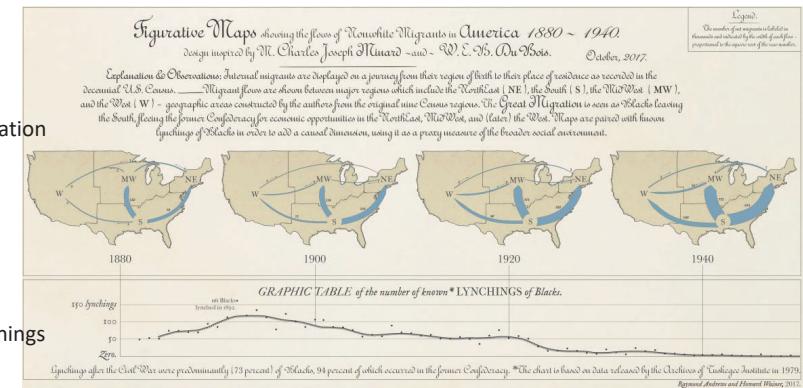


Note the deformation of the map to accommodate the data

53

The Great Migration

In a graphic tribute to C.-J. Minard and W. E. B. Du Bois, Raymond Andrews & Howard Wainer tell the story of the migration of blacks from the southern US after freedom from slavery.



Andrews, R. J. & Wainer, H. The Great Migration: A Graphics Novel Featuring the Contributions of W. E. B. Du Bois and C. J. Minard. *Significance*, 2017, 14, 14-19. See also: <http://infowestrust.com/picturing-the-great-migration/> for the story of this graphic

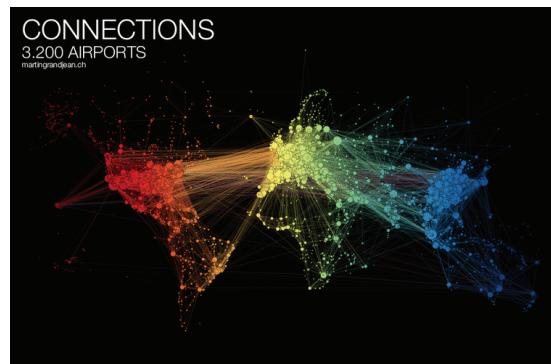
54

Network visualization

Once the domain of mathematicians & computer scientists, graph theory and network visualization turn out to have surprising & interesting applications.

Animated demo by Martin Granjean showing transport of passengers from/to world airports.

It illustrates the difference between geography & **force-directed layout** to focus on volume & connections



From: <http://www.martingrandjean.ch/connected-world-air-traffic-network/>
See more: <https://flowingdata.com/2016/05/31/air-transportation-network/>

56

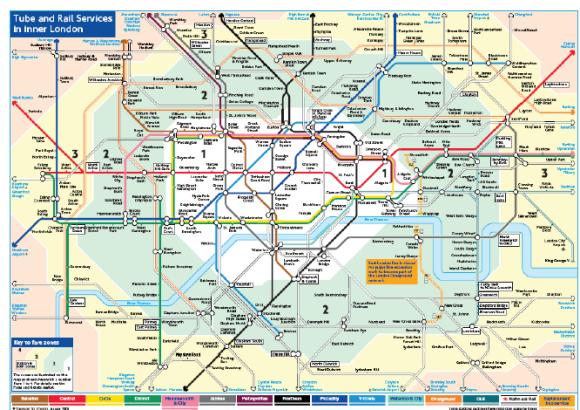
Network visualization: Transport maps

How do I get from Chigwell to Charing Cross?
How much will it cost?

This route map shows the connections and fare zones

The first one was designed by Henry Beck in 1931.

The modern version is zoomable and available on your phone.



See: <https://tfl.gov.uk/maps/travel>

57

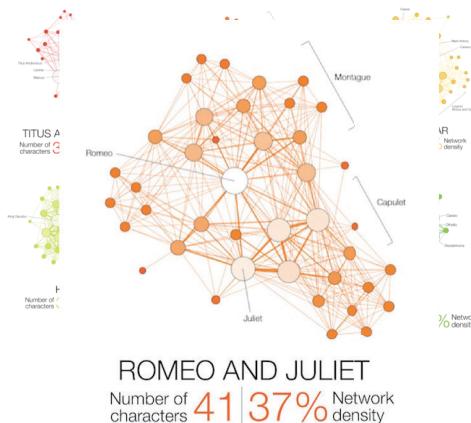
Network visualization: Shakespeare tragedies

A new form of literary criticism?

Martin Grandjean looked at the structure of Shakespeare tragedies through character interactions.

Each circle (node) represents a character, and an edge represents two characters who appeared in the same scene.

The structural characteristics of the graphs have meaningful interpretations.



From: <https://flowingdata.com/2015/12/30/shakespeare-tragedies-as-network-graphs/>

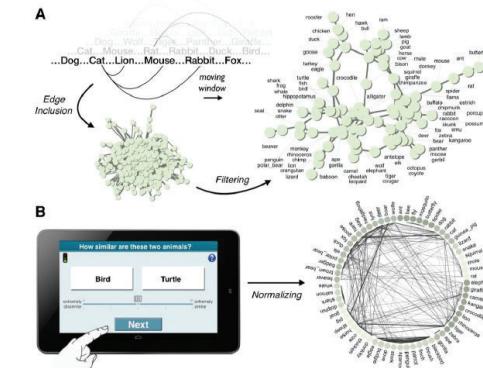
58

Semantic memory: Cognitive structure

Various tasks can be used to assess the relations among words/concepts in our semantic memory

The data can be used to calculate measures of **similarity**, and be shown in network or other diagrams

Verbal fluency task: Say/write all the names of [animals, countries, ...] you can in 1 minute.



Similarity ratings: For each pair, indicate how similar they are

From: Wulff et al. (2018), Structural differences in the semantic networks of younger and older adults

59

Semantic memory: Cognitive structure

Do younger and older adults differ on measures calculated from their network diagrams?

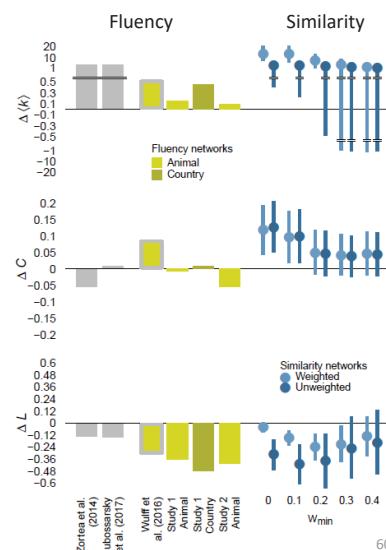
$\langle k \rangle$: Average “degree” # of connections
 C : average local clustering
 L : average path length in network

$\Delta()$: young – old difference

IMHO, this graph tries to do too much.

The fluency data is most important to their argument.

ΔL & $\Delta \langle k \rangle$ show consistent differences between young & old

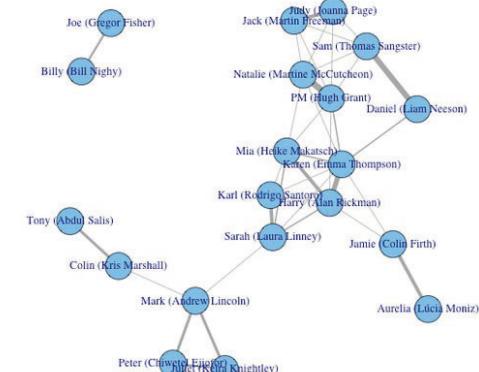
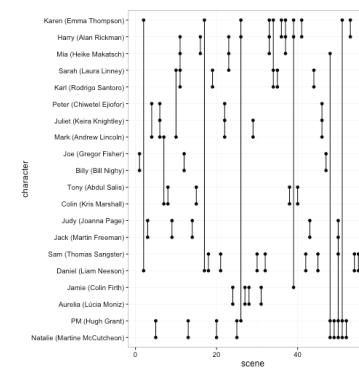


60

Love, Actually: Interactive app

Interactions among characters in *Love, Actually*

Data:



Interactive Shiny app: <https://dgrtwo.shinyapps.io/love-actually-network/>

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WikiLeaks Iraq war logs

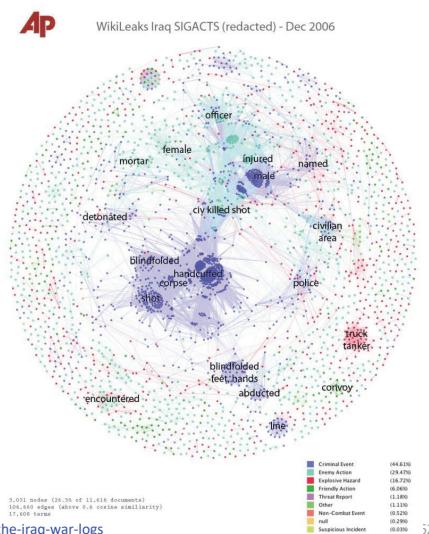
Johnathan Stray & Julian Burgess analyzed > 11,000 documents for SIGACT (“significant action”) reports from the 2006 Iraqi civil war made available by WikiLeaks.

Each report is a dot. Each dot is labelled by the three most “characteristic” words in that report.

Documents that are “similar”
have edges drawn between them,
width \sim similarity

The graph-drawing algorithm placed similar nodes together

17 OF 20



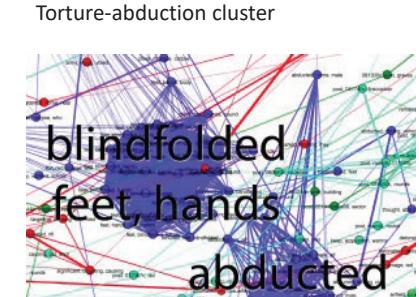
WikiLeaks Iraq war logs

Certain themes became clear, and could be studied in rich detail
The underlying methods use “term frequency–inverse document frequency”
measures of [text-mining](#).

Murder cluster. All contain the word
“corpse”



<http://jonathanstray.com/wp-content/uploads/2010/12/Murders.pdf>



<http://jonathanstray.com/wp-content/uploads/2010/12/Torture-abduction.png>

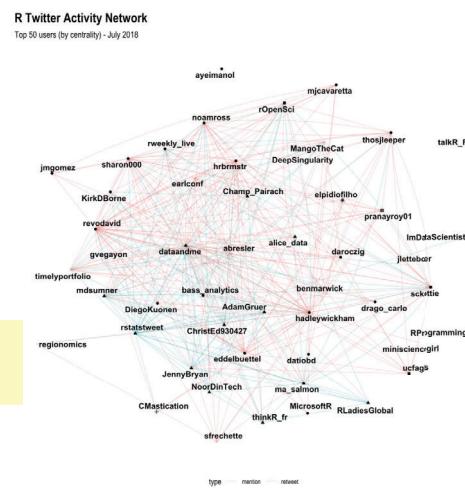
6

Twitter network of R users

Perry Stephenson explores the connections among the top 50 R users on Twitter

The rtweet package provides access to Twitter info

```
library(rtweet)  
followers <-  
get_followers("datavisFriendly"))
```



From: <https://perrystephenson.me/2018/09/29/the-r-twitter-network/>

Twitter
circles

Who do I most often interact with?

Three rings to show my
twitter world

One ring to rule them all:
@datavisFriendly

Other rings: #datavis,
#maps, #rstats, #psy6135



Generated by <http://chirpy.com>

65

Tree-based Visualization

Branching patterns
History as a tree
Treemaps

Ramon Llull, 1298, Tree of Philosophy of Love



History as a Tree: *Geschichtsbaum Europa* (2003)

- The entire history of Europe in one diagram
- space-filling design: resolution $\sim \text{time}^2$
- natural metaphors for roots, branches

Image: <http://euclid.psych.yorku.ca/SCS/Gallery/images/timelines/geschicht1000.jpg>

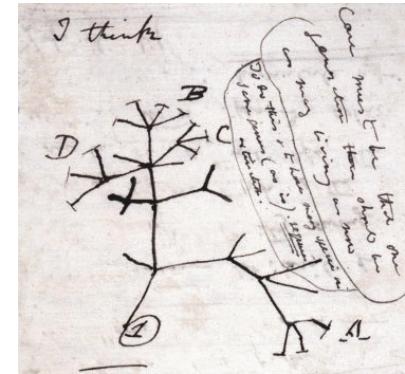
68

Tree diagrams

Trees are natural, organic visual metaphors for branching processes and space-filling designs.



Ramon Llull's tree of science, showing roots and branches of knowledge

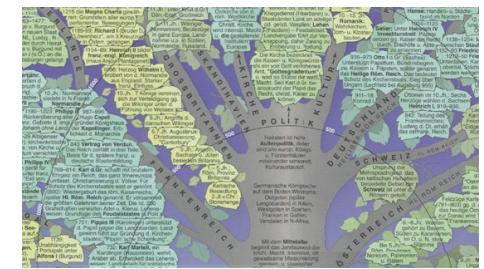


Charles Darwin's first visual sketch of the evolution of species

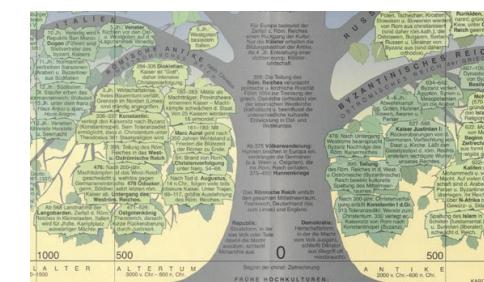
67

History as a Tree

- Branches for countries & domains of thought
- Leaves for all the details



- linear horizontal scale → area $\sim \text{time}^2$

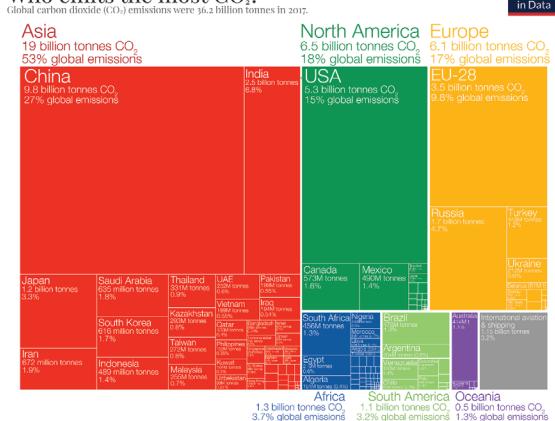


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Treemaps

Treemaps display hierarchical data as a set of nested rectangles.
Each node (leaf) has an area \sim size (CO₂)

Who emits the most CO₂?



The construction makes efficient use of space

Nesting shows relative size at multiple levels

71

Treemaps: Google Newsmap

They turn out to be useful in a wide range of applications

Google NewsMap shows top news stories with

- Size \sim popularity
- Color: domain– **world news, sports, national, ...**
- Shades: recency

Interactivity: Hover, click to show details



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Radial trees: Visual Thesaurus

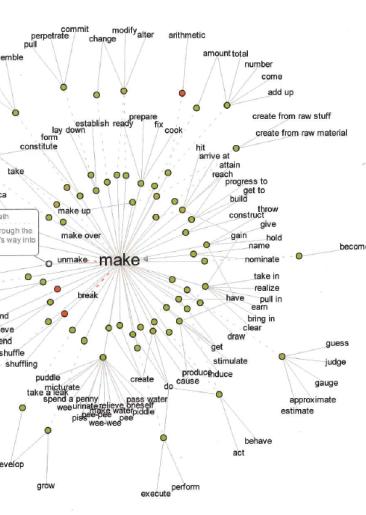
The *Visual Thesaurus*, from Thinkmap was the first application to make word meanings **visual** and **interactive**.

They used a radial layout to show the various related senses of given focus word.

This application was incisive in promoting ideas of interaction with tree-based data: query, zoom, tool-tips,

...

This fig from Manuel Lima, *The Book of Trees*, p. 127



73



Animation & Interactive Graphics

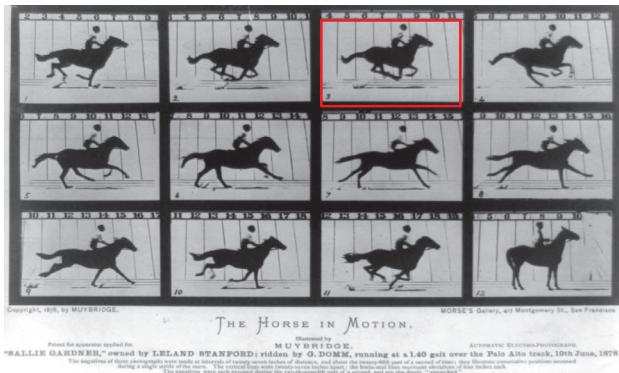
Origins: Visualizing motion
Animated graphics
Dynamically updated graphics
Linking views
Interactive application development frameworks

74

A wager about a horse in motion

In the late 1800s, a popular quasi-scientific question was: Does a horse, in a trot, cantor or gallop ever have all four feet off the ground? This came to be called the **Hypothesis of Unsupported Transit**

Eadweard Muybridge solved the problem by automating multiple photographs

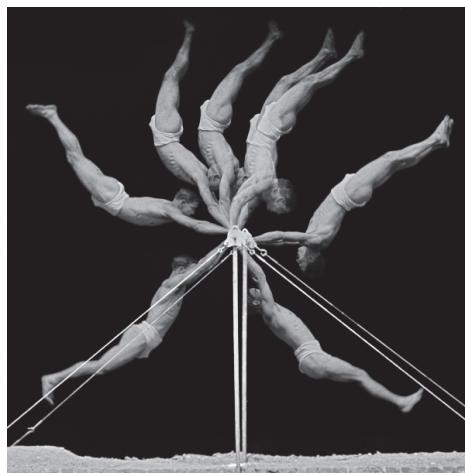


Animation: Chronophotography

Marey pioneered the study of human and animal motion photographically



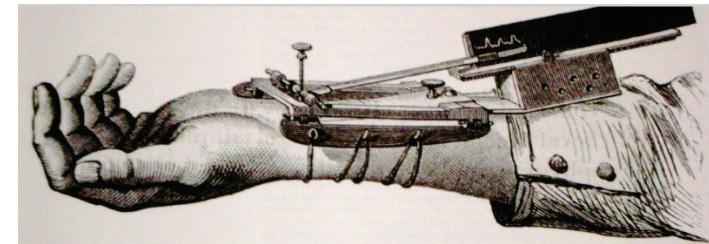
The photographic gun, allowing recording of 12 frames/sec. at intervals of 1/720 of a second



É.-J. Marey: A science of visualizing motion

- Physiology: How to make internal physiological processes subject to visual analysis?
 - Invented many graphic recording devices (heart rate, blood pressure, muscle contraction, etc.)
 - “Every kind of observation can be expressed by graphs”

Marey's sphygmograph, recording a visual trace of arterial blood pressure



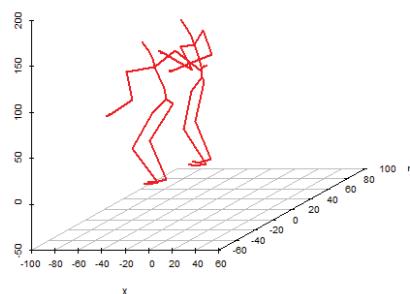
7

Animated graphics

Animated graphics, like movies
are just a series of frames strung
together in a sequence

The data for this animation come from human figures in motion-capture suits dancing the Charleston.

The Carnegie-Mellon Graphics Lab maintains a Motion Capture Database, <http://mocap.cs.cmu.edu/>



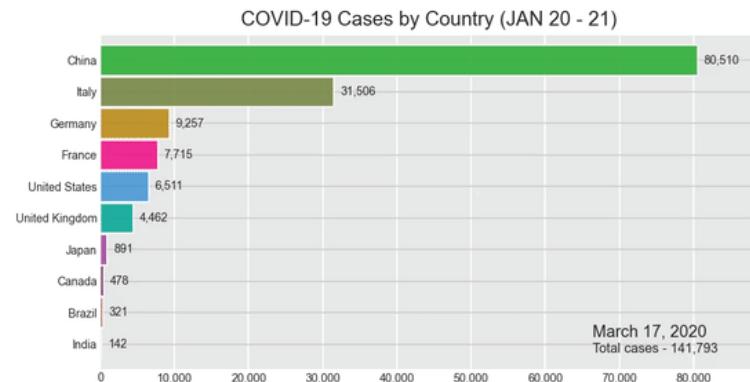
From: <http://blog.revolutionanalytics.com/2017/08/3-d-animations-with-r.html>

7

Bar chart races

Data that changes over time can often be shown in a simpler animated graphic

This example of a **bar chart race** shows the strengths & weaknesses of this approach.



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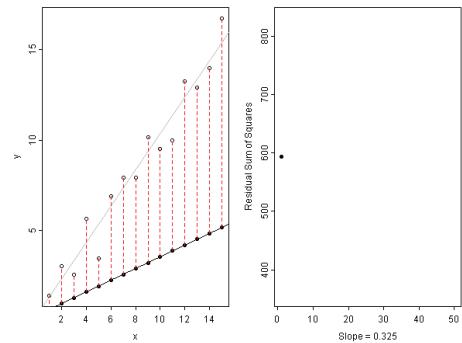
Statistical animations

Statistical concepts can often be illustrated in a dynamic plot of some process.

This example illustrates the idea of least squares fitting of a regression line.

As the slope of the line is varied, the right panel shows the residual sum of squares.

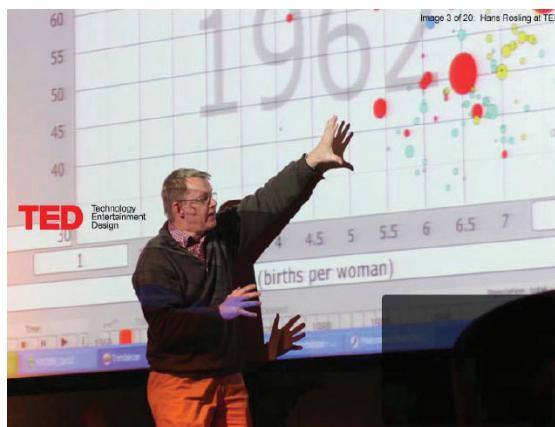
This plot was done using the [animate](#) package in R.



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Animated graphics

Hans Rosling captivated audiences with dynamic graphics showing changes over time in world health data



Video: Hans Rosling, "The best stats you've ever seen,"
https://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen

81

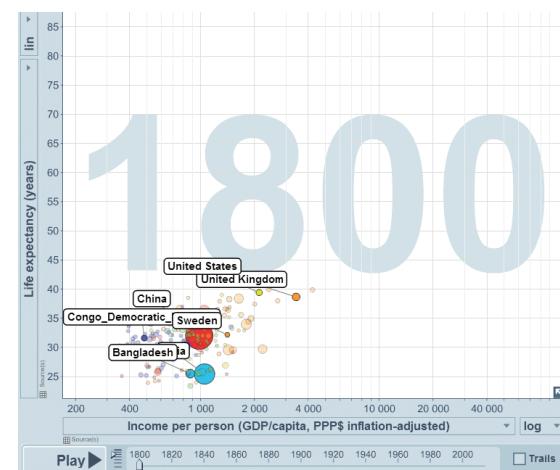
Animation & Interactivity

The Gapminder "moving bubble chart" was the vehicle.

- Choose (x, y) variables
- Choose bubble size variable
- Animate this over time

Liberating the X axis from time opened new vistas for data exploration

Software made this available as a general tool



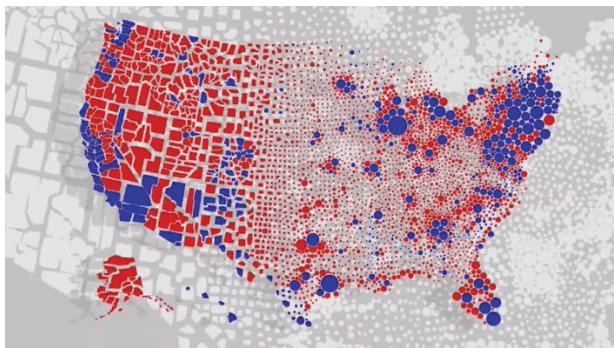
82

Animation: Interpolated views

Animation can also be used to show the difference between two views, using interpolated transitions: Current = α view₁ + (1 - α) view₂

This image showed Rep vs. Dem votes in the 2016 US election, contrasting shading by area vs. shading by population.

Land doesn't vote;
people do



[Image: Karim Douieb/Jetpack.ai]

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<https://www.fastcompany.com/90572489/u-s-election-maps-are-wildly-misleading-so-this-designer-fixed-them>

Linking animated views

This example links a dendrogram to a grand tour and map of the USArests data to visualize a classification in 5 dimensions

The grand tour
animates a series of 2D
projections of the 5D data

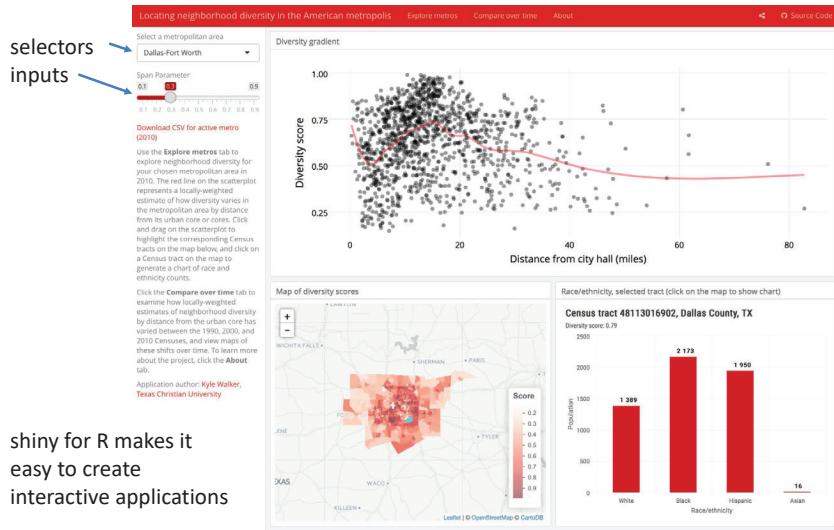
The image is recorded
as a GIF



From: Carson Sievert, <https://plotly-book.cpsievert.me/linking-animated-views.html>

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Interactive application frameworks



https://walkerke.shinyapps.io/neighborhood_diversity/

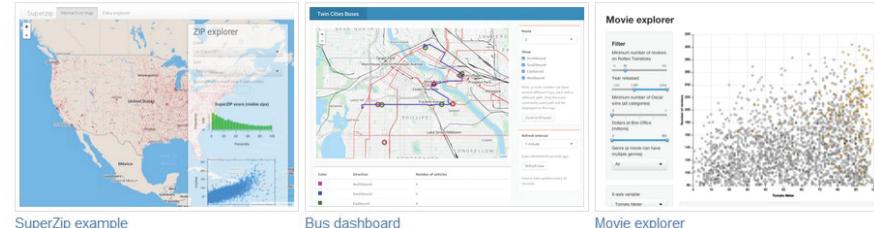
85

shiny gallery

There is now a large collection of shiny applications, <https://shiny.rstudio.com/gallery/>. These integrate other interactive web software: d3, Leaflet, Google Charts, ...

Interactive visualizations

Shiny is designed for fully interactive visualization, using JavaScript libraries like d3, Leaflet, and Google Charts.



SuperZip example

Bus dashboard

Movie explorer

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Summary

- The topics here were largely about data graphs, for analysis & presentation. Mainly not Info-graphics
 - Quantitative data: different forms for 1D, 1.5D, 2D, 3+D data
 - Categorical data: often best shown as areas ~ frequency (bar plots, mosaic plots)
- Thematic maps: visualizing spatially varying data
 - Raw data with different visual encodings
 - Spatial statistical models provide some smoothings
- Networks/trees: visualizing connections
- Animation: show changes over time or space
- Interaction: allow the viewer to explore the data