

# Information Visualization (Part II)

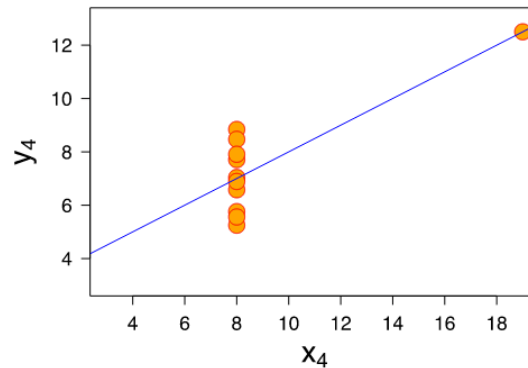
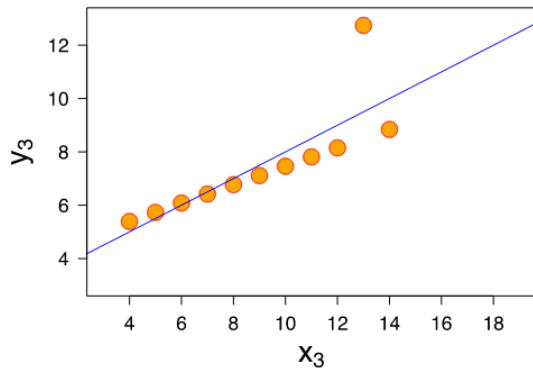
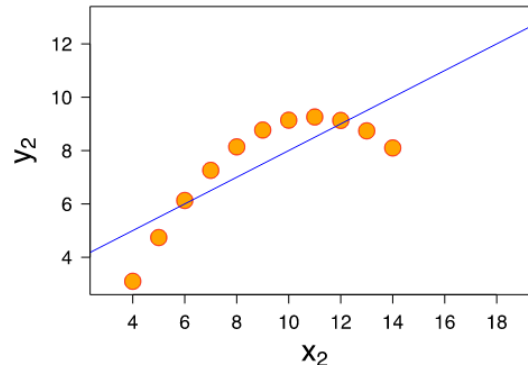
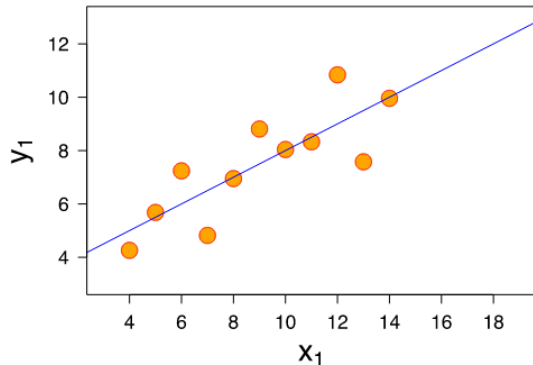
EECS6414 – Data Analytics and Visualization

# Agenda\*

- Review
  - What is data visualization?
  - Jacques Bertin's visual variables (semiotics)
  - Perception & cognition (pre-attentive vs attentive processing)
  - Gestalt principles
  - Tufte's principles of graphical excellence
- Data Types
- A Taxonomy of Representation
  - A detailed listing of data representations

# Part I Review

# Why visualize data? Anscombe's Quartet



## Summary statistics for all four datasets

- $\text{avg}(x) = 9$
- $\text{avg}(y) = 7.50$
- $\text{Var}(x) = 11$
- $\text{Var}(y) = 4.12$
- $\text{Correlation}(x,y) = 0.816$
- A linear regression line:  
 $y = 0.5x + 3$

**Always plot your data!**

## Anscombe's Quartet

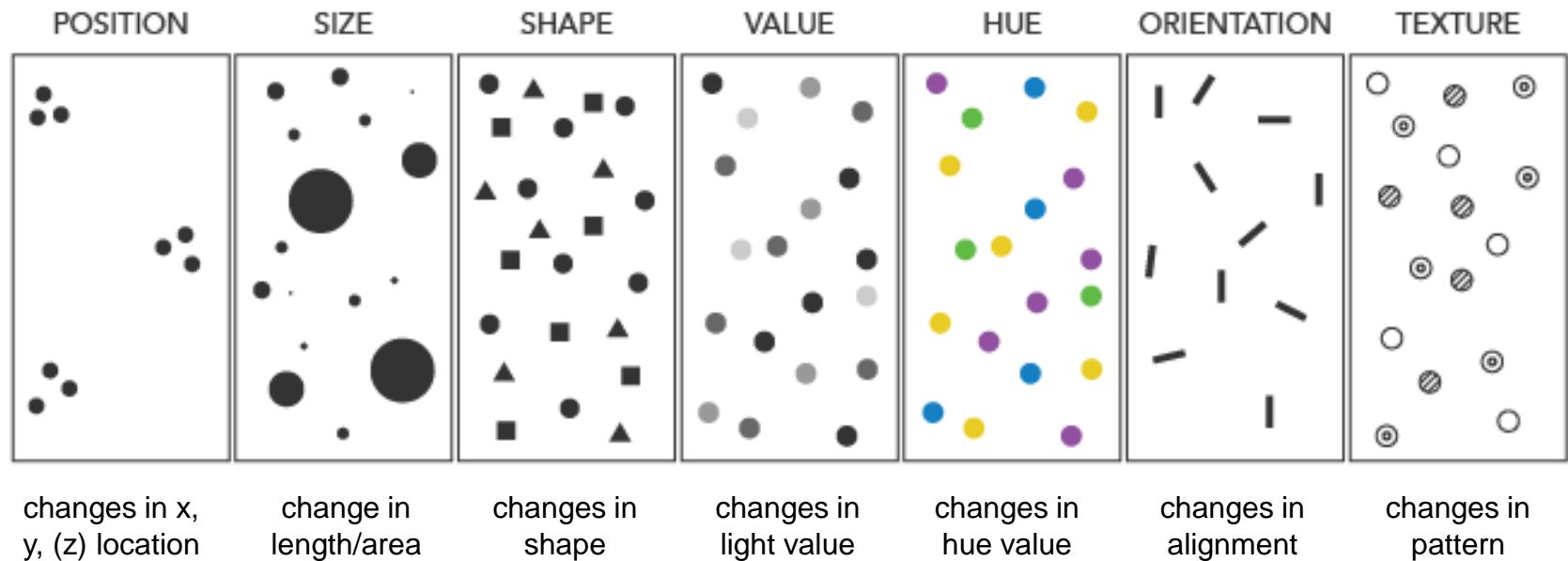
Anscombe, F. (1973). Graphs in statistical analysis. American Statistician, 27:17--21.

# What is data visualization?



Use of **visual elements** like **charts**, **graphs**, and **maps** to see and understand **trends**, **outliers**, and **patterns** in data

# Jacques Bertin's visual variables (vv)



Jacques Bertin proposed an original set of “retinal variables” in Semiology of Graphics (1967)

# Perception & cognition

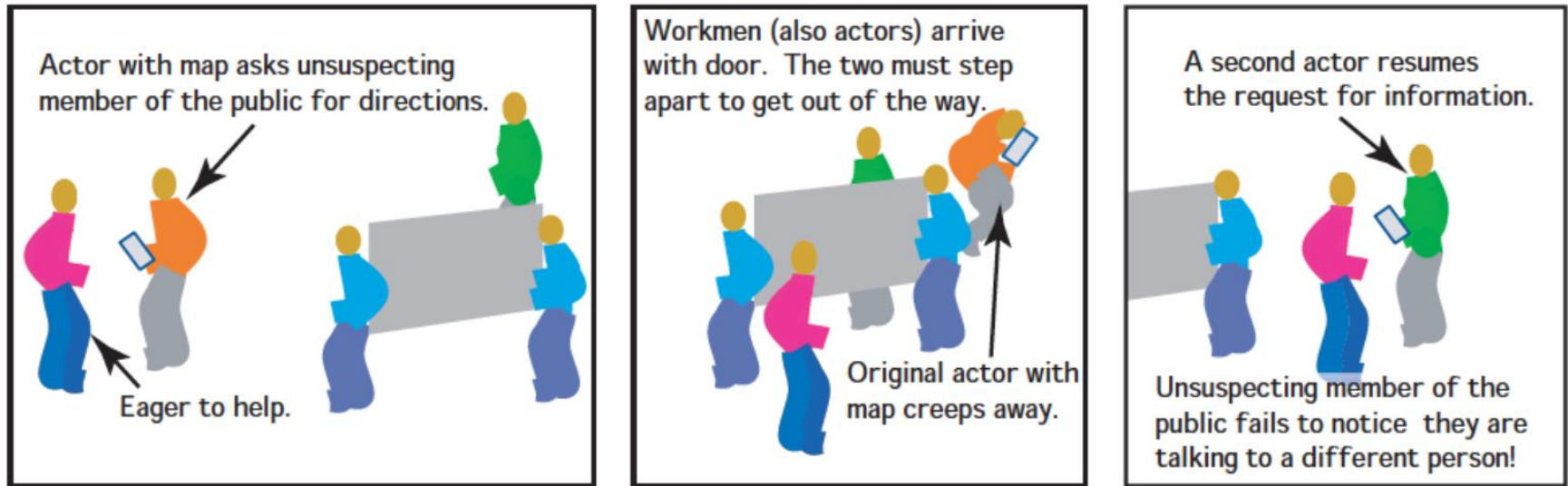


Image: Ware, Colin. Visual thinking: For design. Morgan Kaufmann, 2010

- perception is fragmented
- eyes are constantly scanning and constructing reality

## The “Door Study”\*

<https://www.youtube.com/embed/FWSxSQsspiQ>

\* Daniel J. Simons and Daniel T. Levin. 1998. “Failure to detect changes to people during a real world interaction.” Psychonomic Bulletin and Review. 5: 644–669.

# Pre-attentive vs attentive processing

## Pre-attentive Processing

- bottom-up
- fast, automatic
- instinctive
- efficient
- multitasks

## Attentive Processing

- top-down
- slow, deliberate
- focused
- single-task

### goal of information design

- help humans process information as efficiently as possible
- make as much use of pre-attentive processing as possible



# Gestalt Principles (Princ. of Visual Grouping)

- Figure/Ground
- Proximity
- Similarity
- Symmetry
- Continuity
- Closure

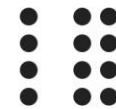
## Gestalt Principles

UX CHEAT.com



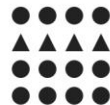
### Good Figure

Objects grouped together tend to be perceived as a single figure. Tendency to simplify.



### Proximity

Objects tend to be grouped together if they are close to each other.



### Similarity

Objects tend to be grouped together if they are similar.



### Continuity

When there is an intersection between two or more objects, people tend to perceive each object as a single uninterrupted object.



### Closure

Visual connection or continuity between sets of elements which do not actually touch each other in a composition.



### Symmetry

The object tend to be perceived as symmetrical shapes that form around their center.

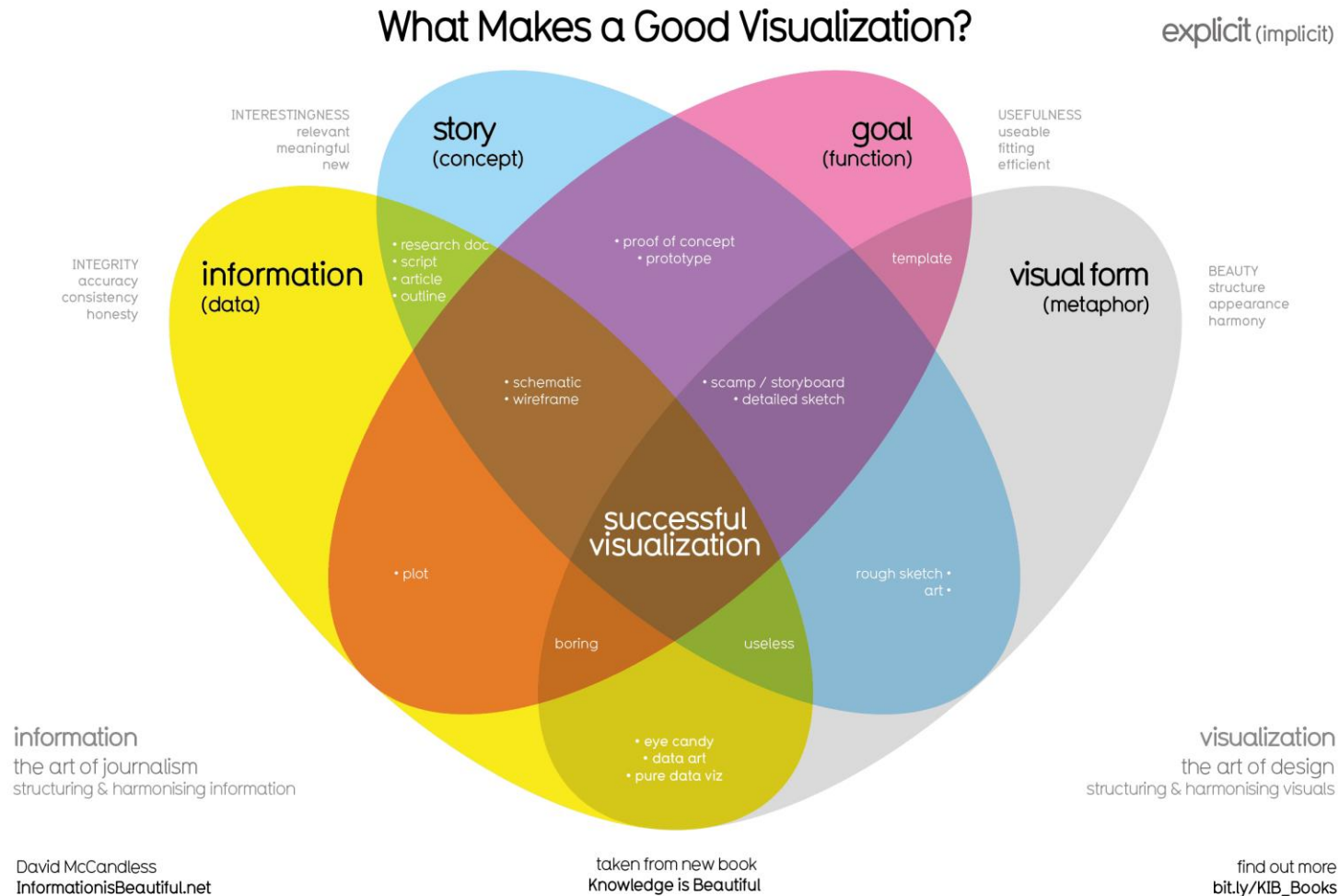
# Principles of Graphical Excellence (Tufte' 01)

- Show the data
- Induce the viewer to think about the substance of the findings rather than the methodology, the graphical design, or other aspects
- Avoid distorting what the data have to say
- Present many numbers in a small space, i.e., efficiently
- Make large data sets coherent
- Encourage the eye to compare different pieces of data
- Reveal the data at several levels of detail, from a broad overview to the fine structure
- Serve a clear purpose: description, exploration, tabulation, decoration
- Be closely integrated with the statistical and verbal descriptions of the data set

# High data to ink ratio (demo)

**Remove**  
to improve  
(the **data-ink** ratio)

# What makes a visualization beautiful?



<https://informationisbeautiful.net/visualizations/what-makes-a-good-data-visualization/>

# Physical visualizations (data sculpture)

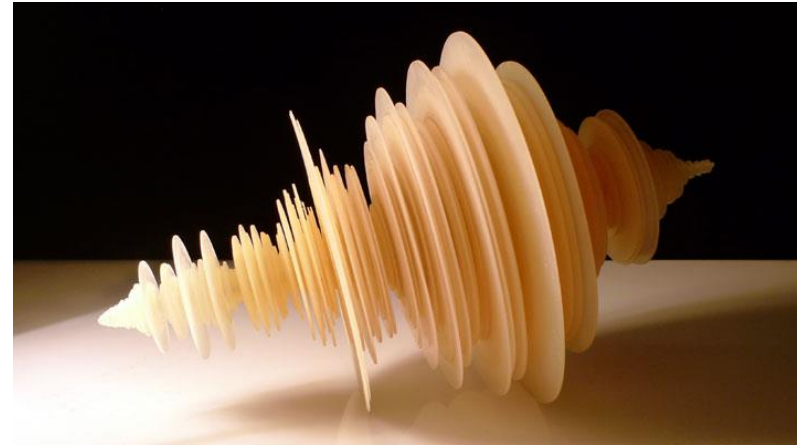
Keyboard Frequency Sculpture



A 3D bar chart on top of a keyboard which shows the frequency of each letter in the alphabet

Source: Michael Knuepfel

2011 – Tōhoku Japanese Earthquake Sculpture

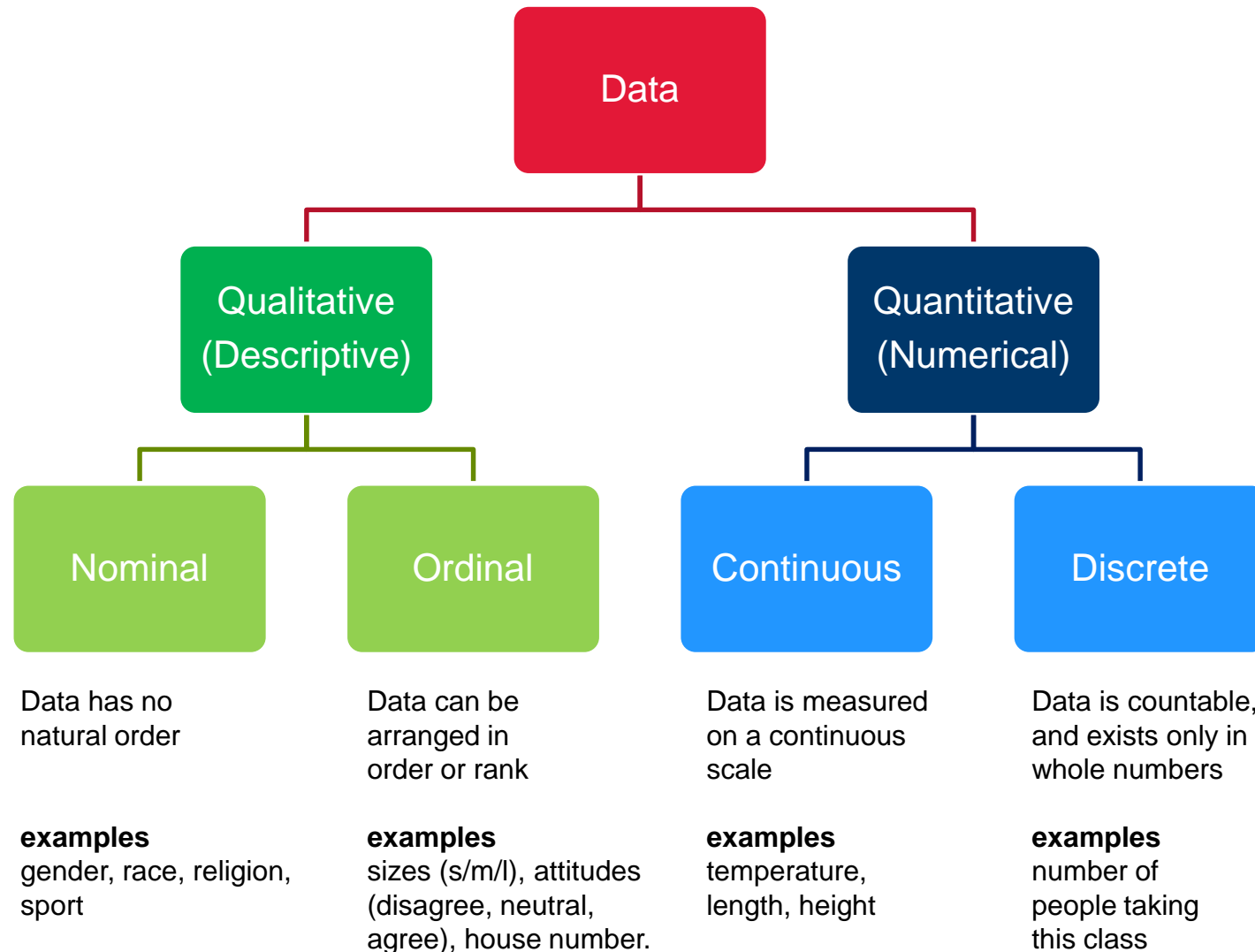


A data sculpture by Luke Jerram that depicts nine minutes of seismographic readings during the 9.0 earthquake.

Source: Gizmodo

# Data Types

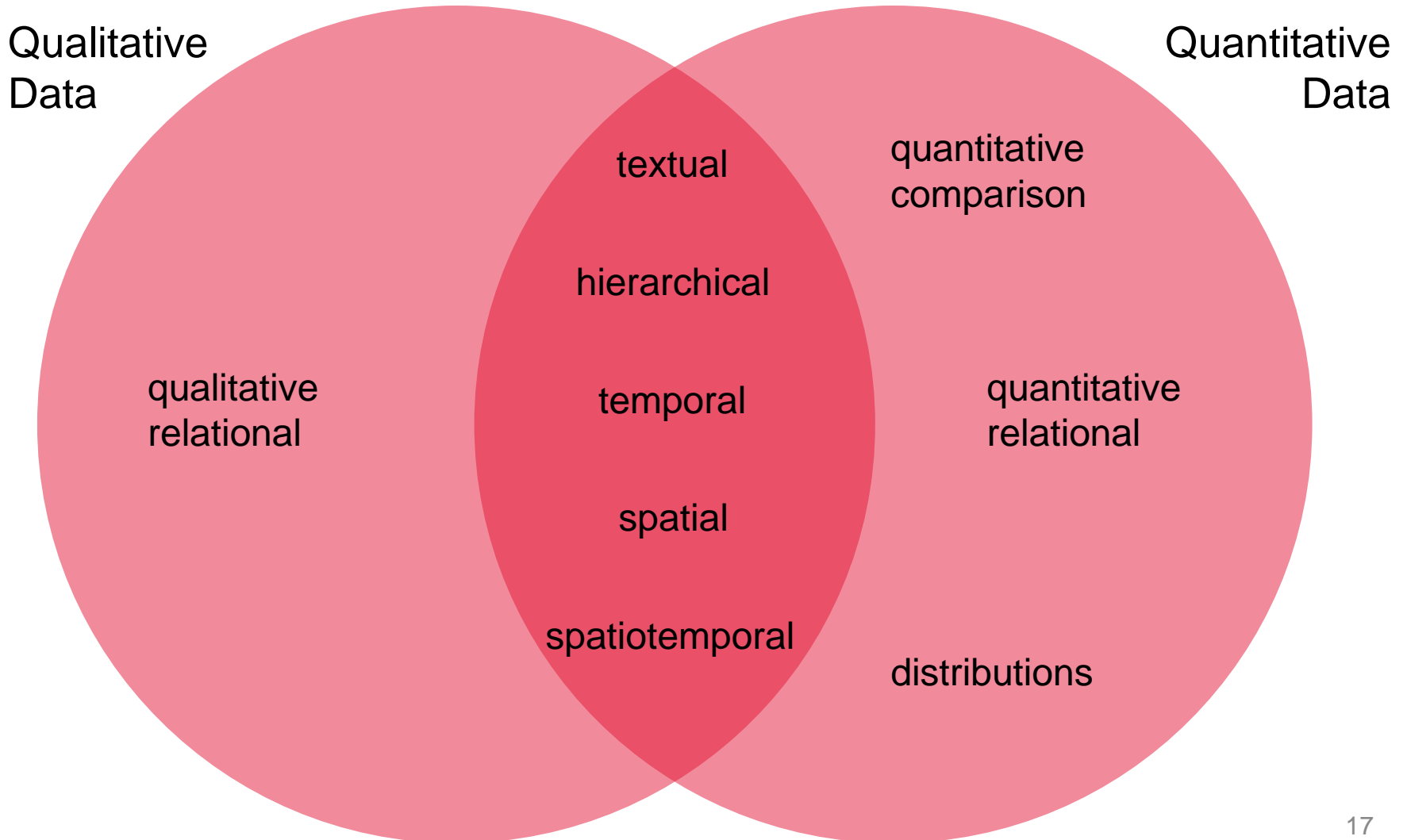
# Data types



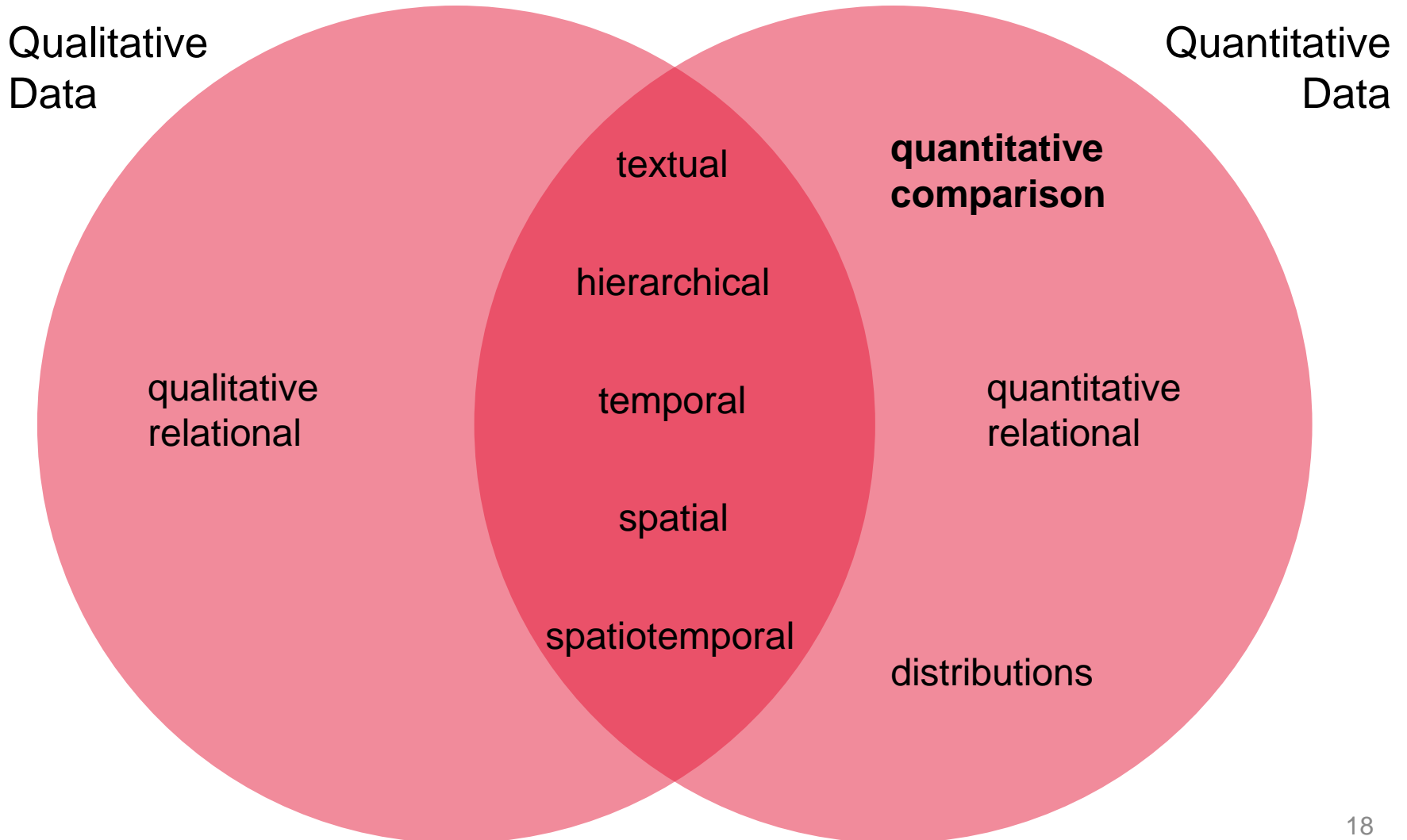
# Information Visualization Taxonomy



# Information Visualization Taxonomy



# Quantitative Comparison Structures



# Pie Chart

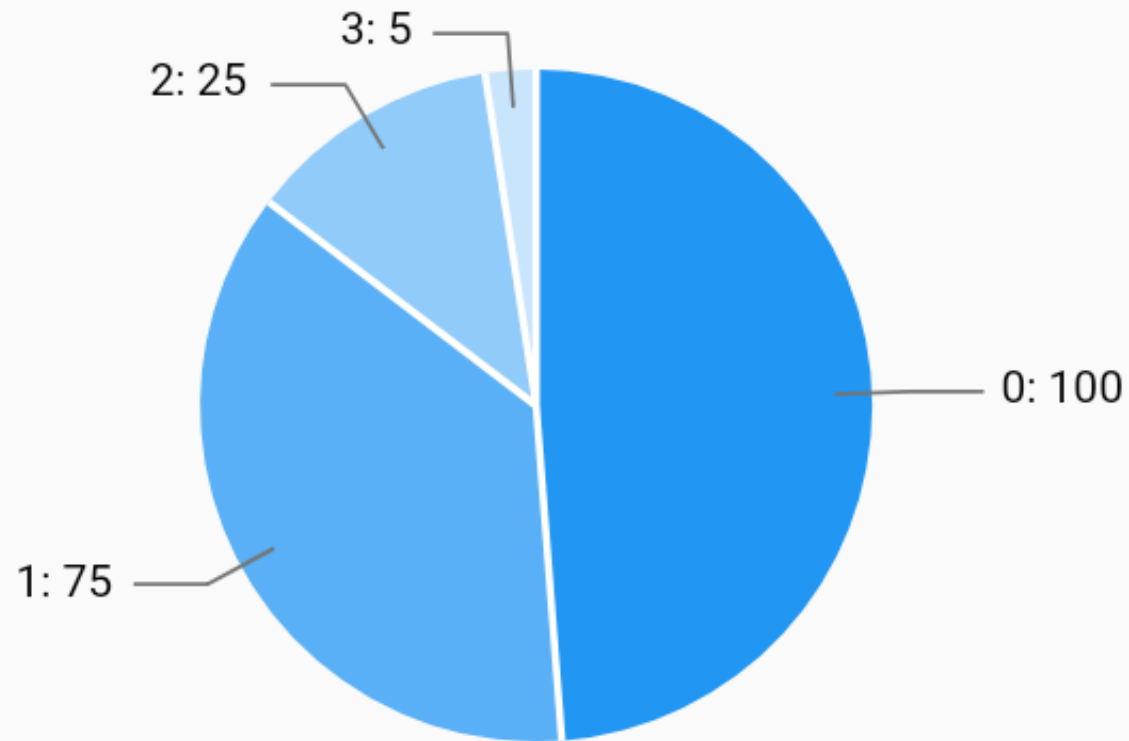


Image: <https://google.github.io/charts/flutter/gallery.html>

# Doughnut Chart

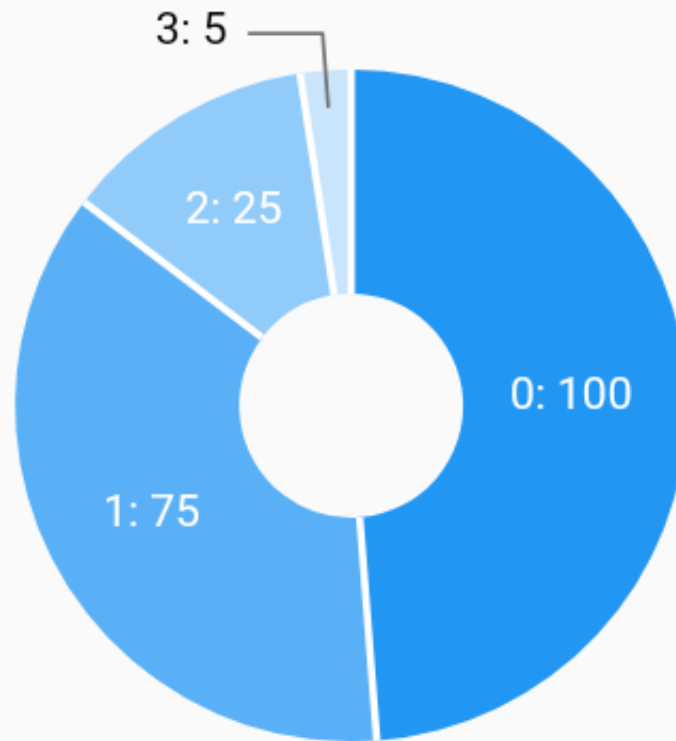


Image: <https://google.github.io/charts/flutter/gallery.html>

# Bar Chart

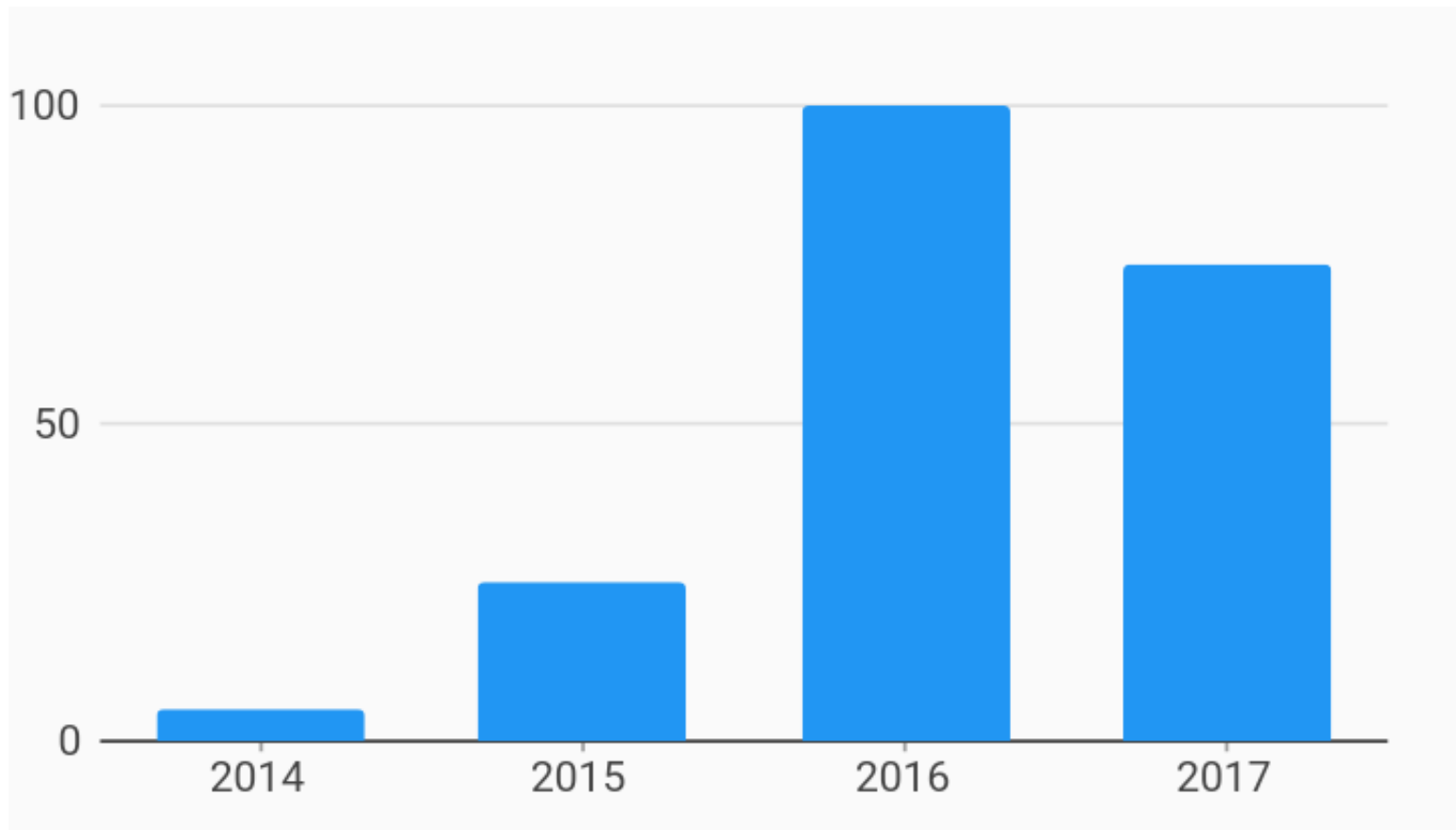


Image: <https://google.github.io/charts/flutter/gallery.html>

# Stacked Bar Chart

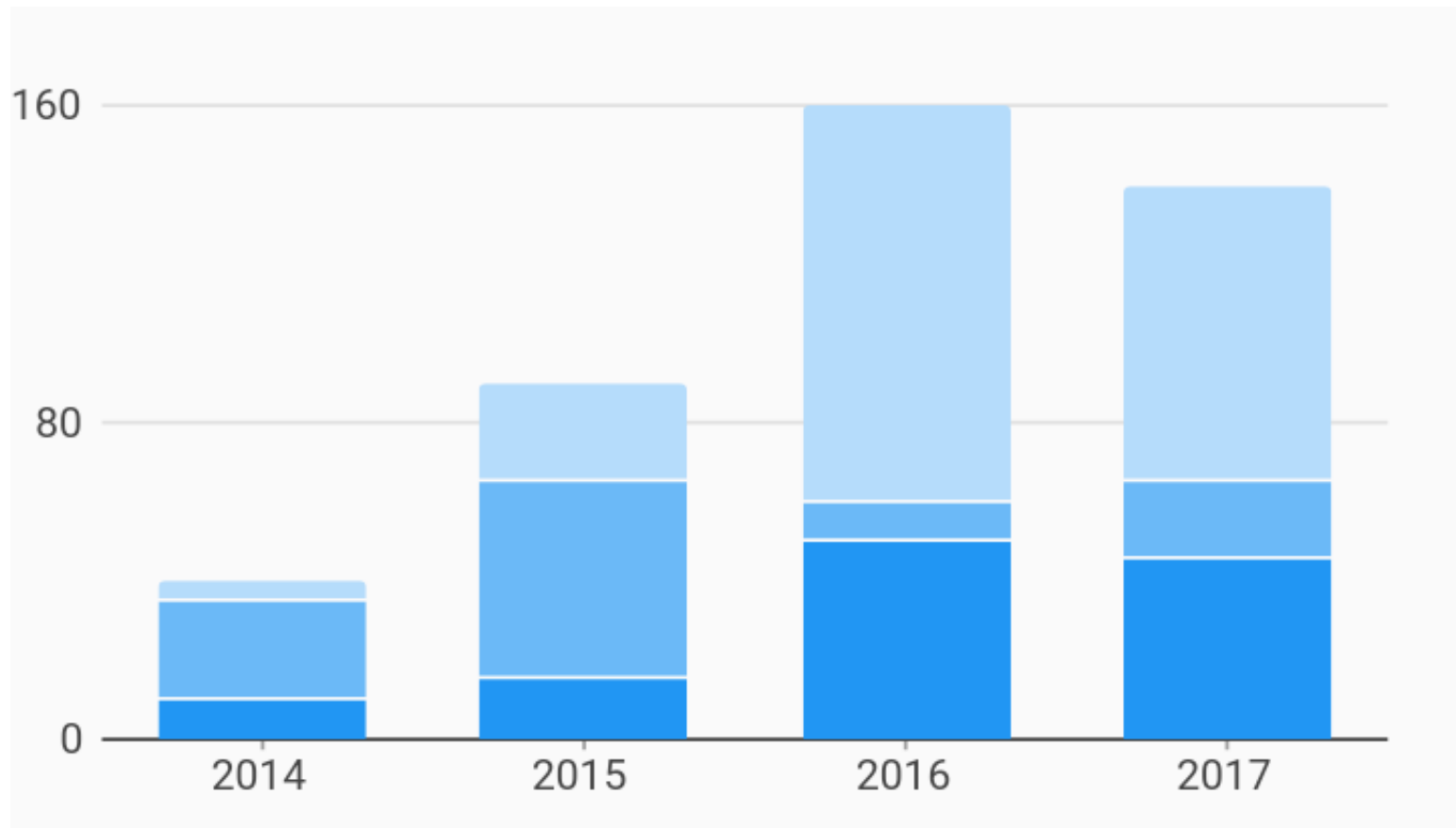


Image: <https://google.github.io/charts/flutter/gallery.html>

# Clustered/Grouped Bar Chart

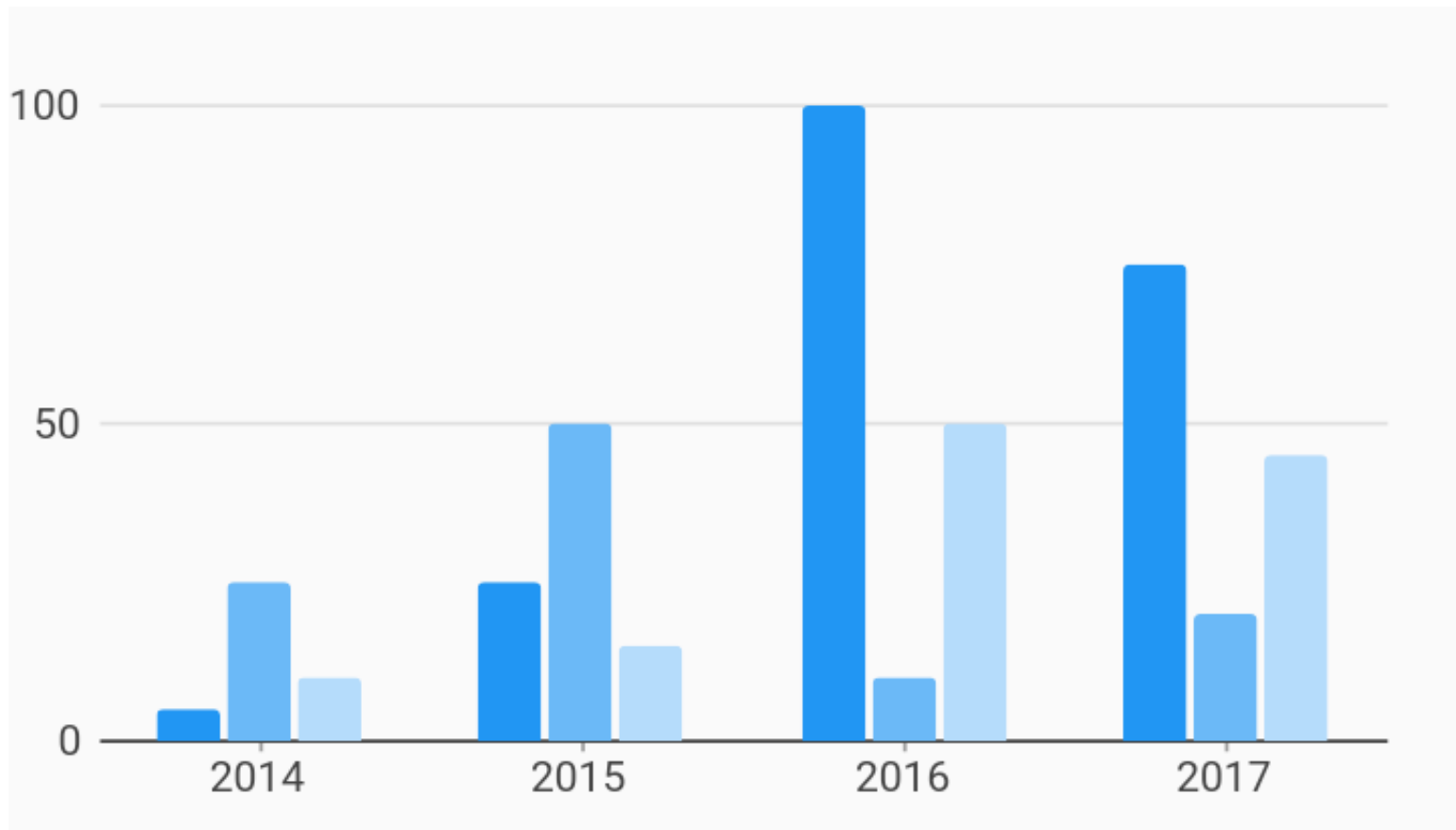


Image: <https://google.github.io/charts/flutter/gallery.html>

# Grouped-stacked Bar Chart

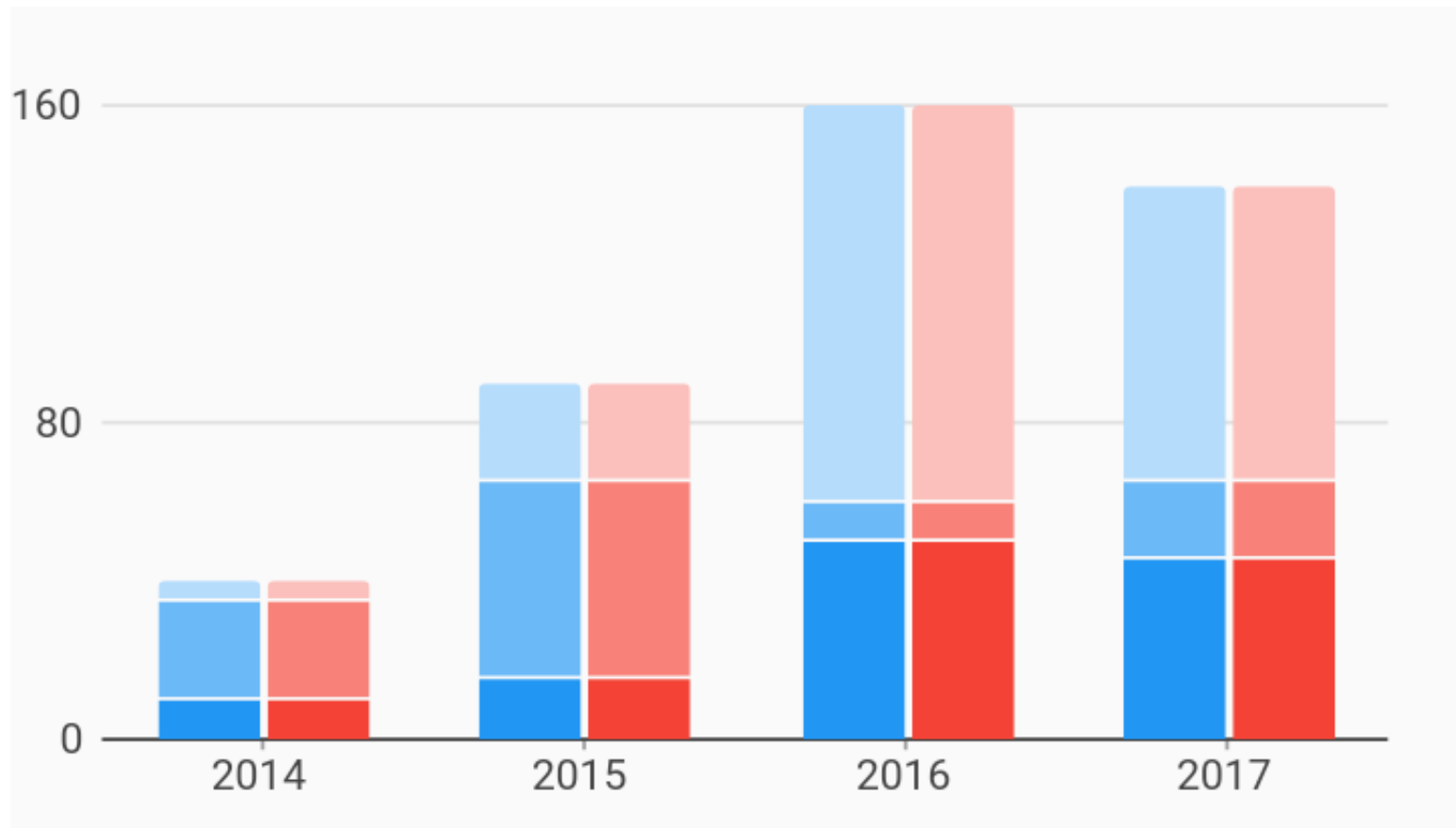


Image: <https://google.github.io/charts/flutter/gallery.html>



# Bubble Chart

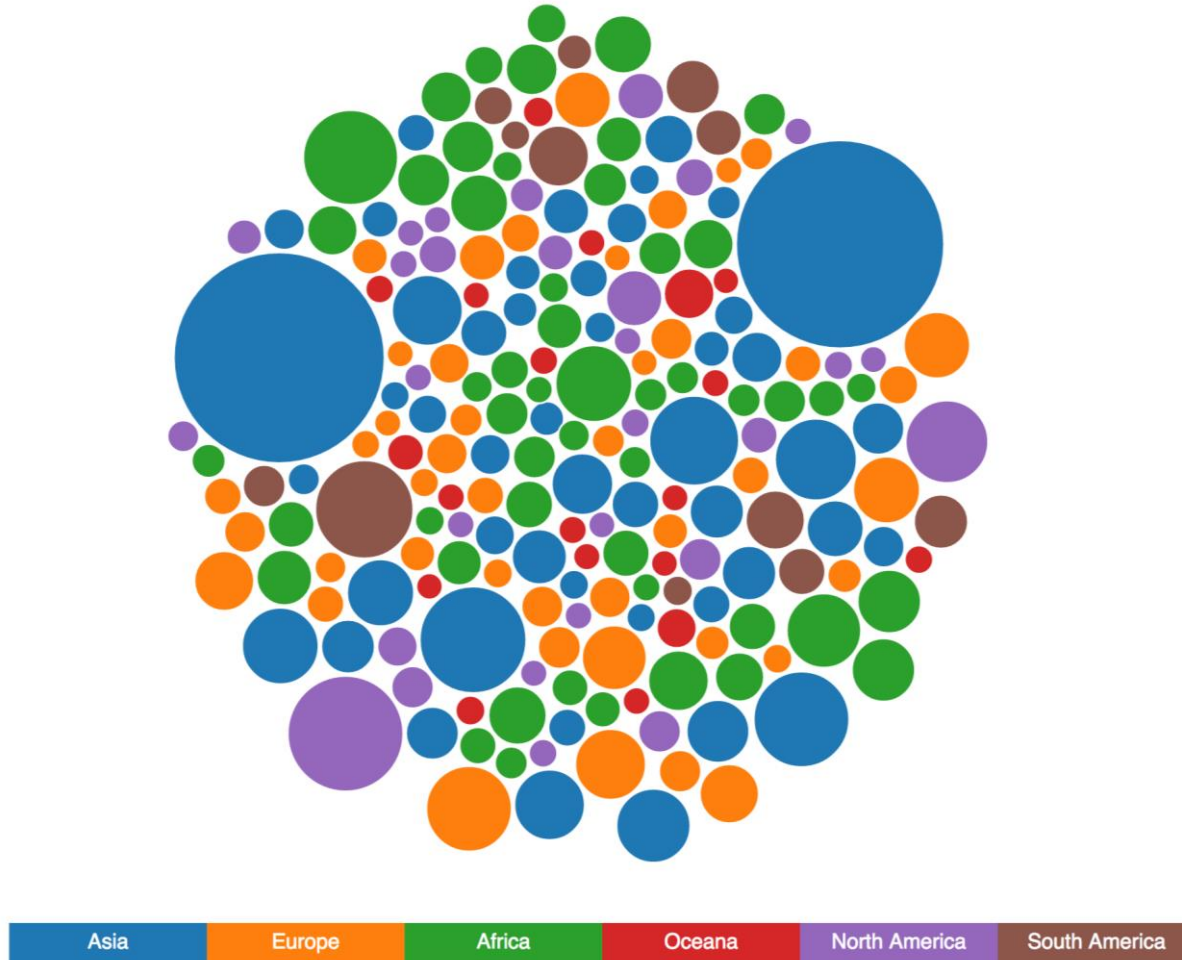


Image: <https://github.com/UsabilityEtc/d3-country-bubble-chart>

# Bubble Chart (interactive)

## Four Ways to Slice Obama's 2013 Budget Proposal

Explore every nook and cranny of President Obama's federal budget proposal.

All Spending

Types of Spending

Changes

Department Totals

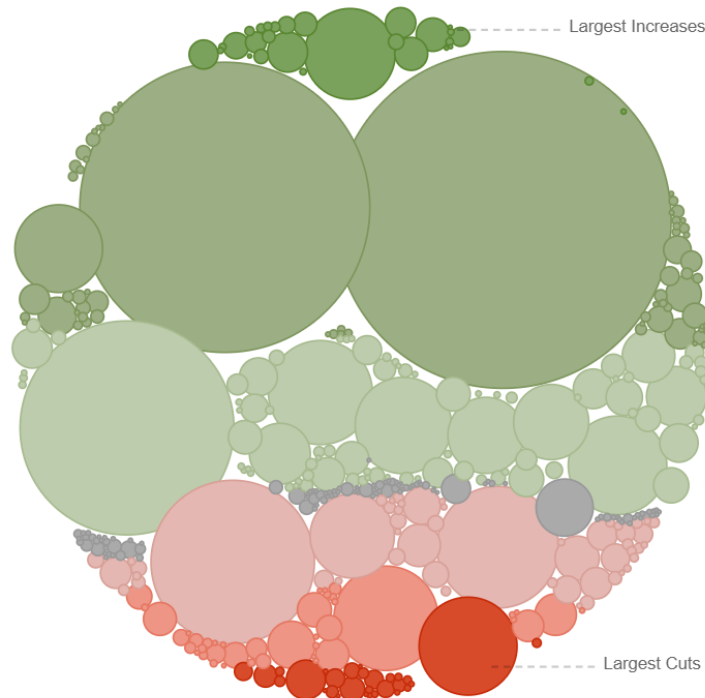
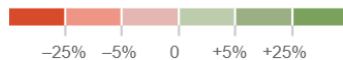
### How \$3.7 Trillion Is Spent

Mr. Obama's budget proposal includes \$3.7 trillion in spending in 2013, and forecasts a \$901 billion deficit.

Circles are sized according to the proposed spending.



Color shows amount of cut or increase from 2012.



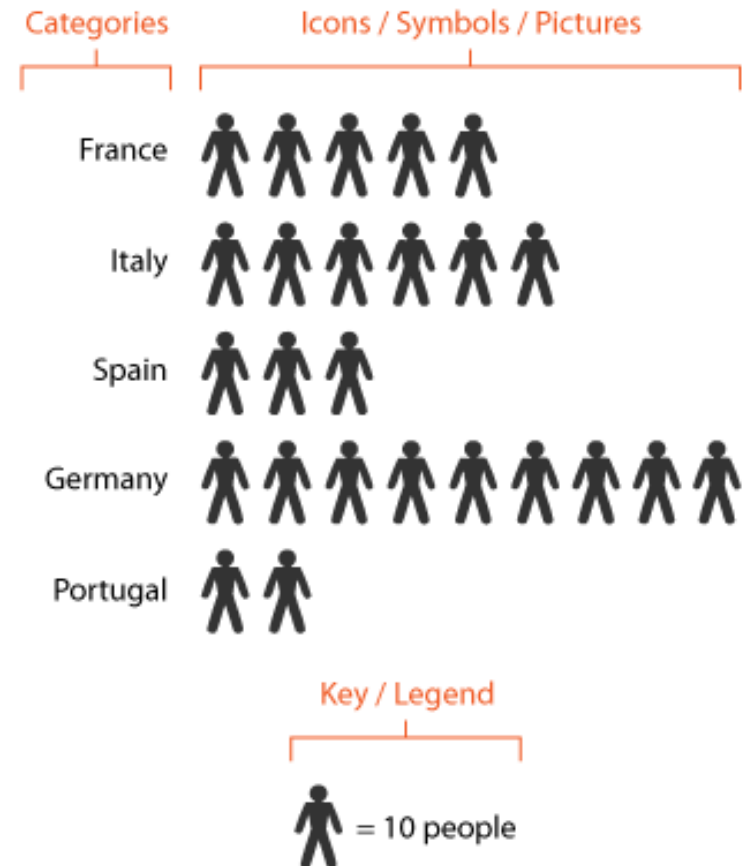
The proposal forecasts a \$901 billion deficit.

Image: [http://www.nytimes.com/interactive/2012/02/13/us/politics/2013-budget-proposal-graphic.html?\\_r=1&](http://www.nytimes.com/interactive/2012/02/13/us/politics/2013-budget-proposal-graphic.html?_r=1&)

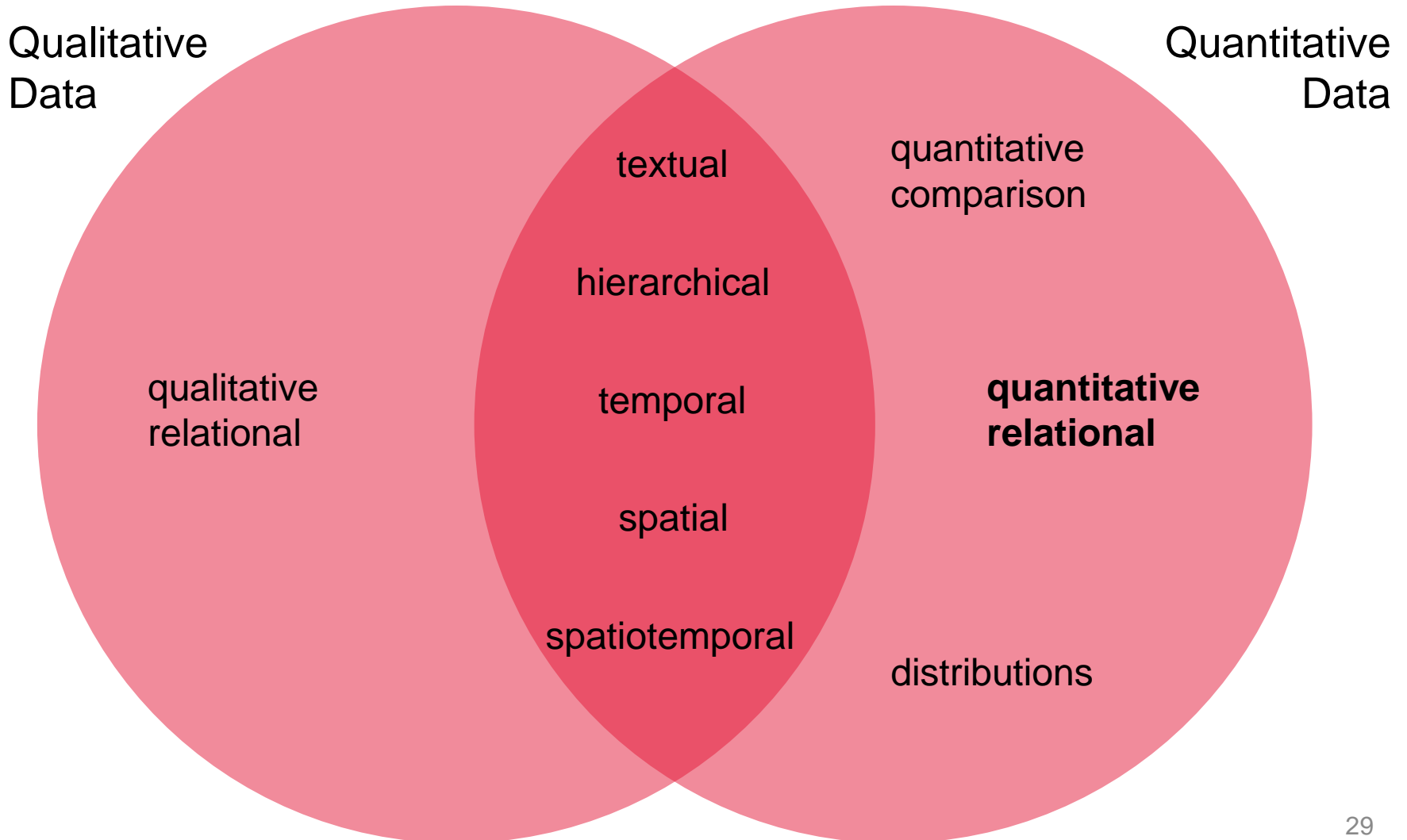
# Pictogram Chart (for discrete data)

use of icons to give a more engaging overall view of small sets of discrete data

can help overcome differences in language, culture and education



# Quantitative Relational Structures



# Line Chart

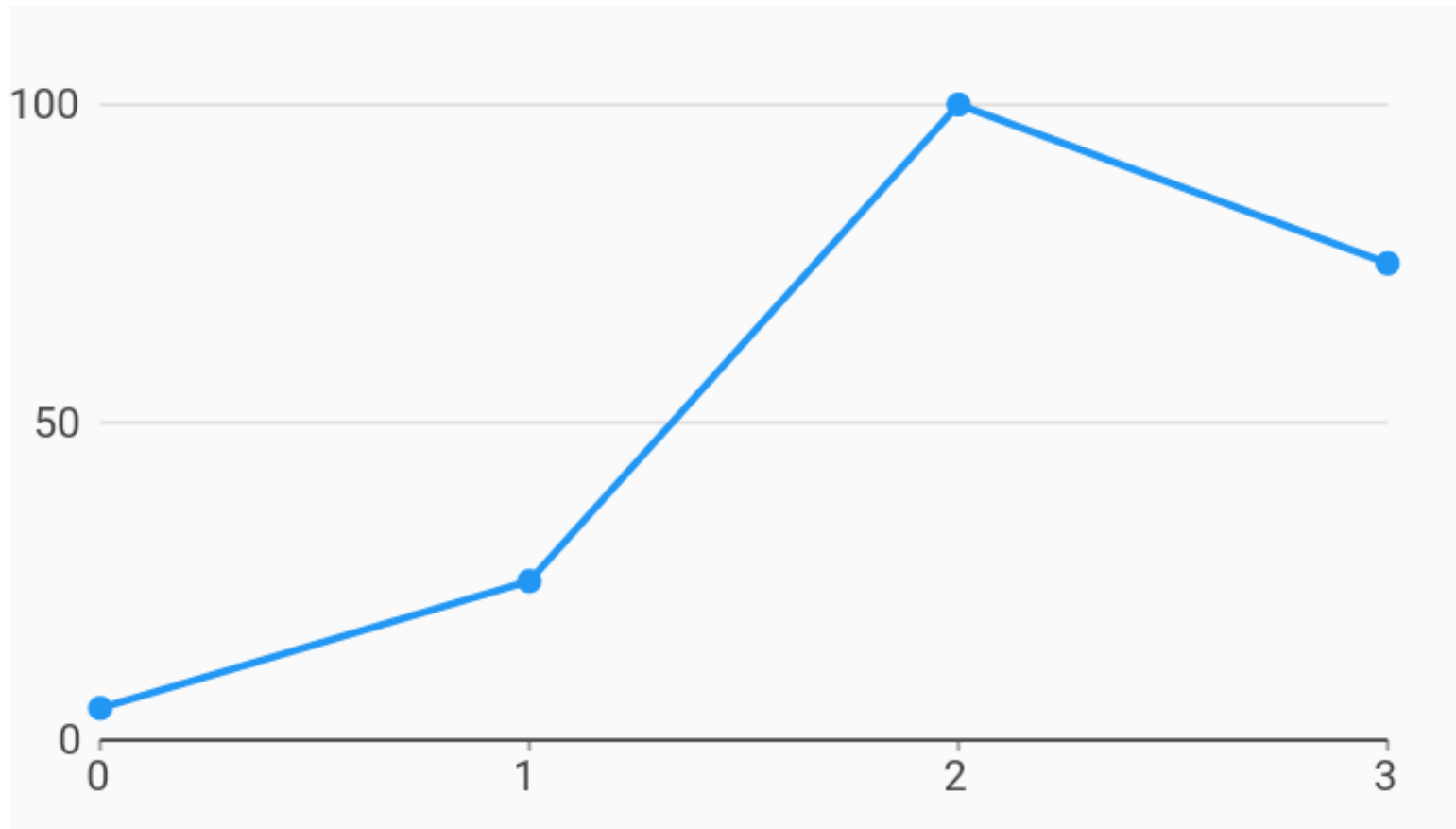


Image: <https://google.github.io/charts/flutter/gallery.html>

# Scatter Plot

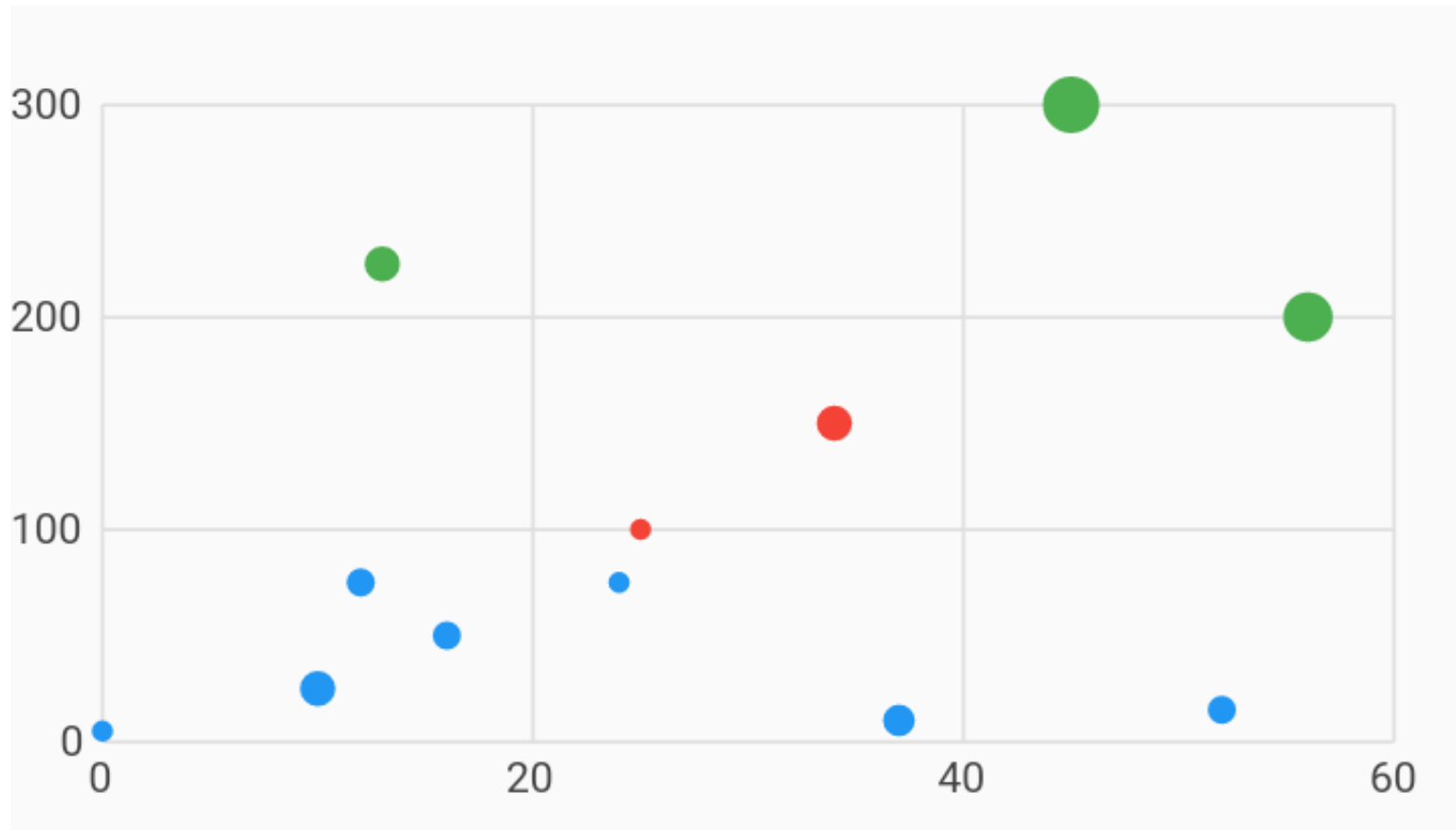


Image: <https://google.github.io/charts/flutter/gallery.html>

# 3d Coordinate Systems

Alternative ways to define plane or 3D-space:

- Cartesian
- Cylindrical
- Spherical

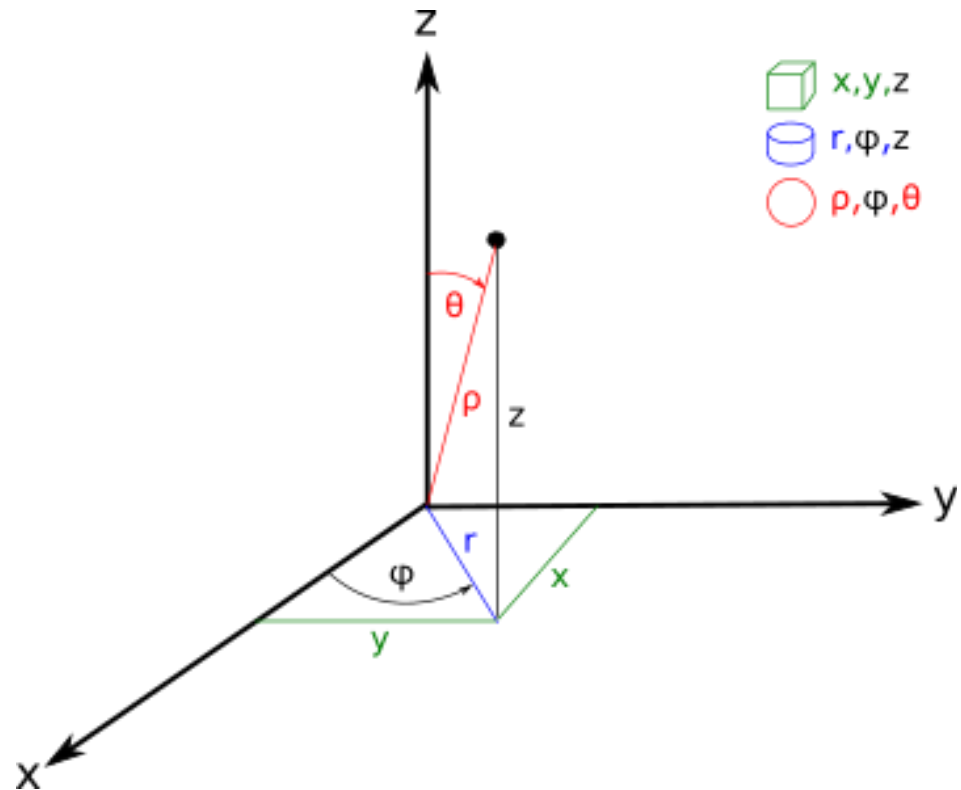


Image: <https://planetcalc.com/7952/>

# Radar Chart

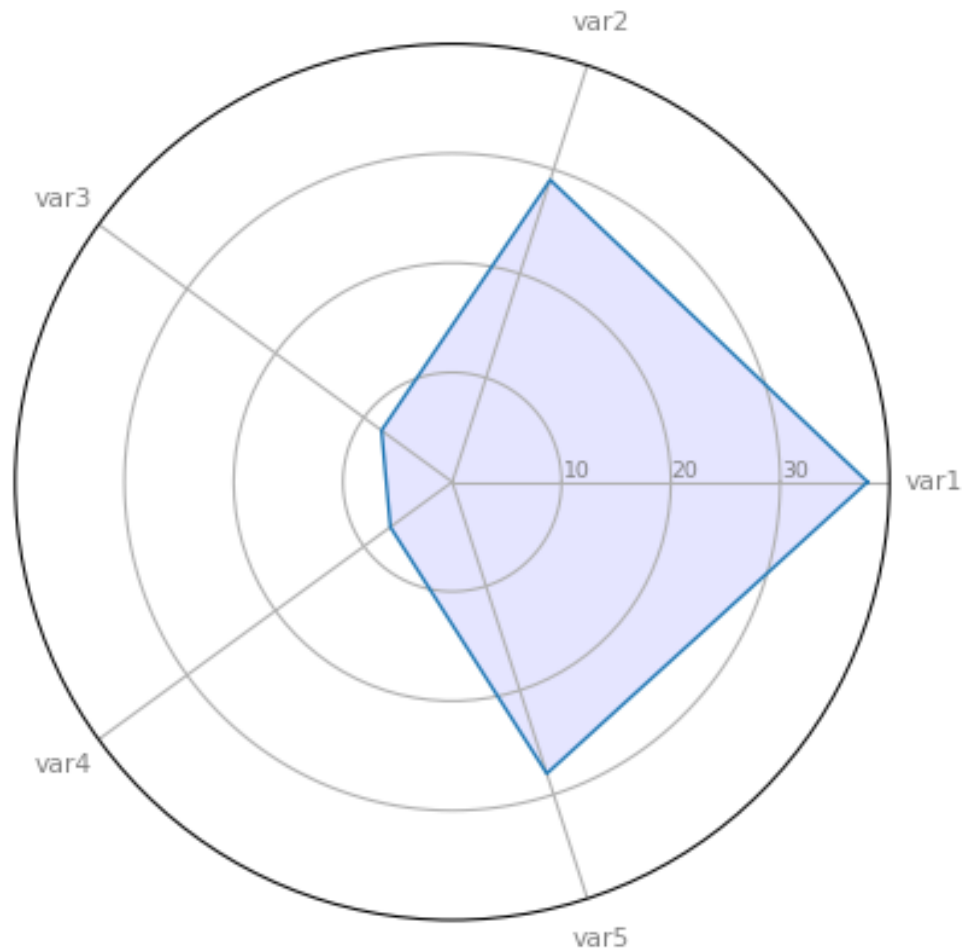


Image: <https://python-graph-gallery.com/390-basic-radar-chart/>



# Surface Plot

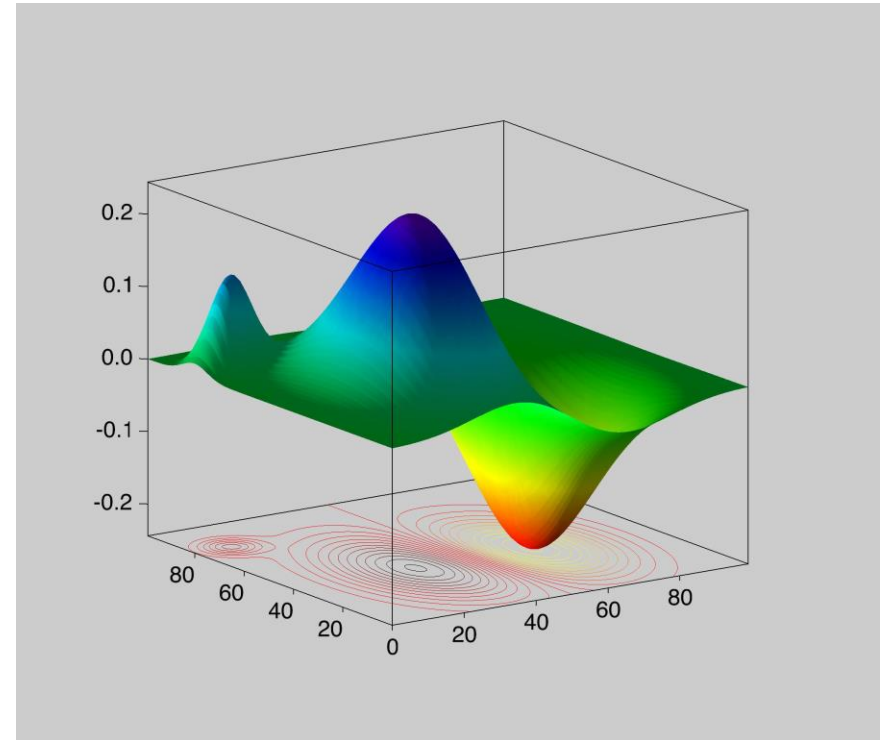
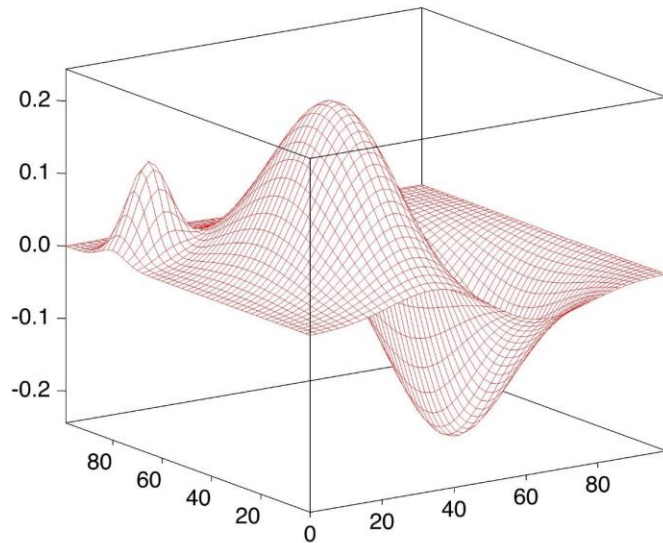


Image: <https://google.github.io/charts/flutter/gallery.html>

# Heat Map

Google eye-tracking heatmap study to optimize analysis of search results

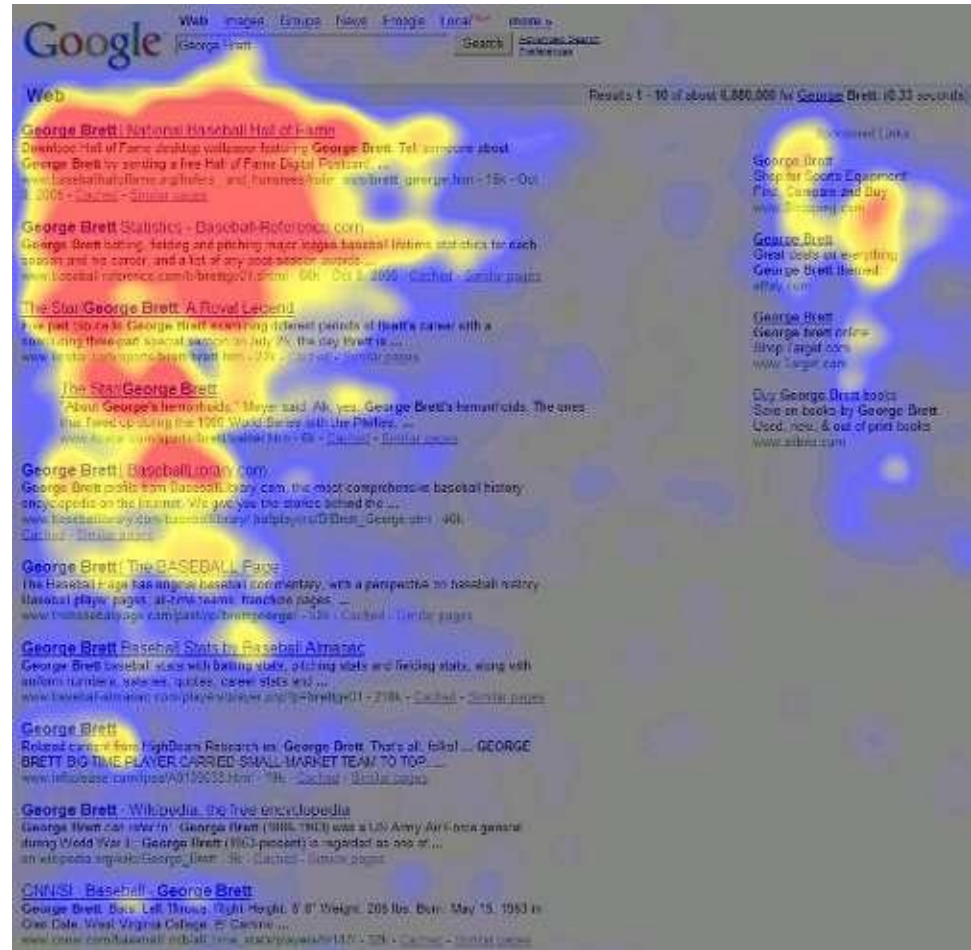


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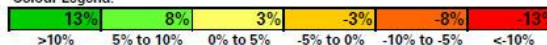
# Heat Map/ Co-occurrence Map

Flows into all fund classes (all, including ETFs) – a time series

Figure 15: Heat map\* showing the flows as % of total assets into various fund classes (all including ETFs)

Fund Category	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013 YTD
<b>Total Equity Funds</b>	4%	3%	3%	1%	-3%	2%	2%	-1%	1%	3.4%
<b>Total Developed Market Equity Funds</b>	4%	2%	2%	-1%	-3%	-1%	0%	0%	0%	3.8%
International Equity Funds	8%	6%	7%	6%	-4%	4%	1%	1%	1%	3.8%
US Equity Funds	1%	-1%	-1%	0%	0%	-4%	0%	0%	-1%	3.5%
Western Europe Equity Funds	1%	-1%	7%	-13%	-12%	1%	-3%	-2%	-2%	0.4%
Japan Equity Funds	52%	44%	0%	27%	-18%	-19%	-3%	5%	10%	24.7%
Pacific Equity Funds	7%	-3%	12%	-1%	-16%	17%	8%	-8%	1%	7.9%
<b>Total Emerging Market Equity Funds</b>	3%	16%	11%	12%	-7%	27%	16%	-5%	7%	0.4%
Global Emerging Market Equity Funds	-10%	3%	4%	10%	-4%	32%	23%	-1%	12%	2.5%
EMEA Equity funds	27%	40%	-6%	-2%	-8%	11%	20%	-11%	-4%	-7.4%
Latin America Equity Funds	10%	81%	27%	46%	-12%	48%	4%	-12%	-1%	-8.5%
Asia Pacific Ex-Japan Funds	21%	22%	27%	14%	-9%	21%	10%	-7%	3%	0.2%
<b>Total Bond Funds</b>	14%	4%	8%	-2%	-10%	24%	16%	4%	11%	1.5%
<b>International Bond Funds</b>	12%	12%	10%	-2%	-24%	25%	23%	3%	6%	1.1%
<b>Corporate High Yield Bond Funds</b>	NA	-18%	-2%	-4%	-5%	40%	15%	4%	18%	1.4%
<b>US Bond Funds</b>	NA	-17%	-9%	4%	-2%	23%	10%	6%	12%	2.2%
Western Europe Bond funds	NA	1%	58%	-8%	-46%	29%	-7%	-28%	2%	-3.4%
Germany Bond funds	NA	NA	NA	NA	NA	NA	29%	25%	-13%	-5.7%
Switzerland Bond funds	NA	NA	NA	NA	NA	NA	-65%	-19%	-2%	-2.0%
United Kingdom Bond funds	NA	22%	-17%	-141%	-26%	64%	8%	-3%	0%	-4.1%
<b>Emerging Markets Debt Funds</b>	12%	24%	18%	9%	-21%	19%	54%	7%	25%	2.4%
Asia ex-Japan Bond funds	NA	4%	3%	16%	-10%	2%	71%	25%	12%	2.2%
Emerging Europe Bond funds	NA	40%	-12%	-18%	-37%	-19%	-8%	-39%	-9%	0.1%
Lat-Am Bond funds	NA	28%	-22%	-33%	-30%	19%	46%	38%	68%	2.8%
<b>Money Market Funds</b>	NA	NA	NA	NA	31%	-17%	-15%	-4%	-1%	-2.7%

Colour Legend:



Source: EPFR, Deutsche Bank calculations

Image: <https://www.zerohedge.com/news/2013-08-09/definitive-fund-flows-heatmap-10-years-capital-flows>

# Area Graph

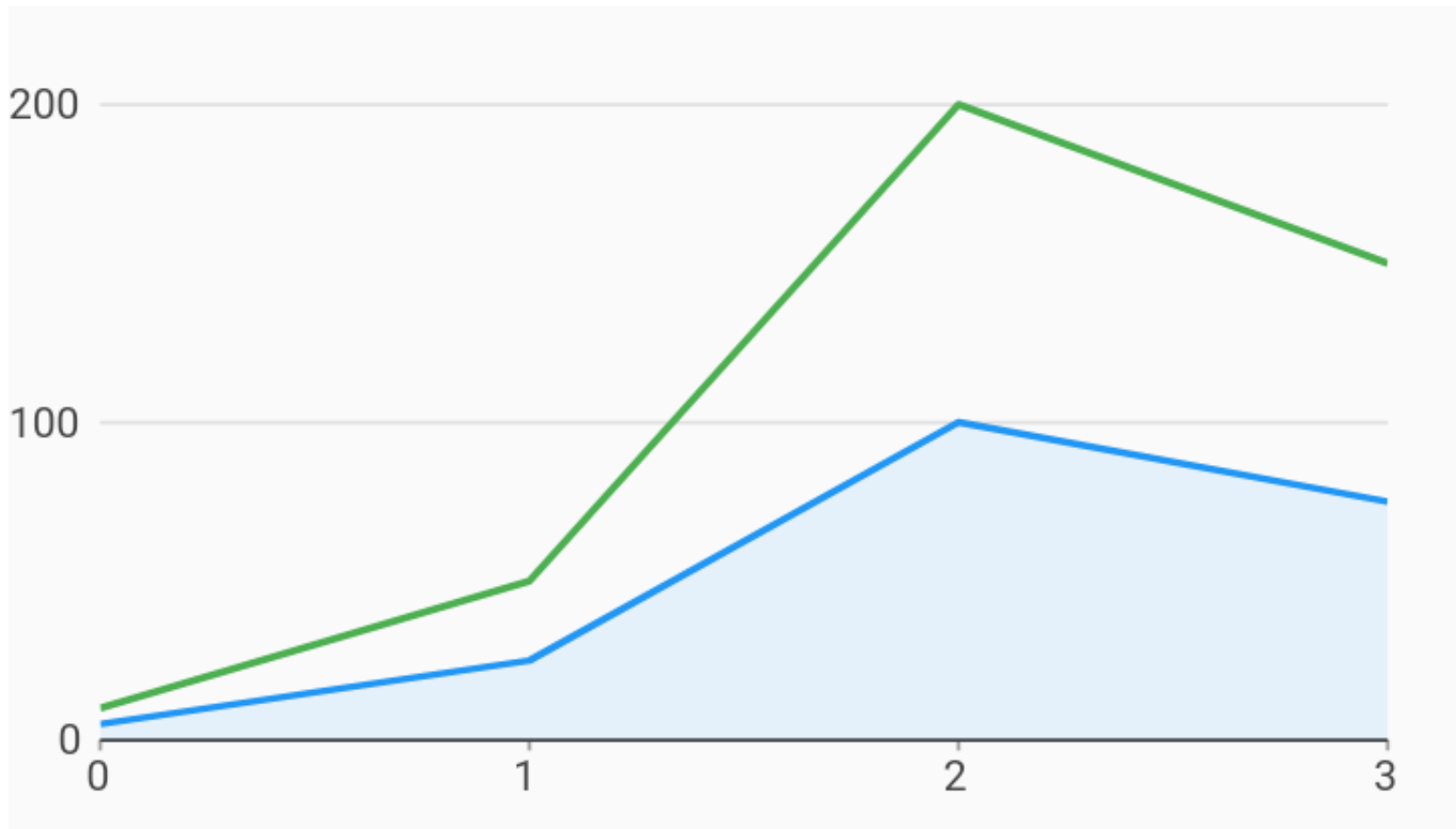


Image: <https://google.github.io/charts/flutter/gallery.html>

# Stacked Area Graph

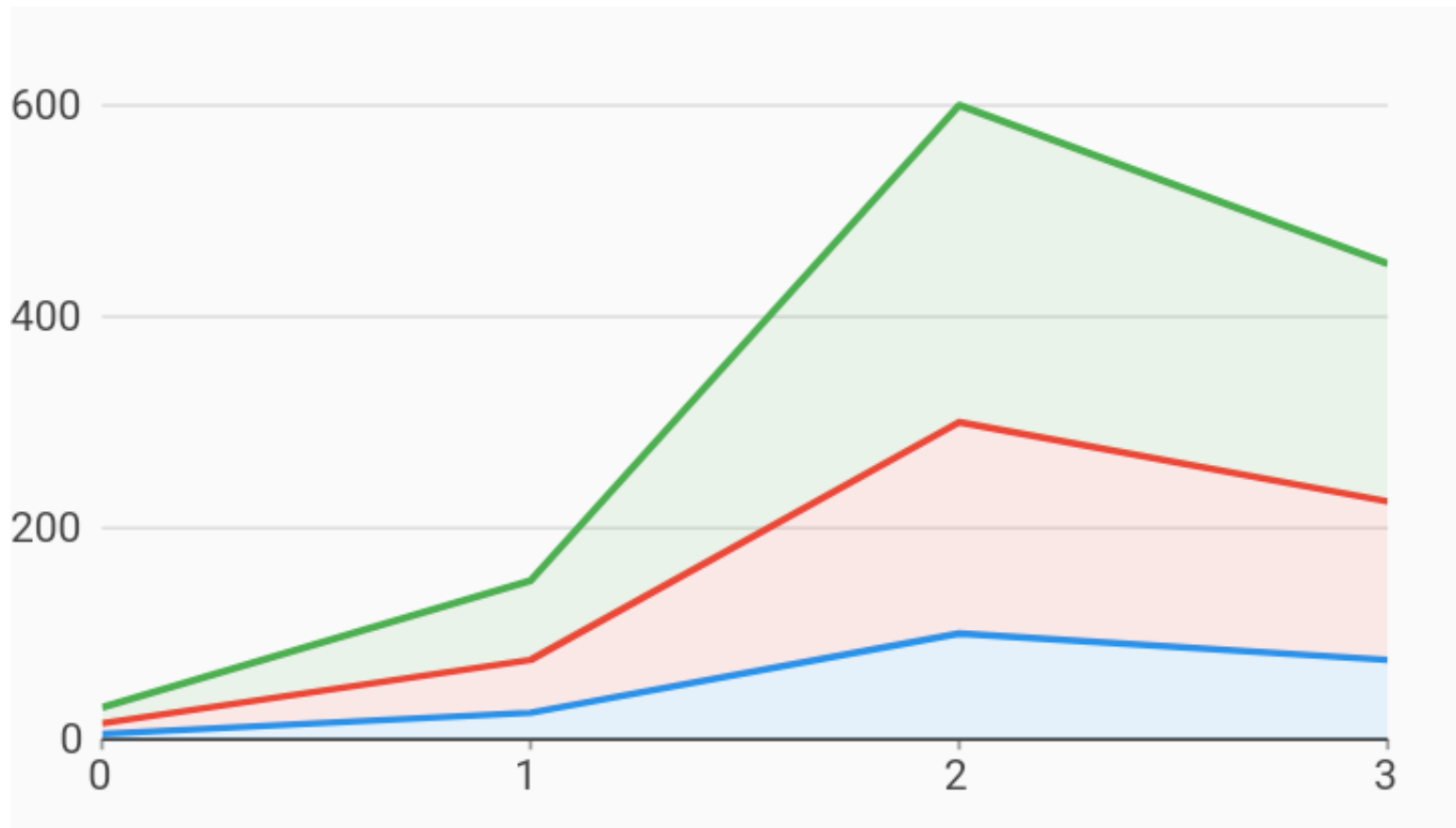
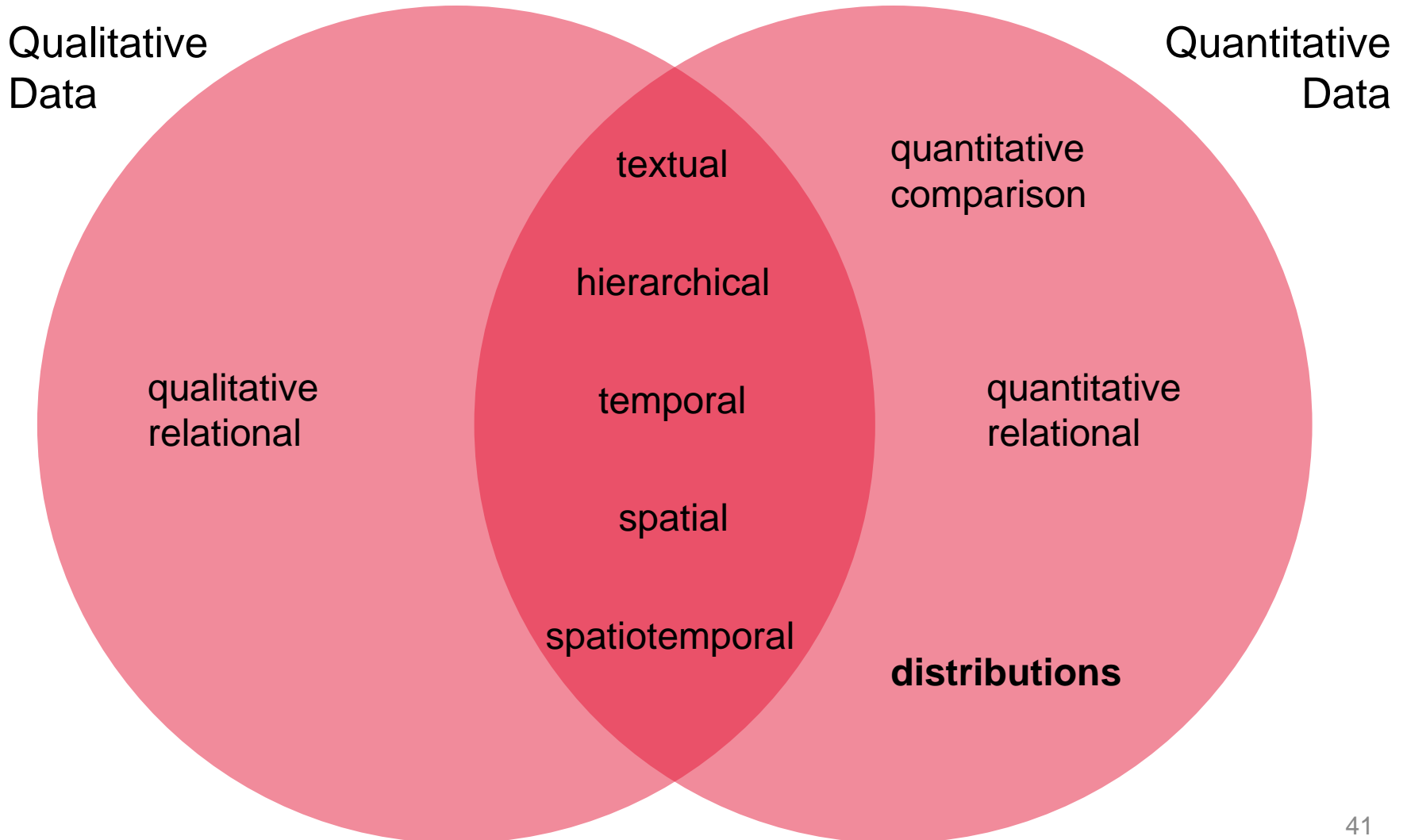
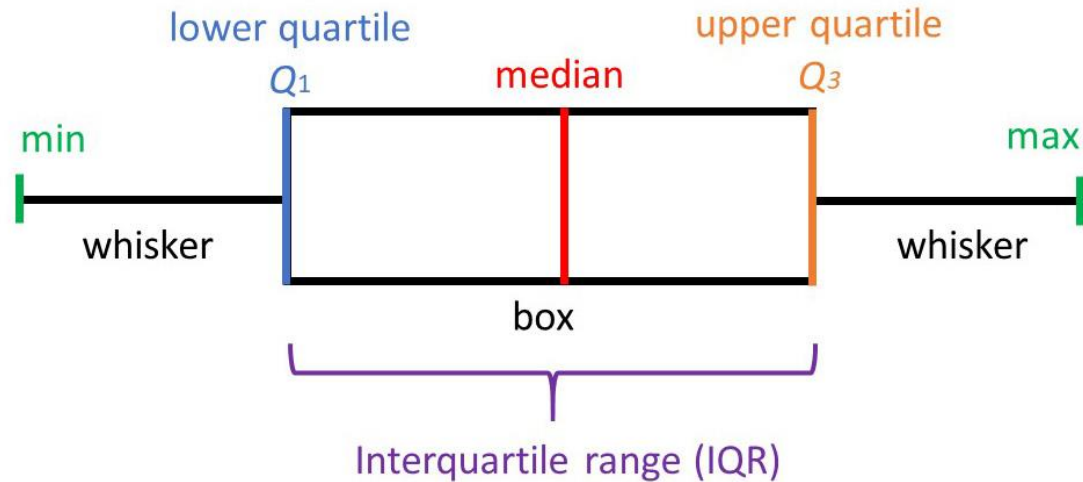


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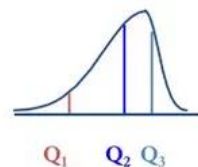
# Distribution Structures



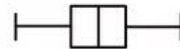
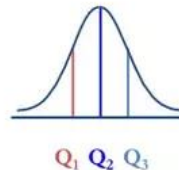
# Box and Whisker Box



Left-Skewed



Symmetric



Right-Skewed

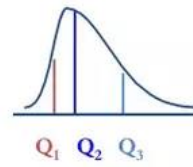


Image: <https://www.simplypsychology.org/boxplots.html>

# Box and Whisker Box

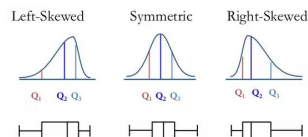
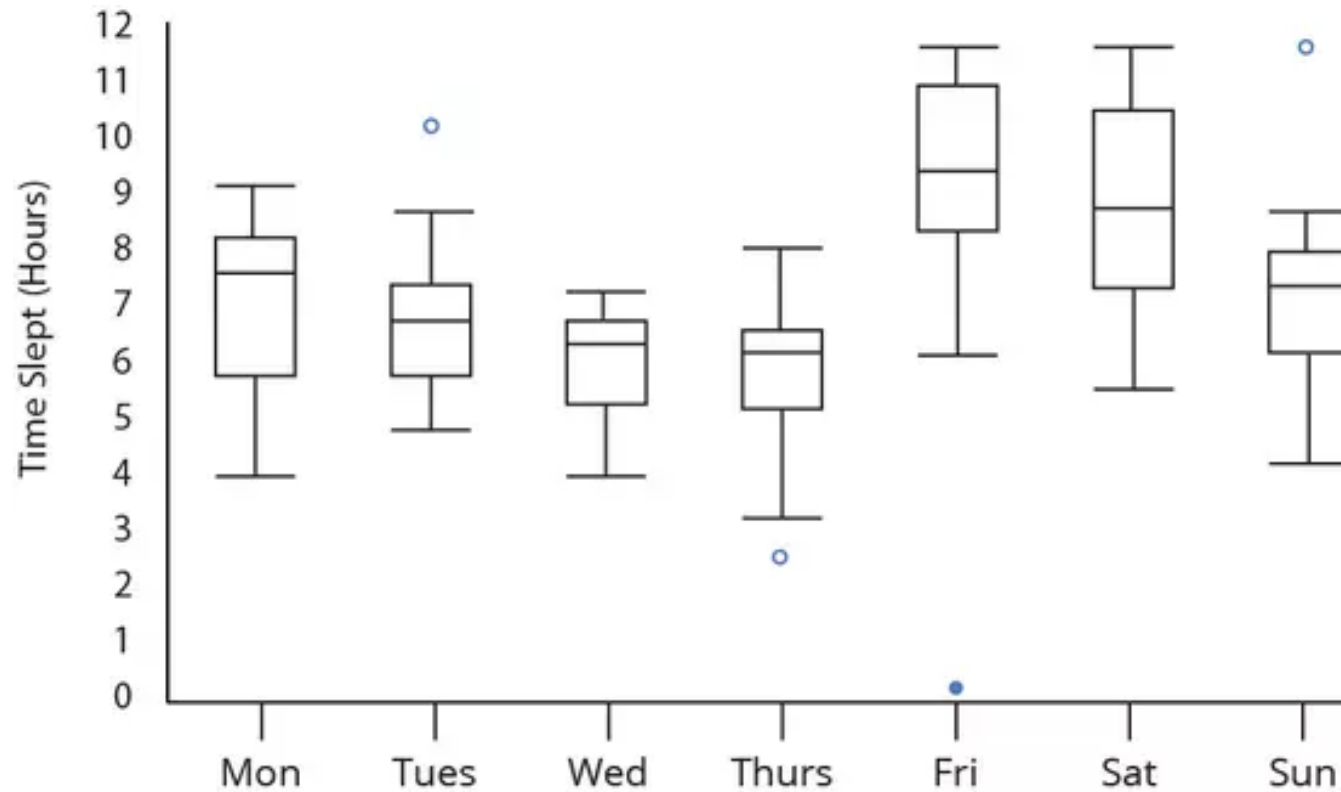


Image: <https://www.simplypsychology.org/boxplots.html>



# Histogram

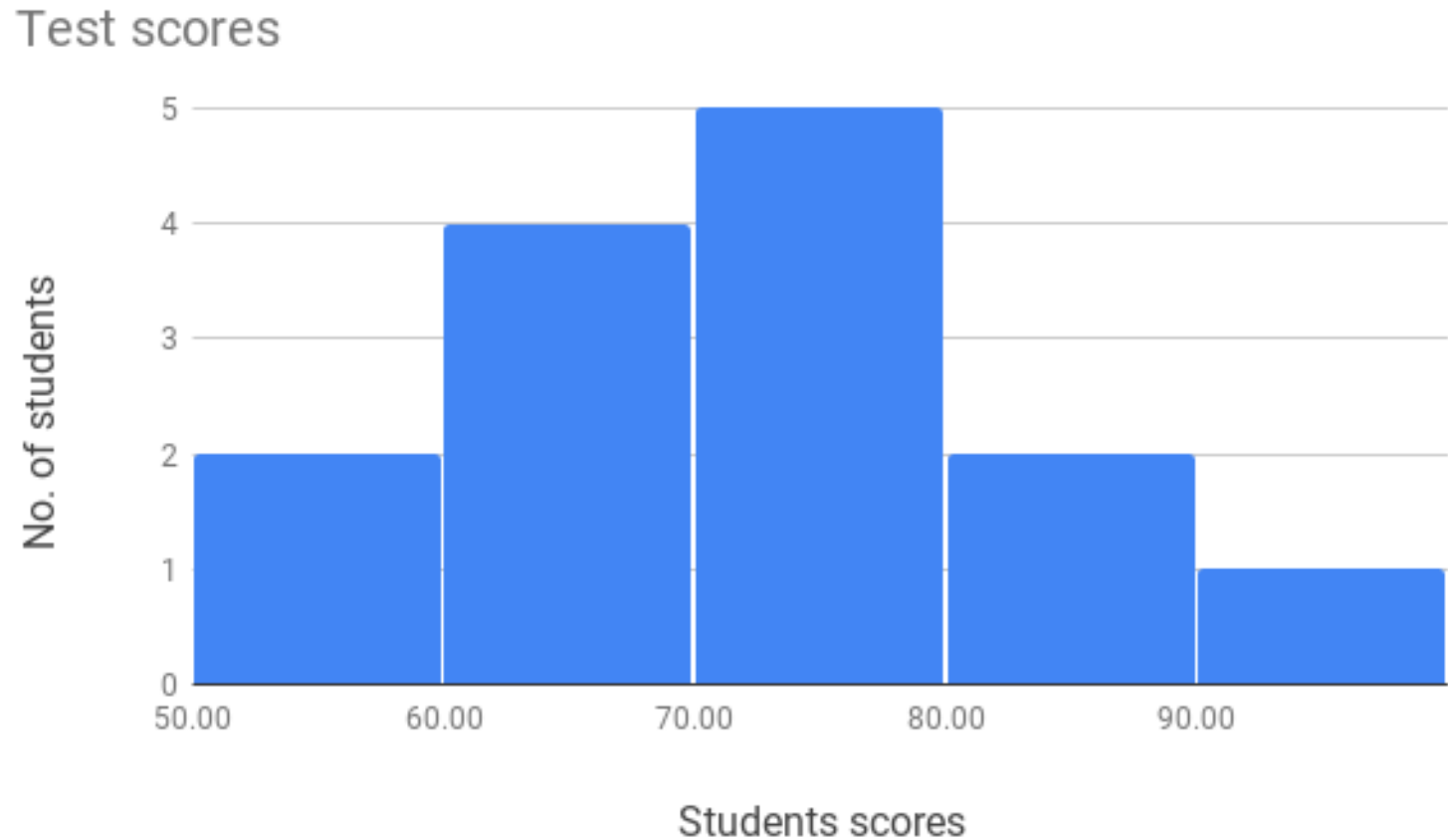
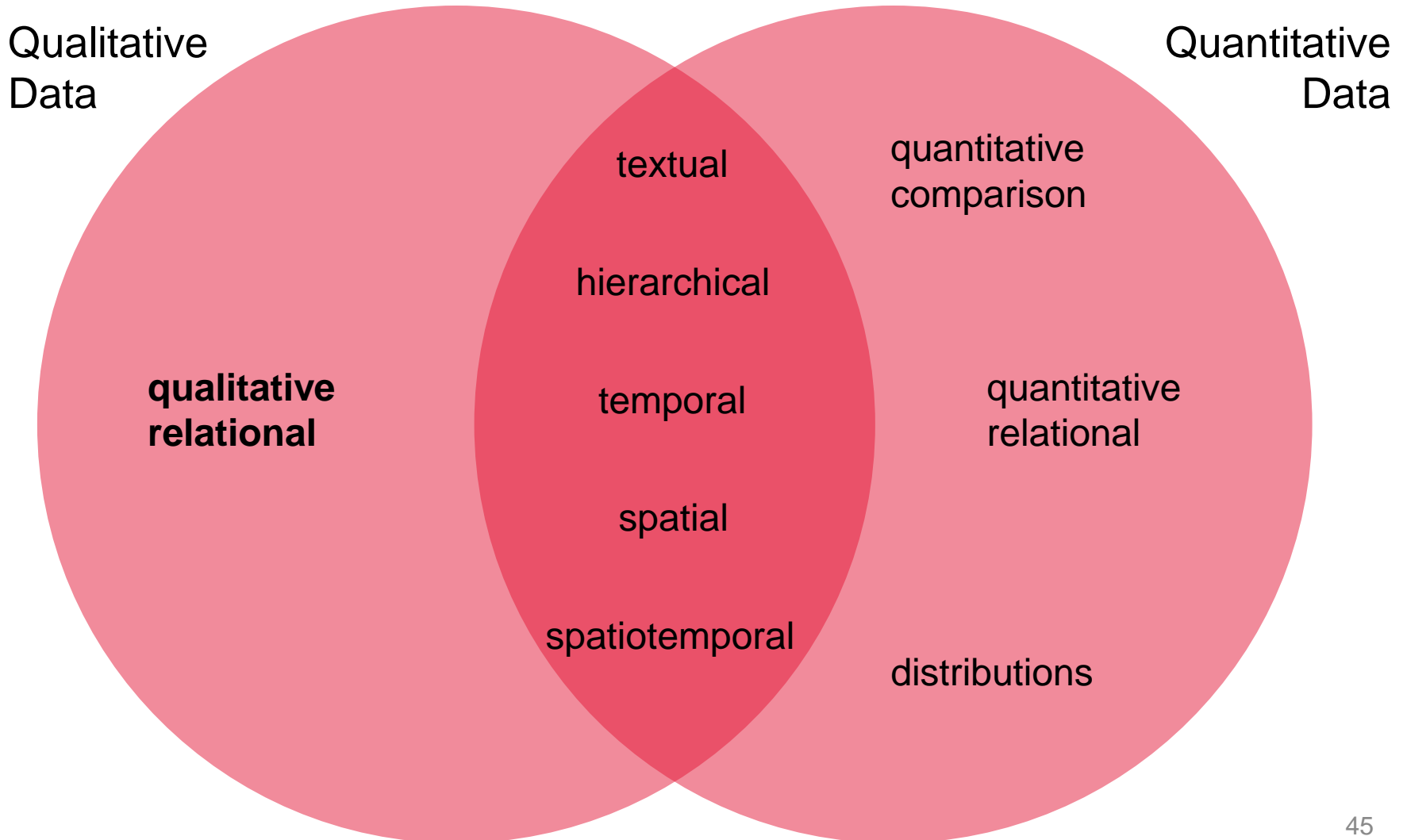


Image: <https://support.google.com/docs/answer/9146867?hl=en>

# Quantitative Relational Structures



# Networks: Force-directed Layout

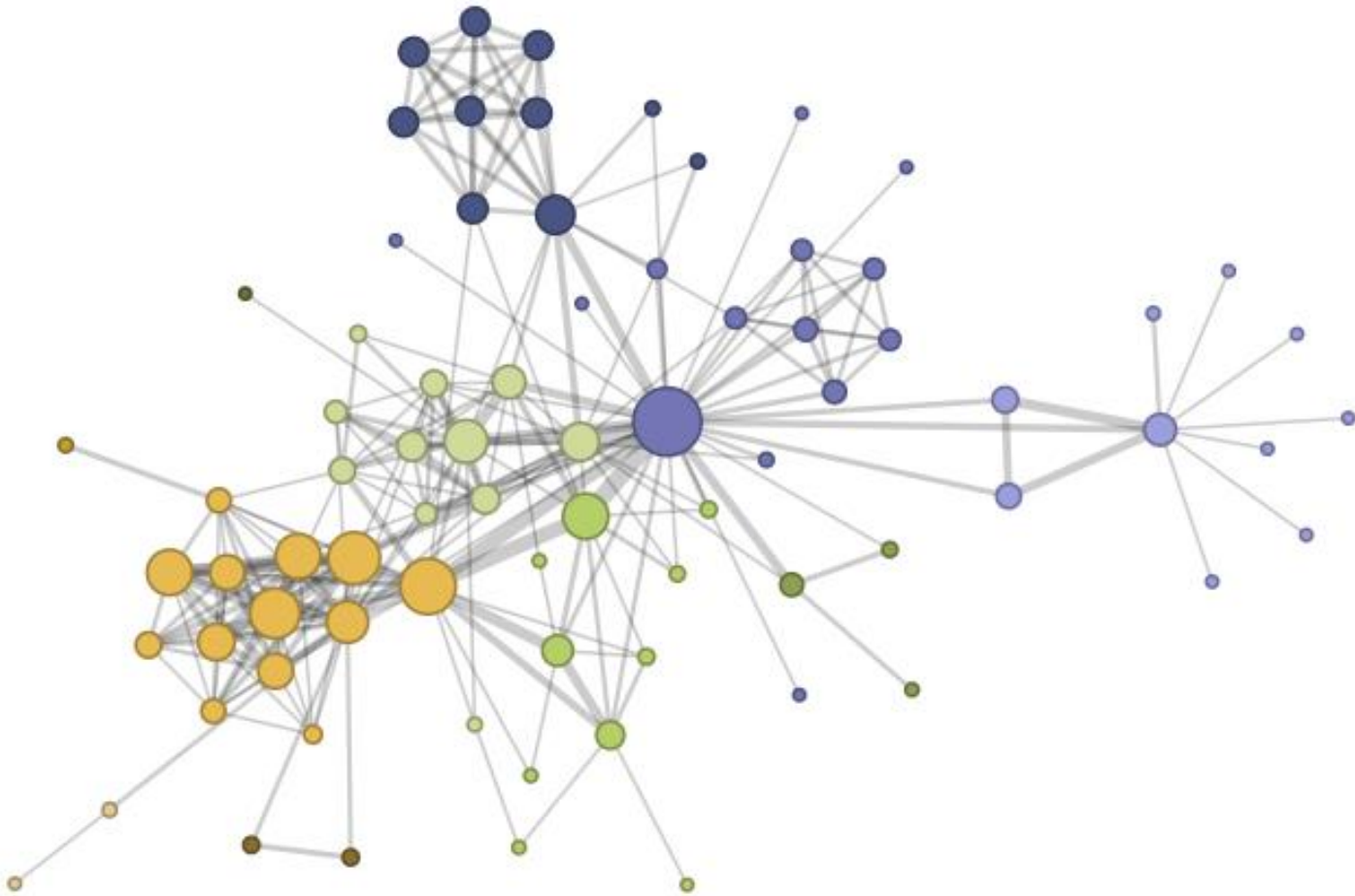


Image: <https://homes.cs.washington.edu/~jheer/files/zoo/>

# Networks: Arc Graph

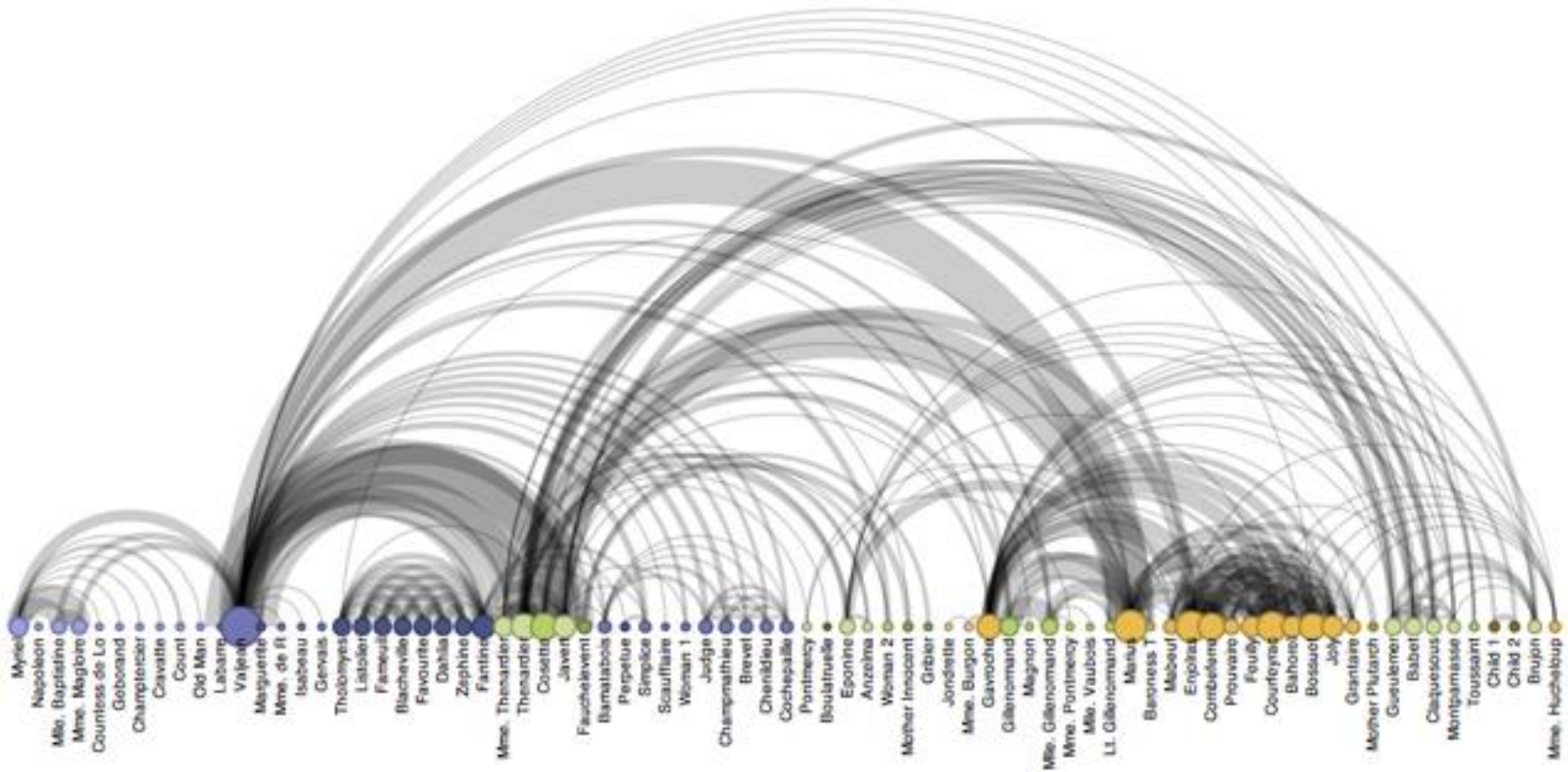


Image: <https://homes.cs.washington.edu/~jheer/files/zoo/>

# Networks: Adjacency Matrix

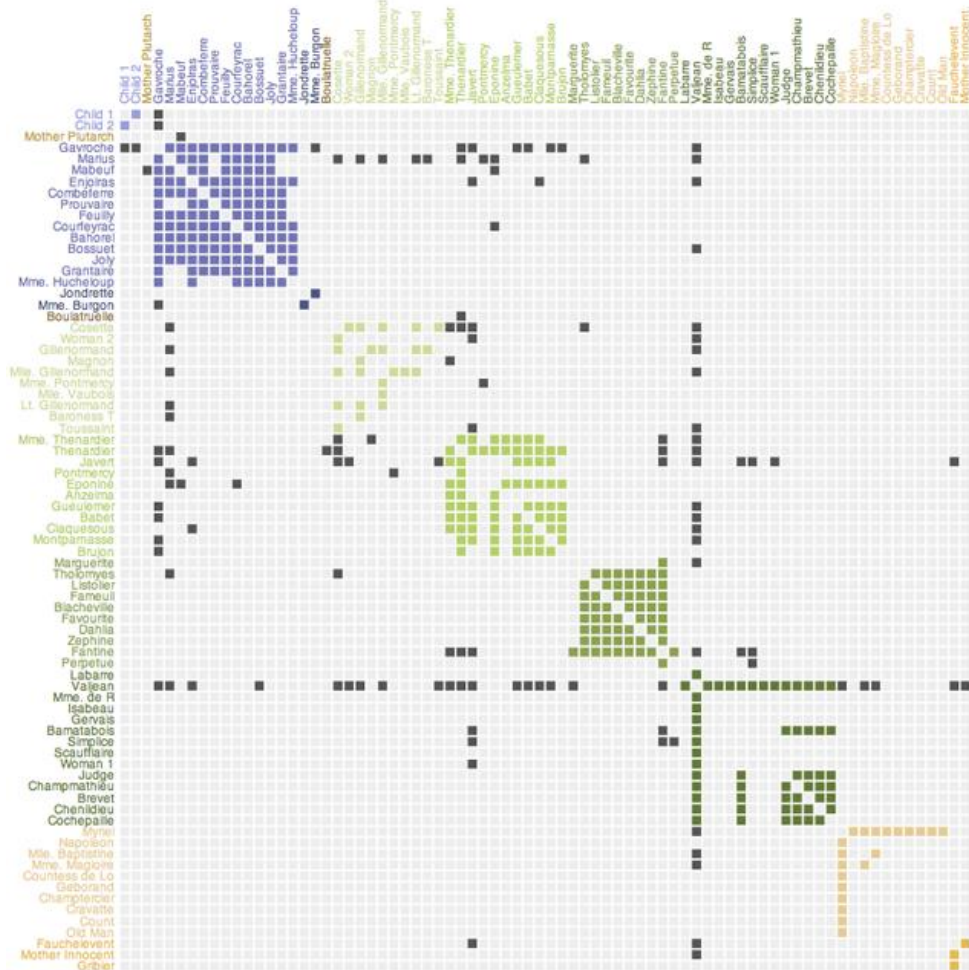


Image: <https://homes.cs.washington.edu/~jheer/files/zoo/>

# Networks: Chord Diagram

## movement of refugees within Africa in 2011

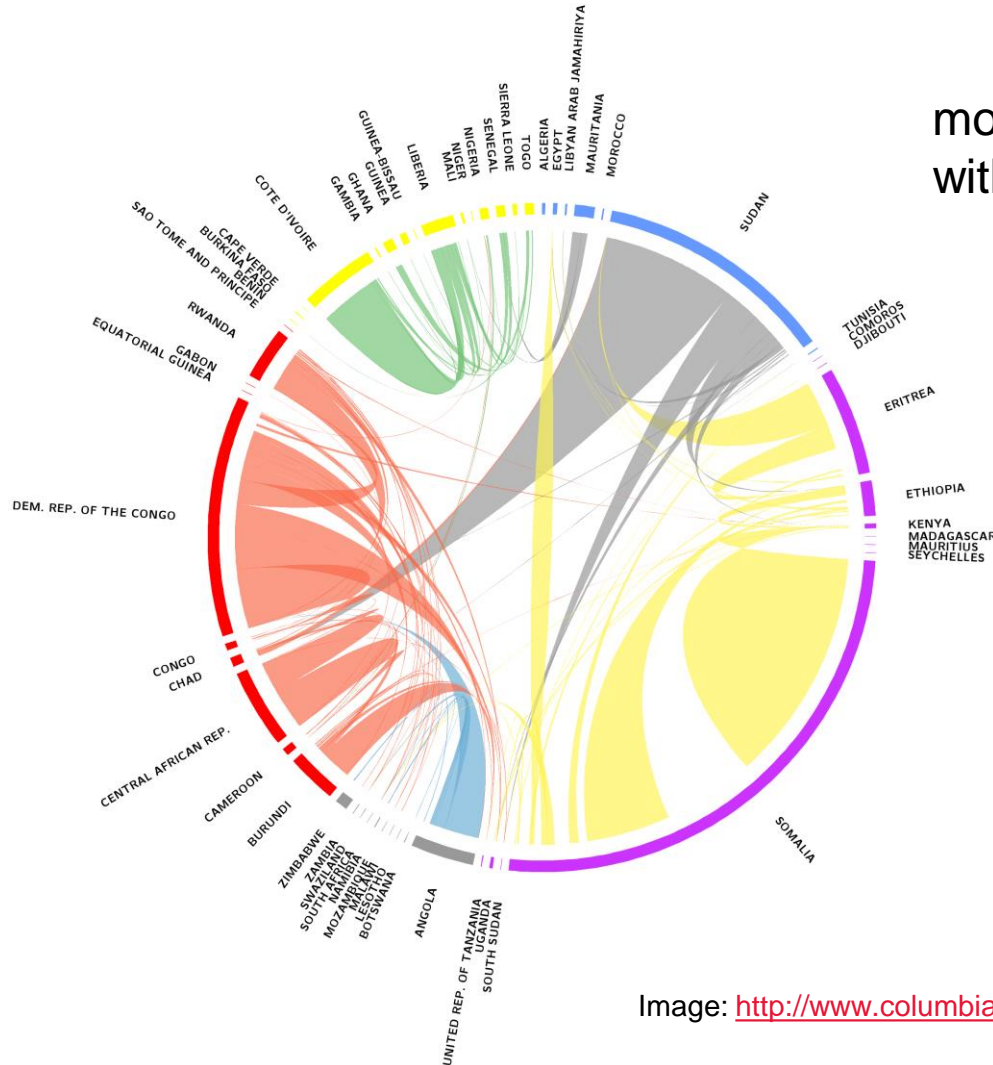
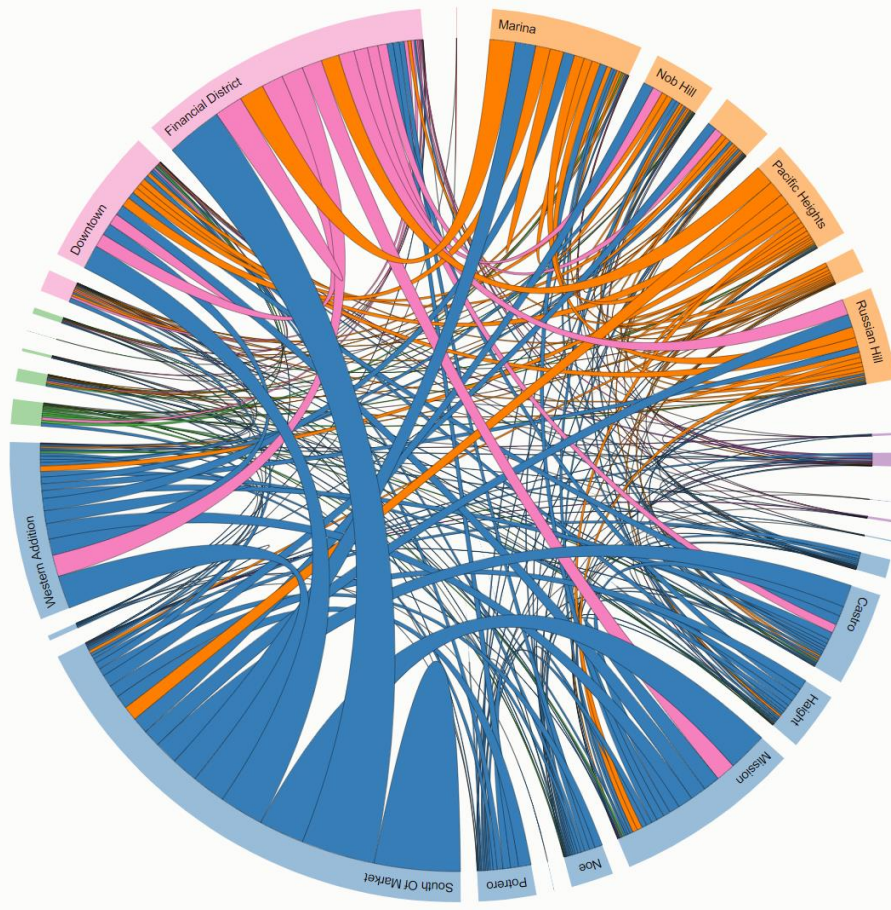


Image: <http://www.columbia.edu/~yq2154/Africa/crossBorder.html>



# Networks: Chord Diagram (interactive)



Uber rides in SF  
by neighborhoods

Image: <https://bost.ocks.org/mike/uberdata/>

# Networks: Sankey Charts

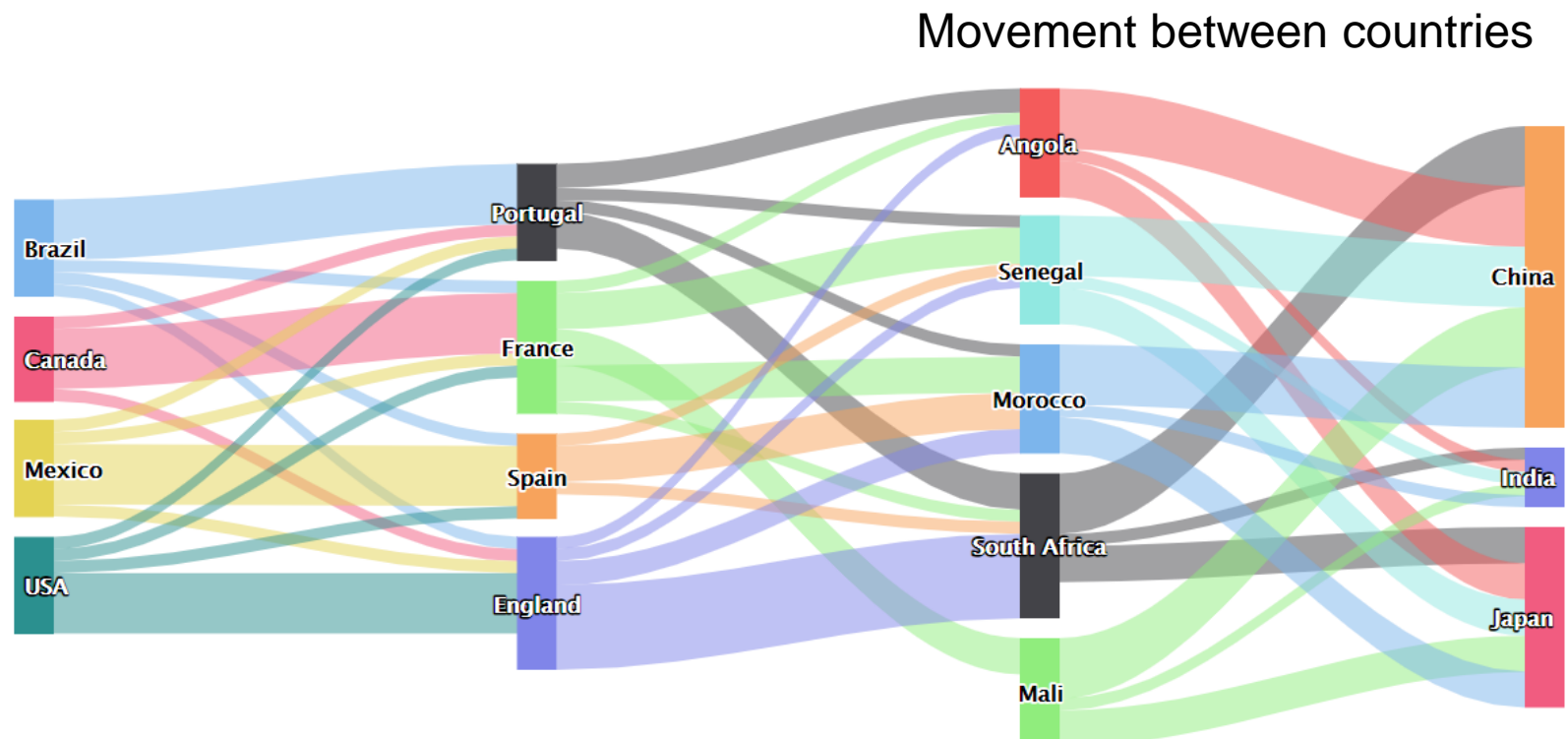
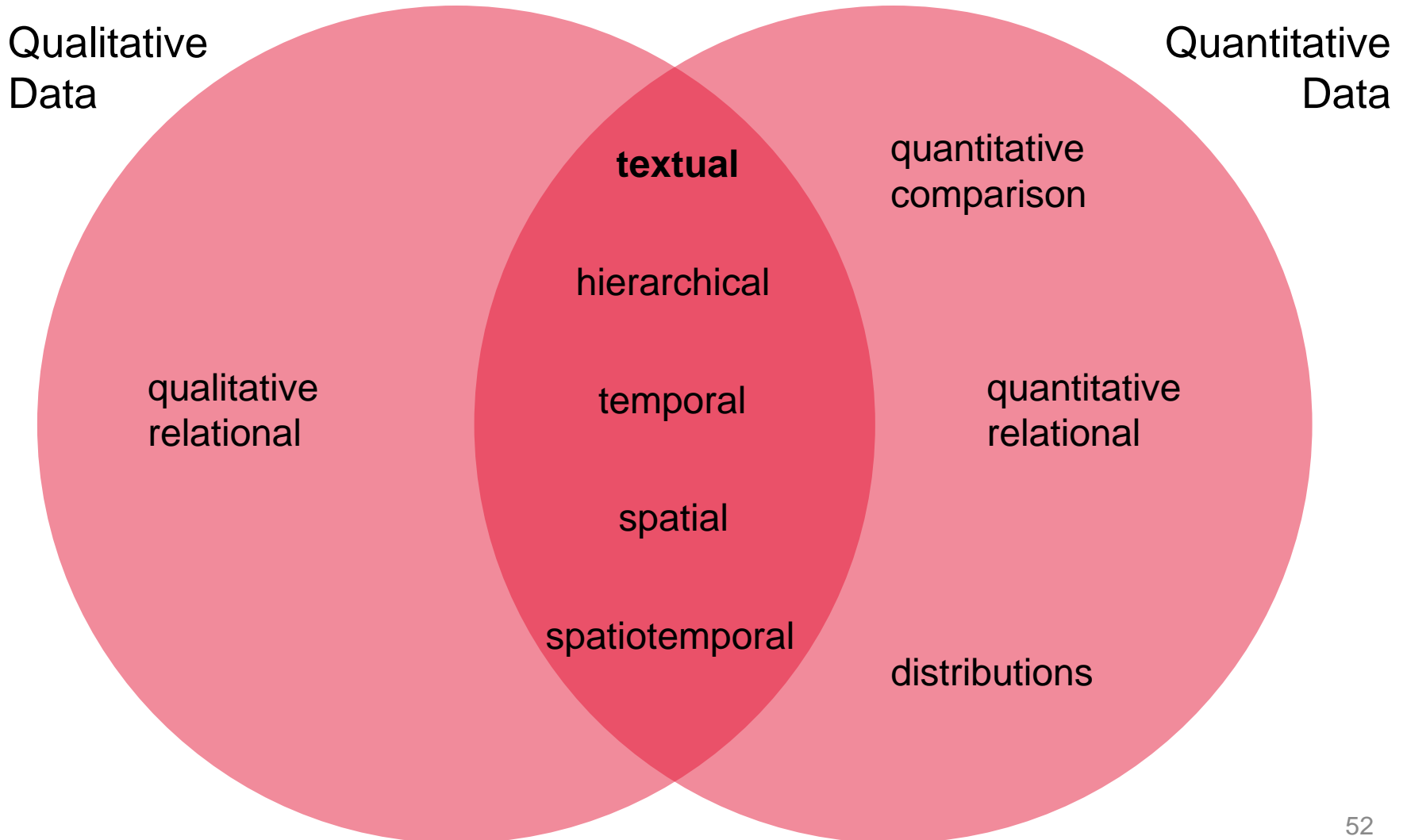


Image: <https://www.highcharts.com/demo/sankey-diagram>



# Textual Structures



# Word Cloud

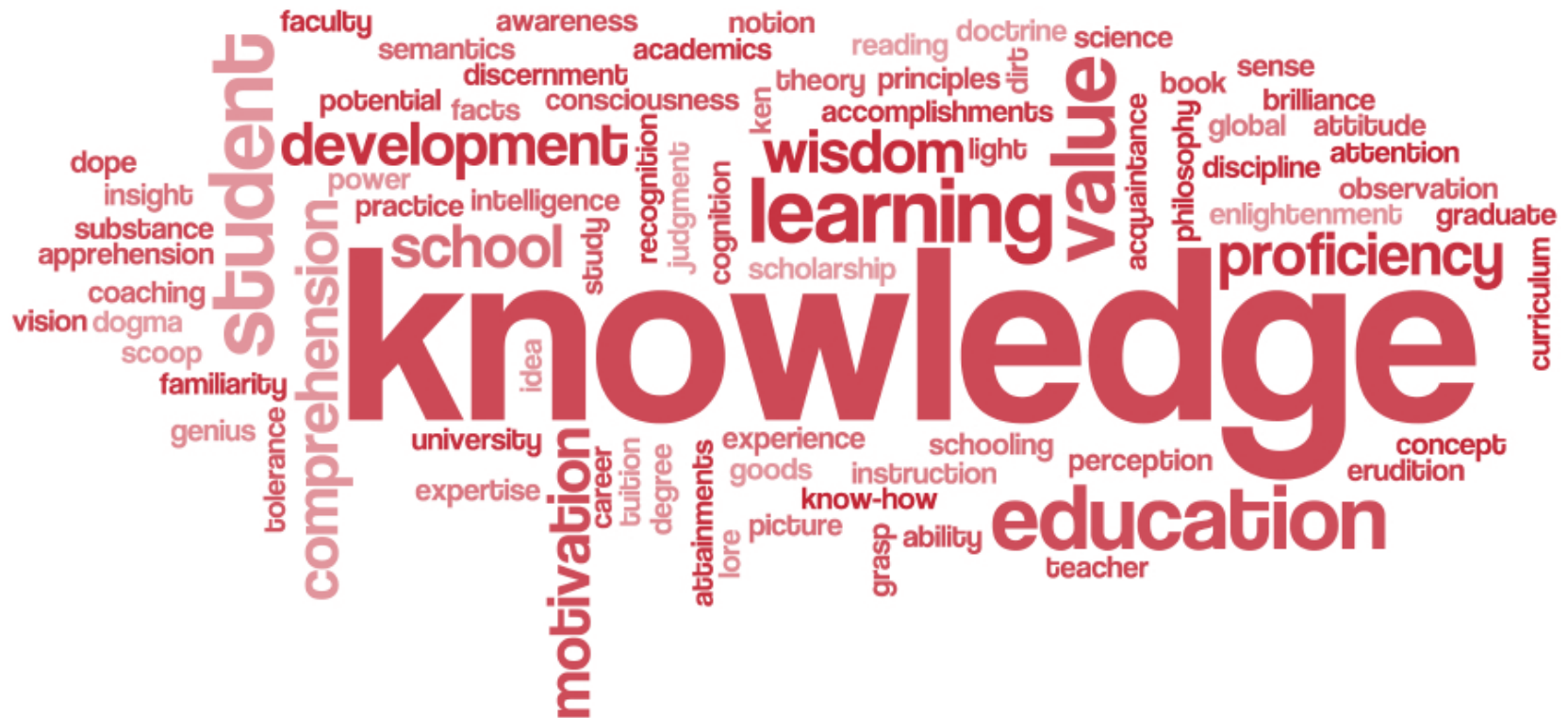


Image: <https://blog.sharetolearn.com/classroom-resources/word-clouds-writing/>

# Word Tree

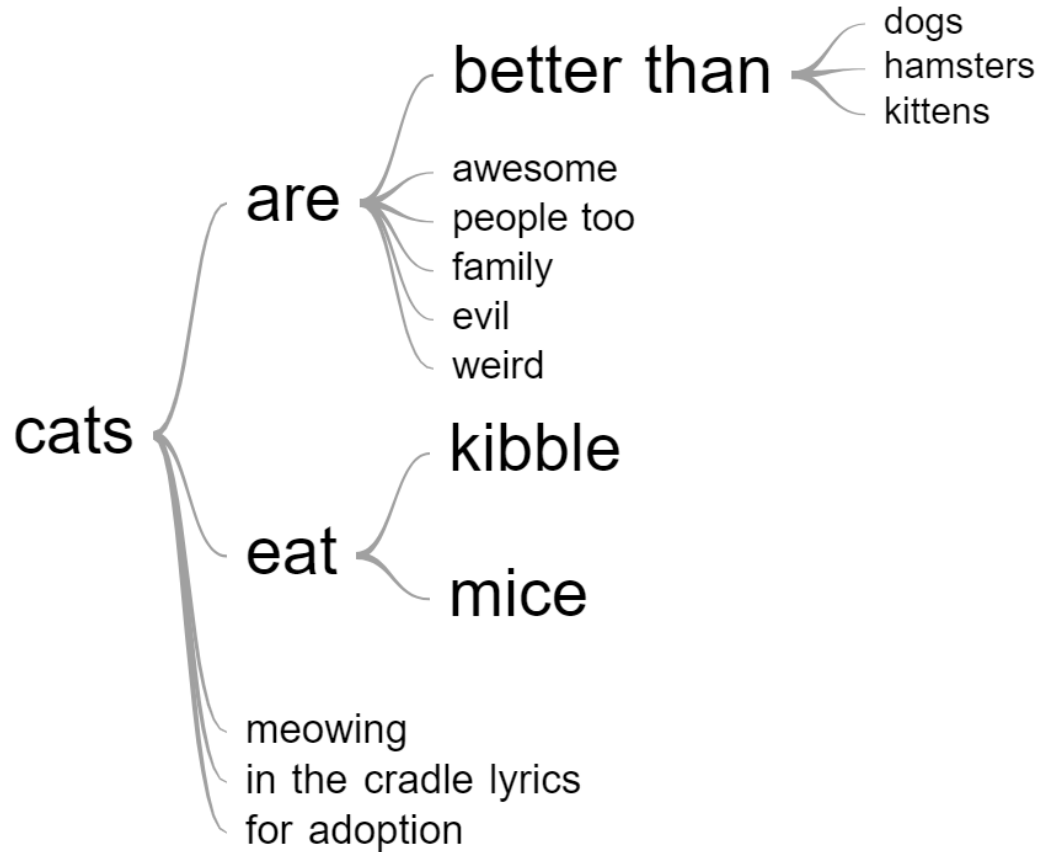
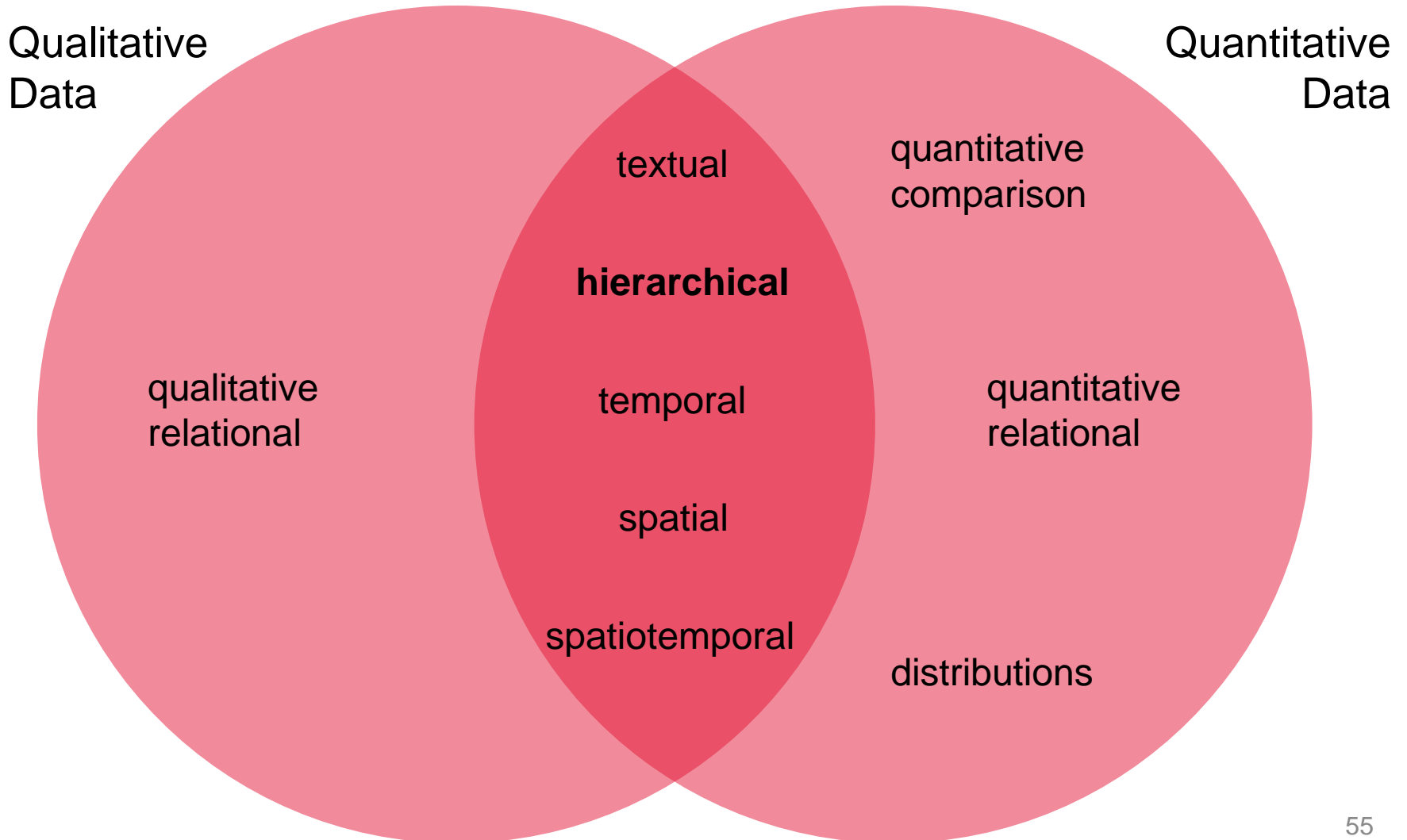


Image: <https://developers.google.com/chart/interactive/docs/gallery/wordtree>

# Hierarchical Structures



# Tree Diagram (root, branches, nodes, leaves)

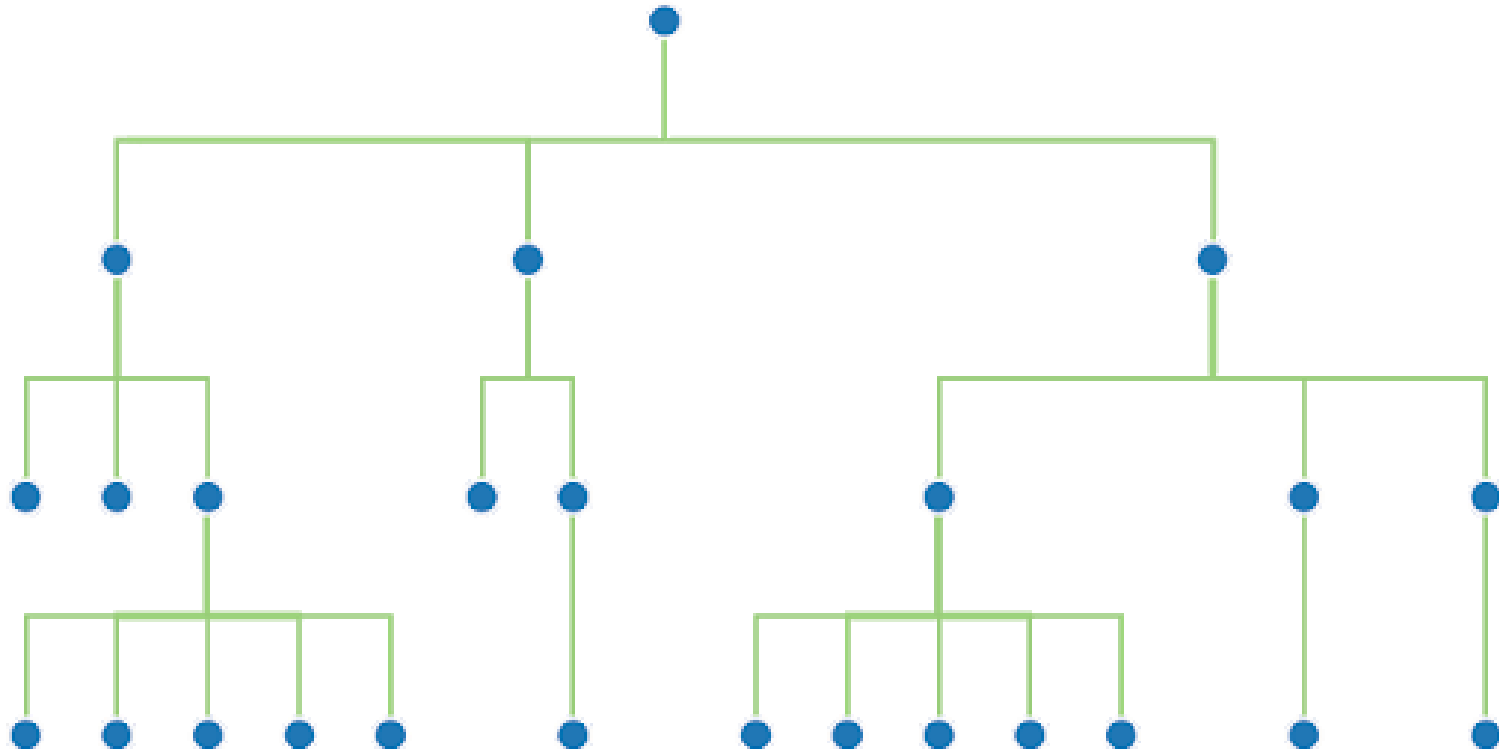


Image: <http://visualizingrights.org/kit/charts/tree-diagram.html>

# Horizontal Trees

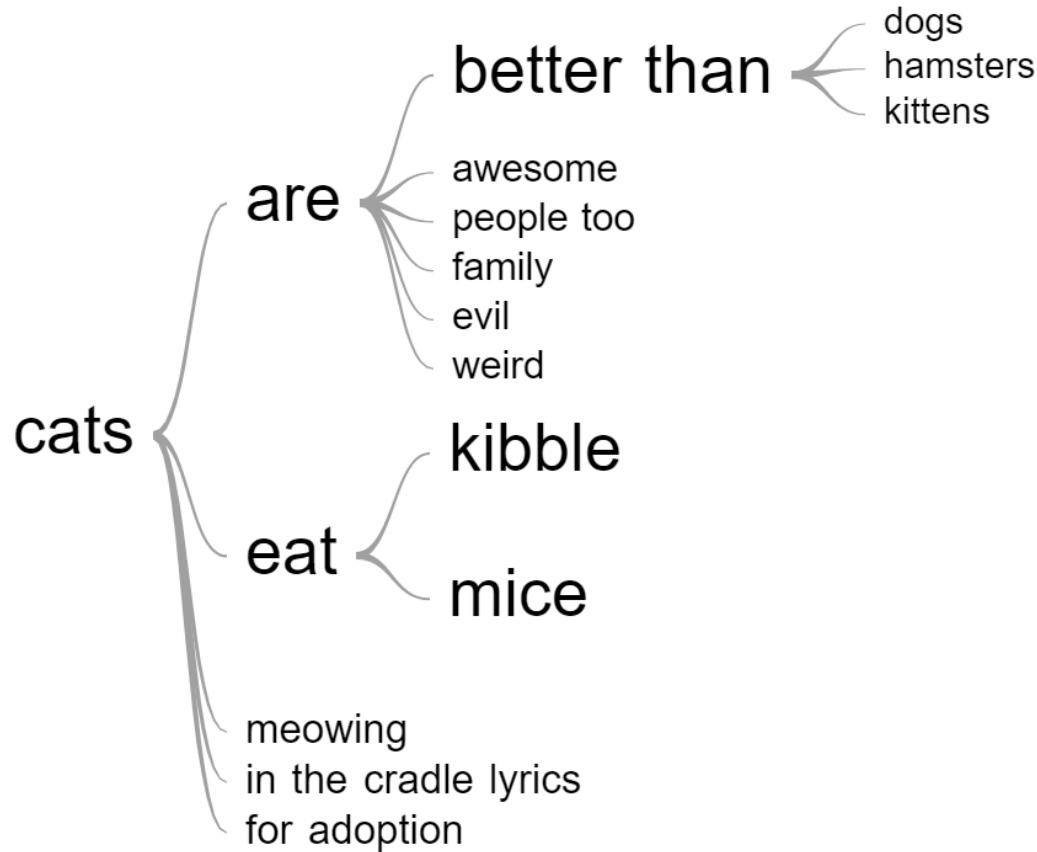


Image: <https://developers.google.com/chart/interactive/docs/gallery/wordtree>

# Node-link Diagram or Dendrogram

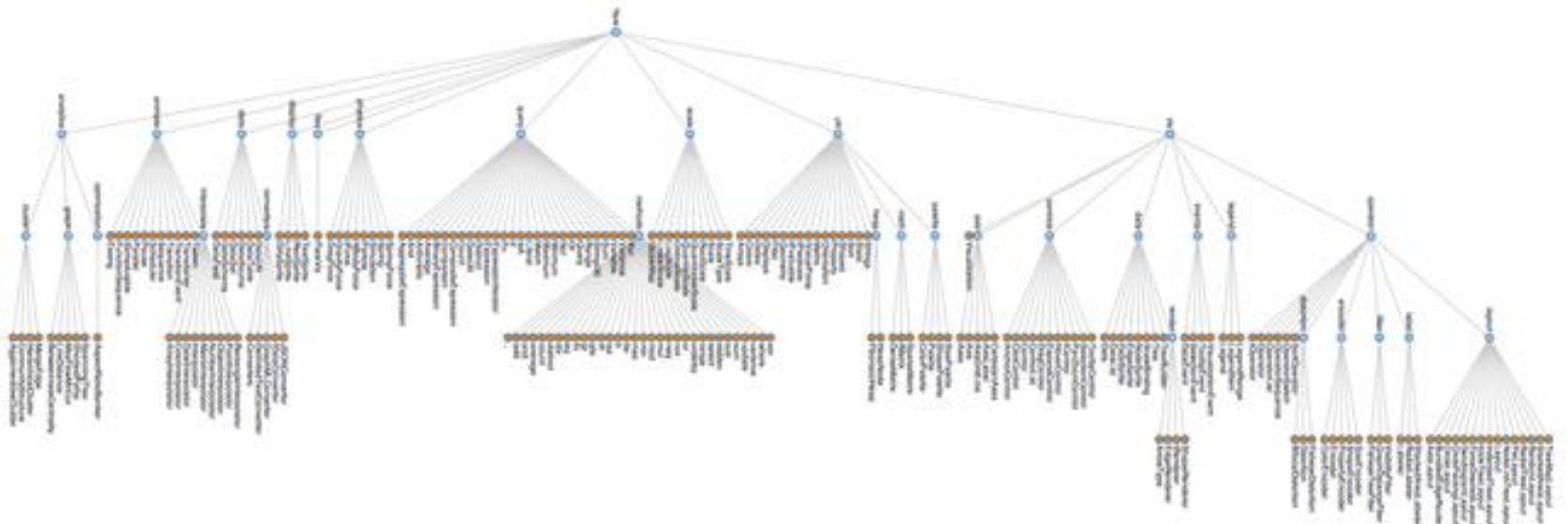


Image: <https://homes.cs.washington.edu/~jheer/files/zoo/>

# Indented Trees & Circular Dendrogram

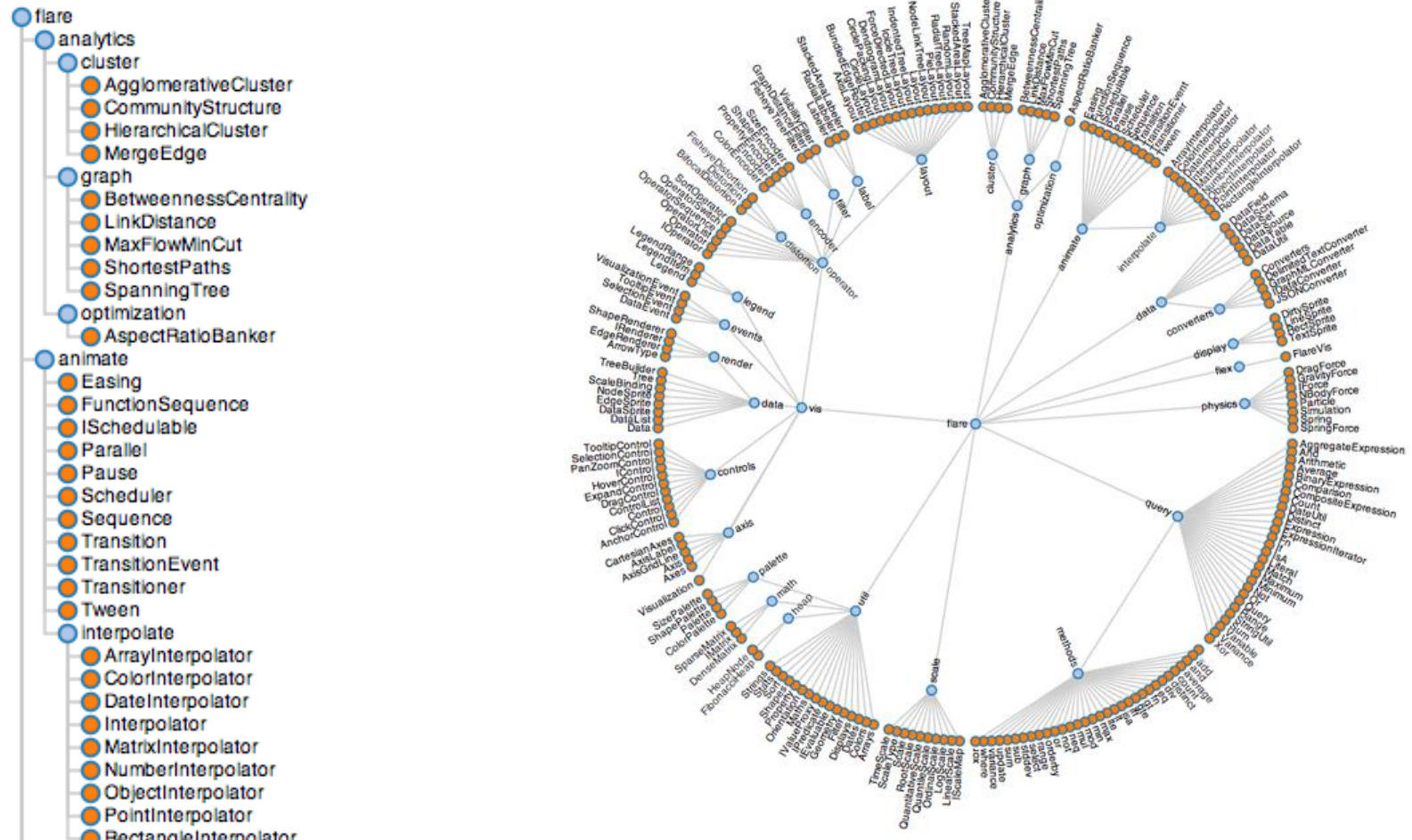


Image: <https://homes.cs.washington.edu/~jheer/files/zoo/>



# Radial Trees

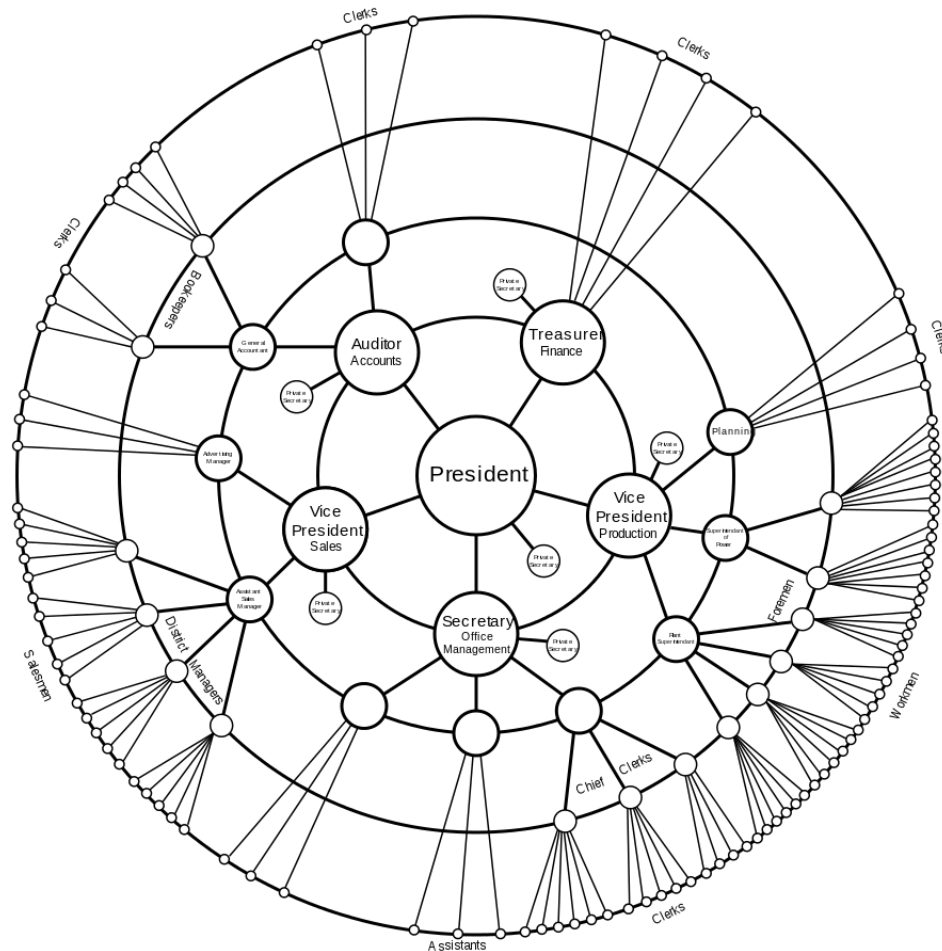


Image: [https://en.wikipedia.org/wiki/Radial\\_tree](https://en.wikipedia.org/wiki/Radial_tree)

# Hyperbolic Trees

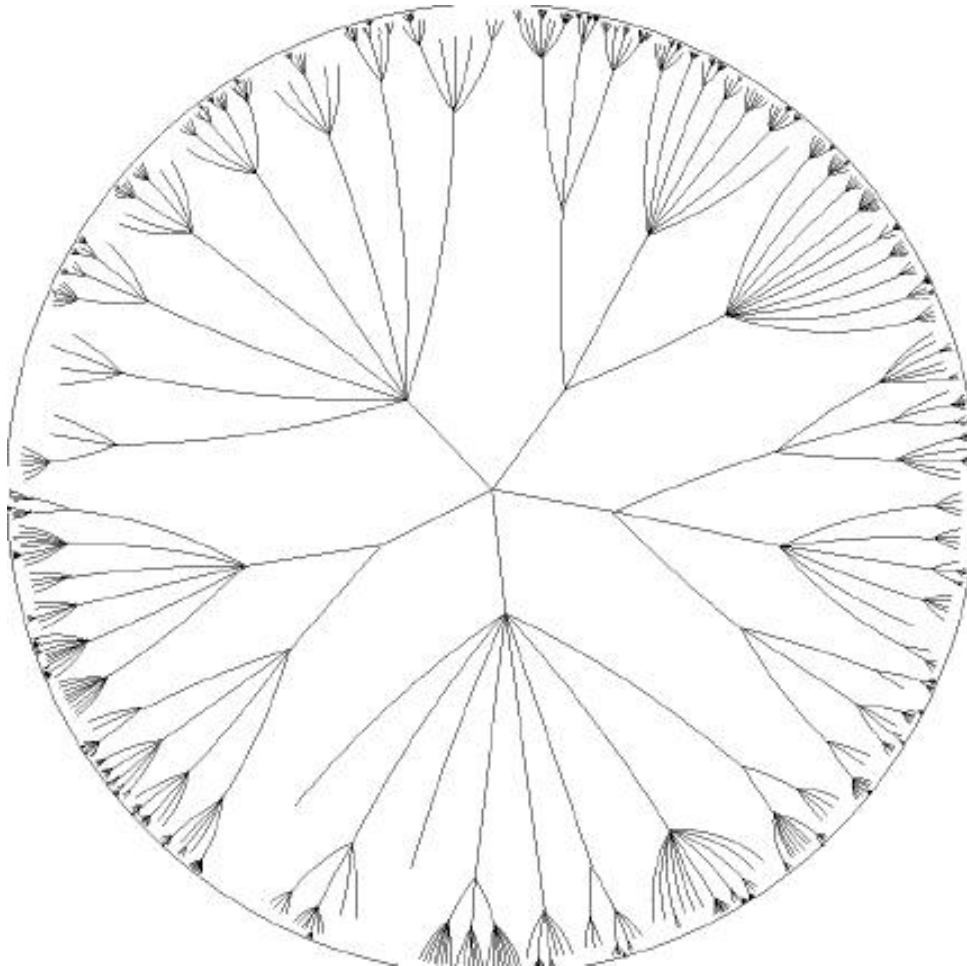


Image: [https://infovis-wiki.net/wiki/Hyperbolic\\_trees](https://infovis-wiki.net/wiki/Hyperbolic_trees)

# Rectangular TreeMaps: World Population

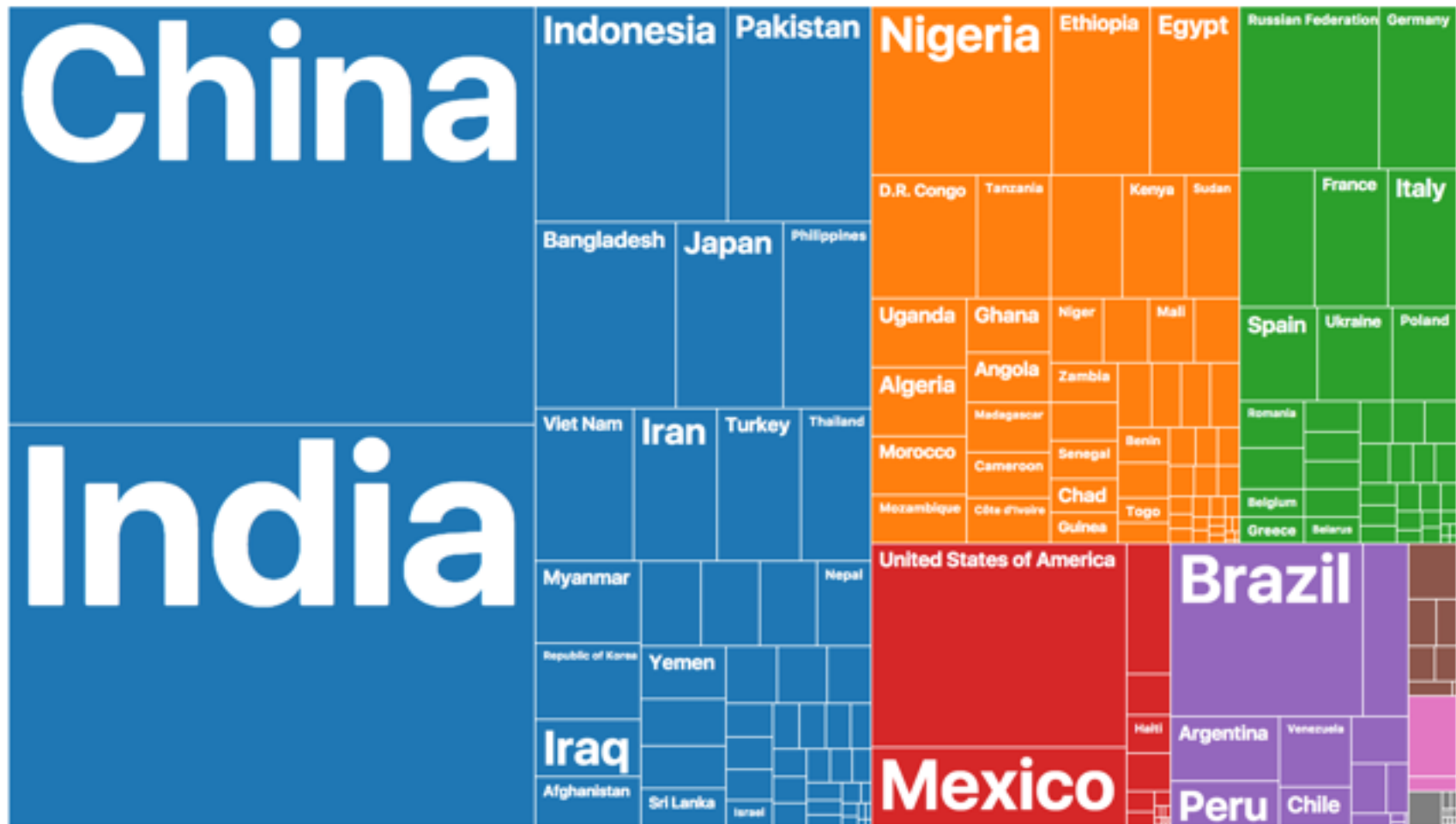
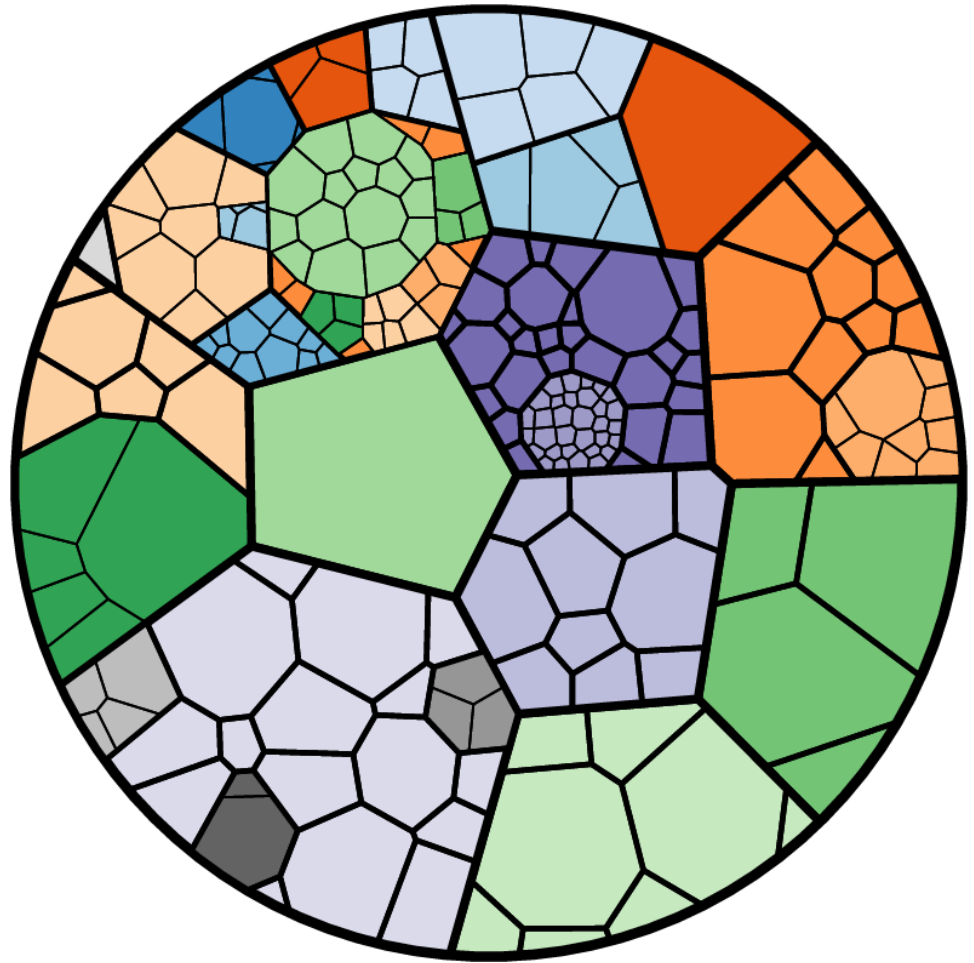


Image: <https://www.populationpyramid.net/population-size-per-country/2020/>

# Voronoi TreeMap

Voronoi treemaps are an alternative to traditional rectangular treemaps

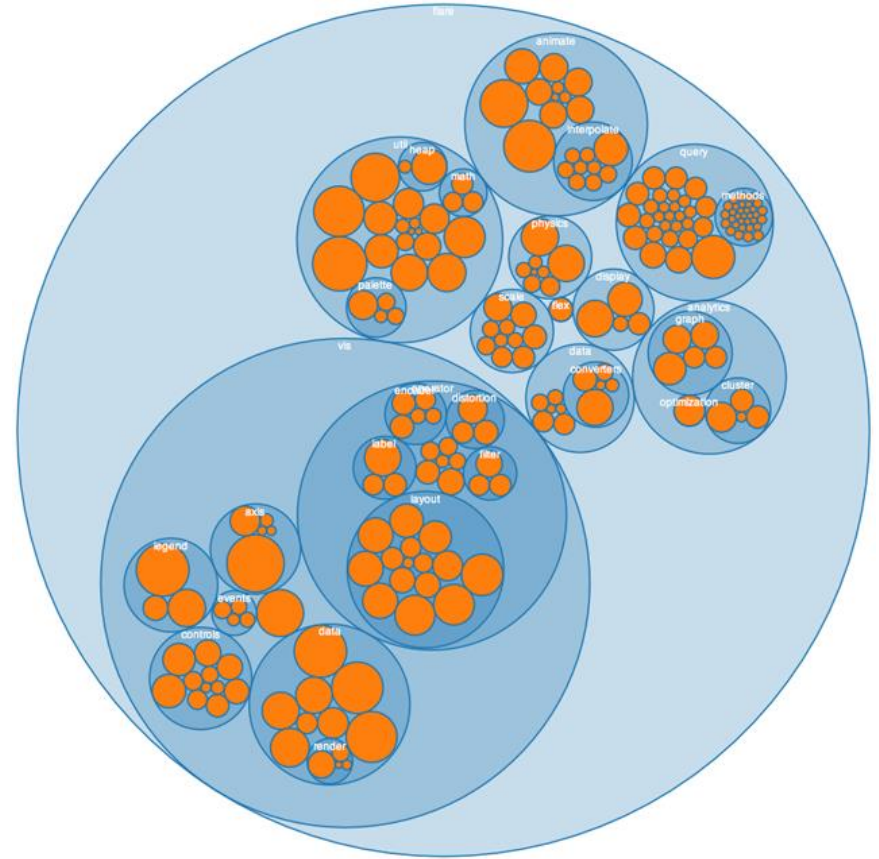
- often more aesthetically pleasing



# Circular TreeMap

packing circles instead of subdividing rectangles can produce a different sort of enclosure diagram that has an organic appearance

- circle-packing layouts reveals the hierarchy
- node sizes can be rapidly compared using area



# Radial TreeMap (aka Sunbursts)

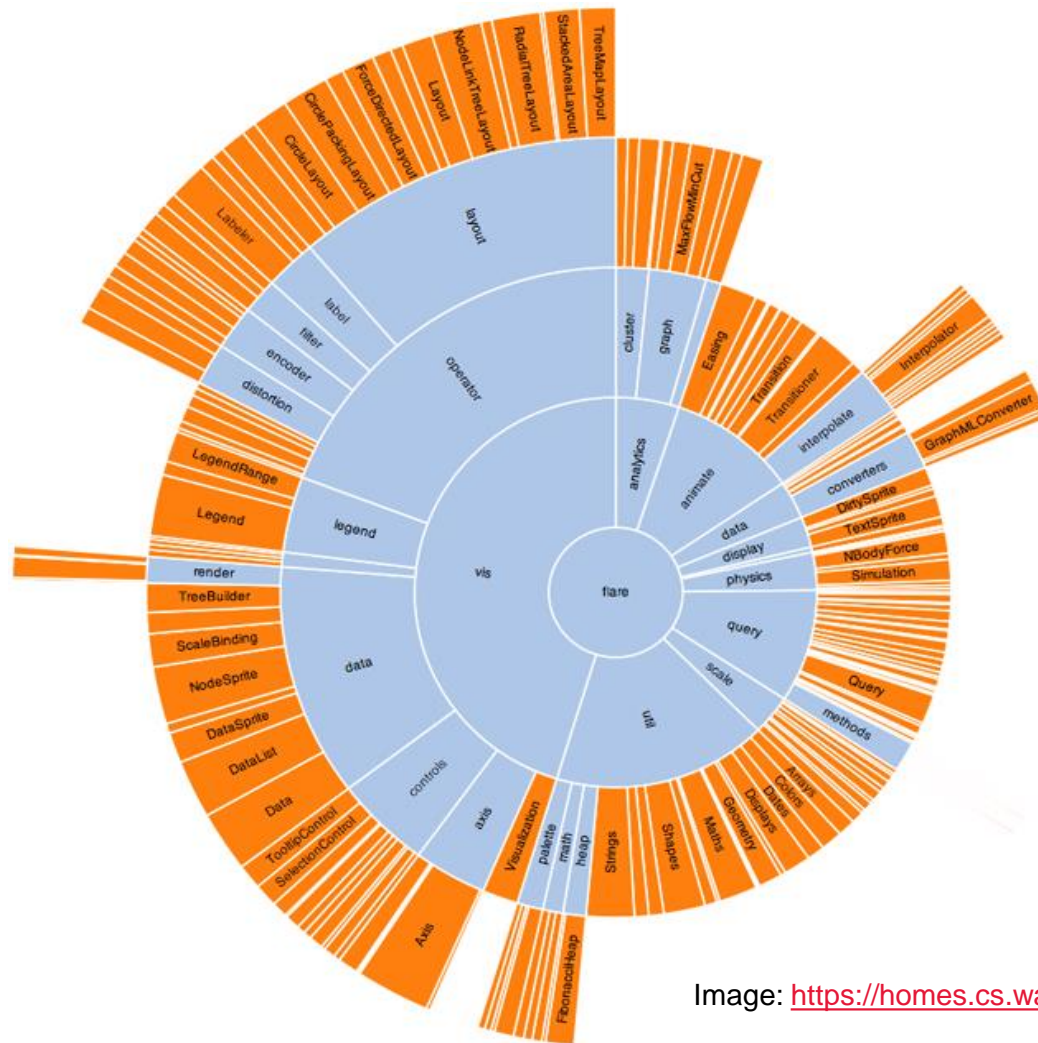


Image: <https://homes.cs.washington.edu/~jheer/files/zoo/>

# Icicle TreeMap

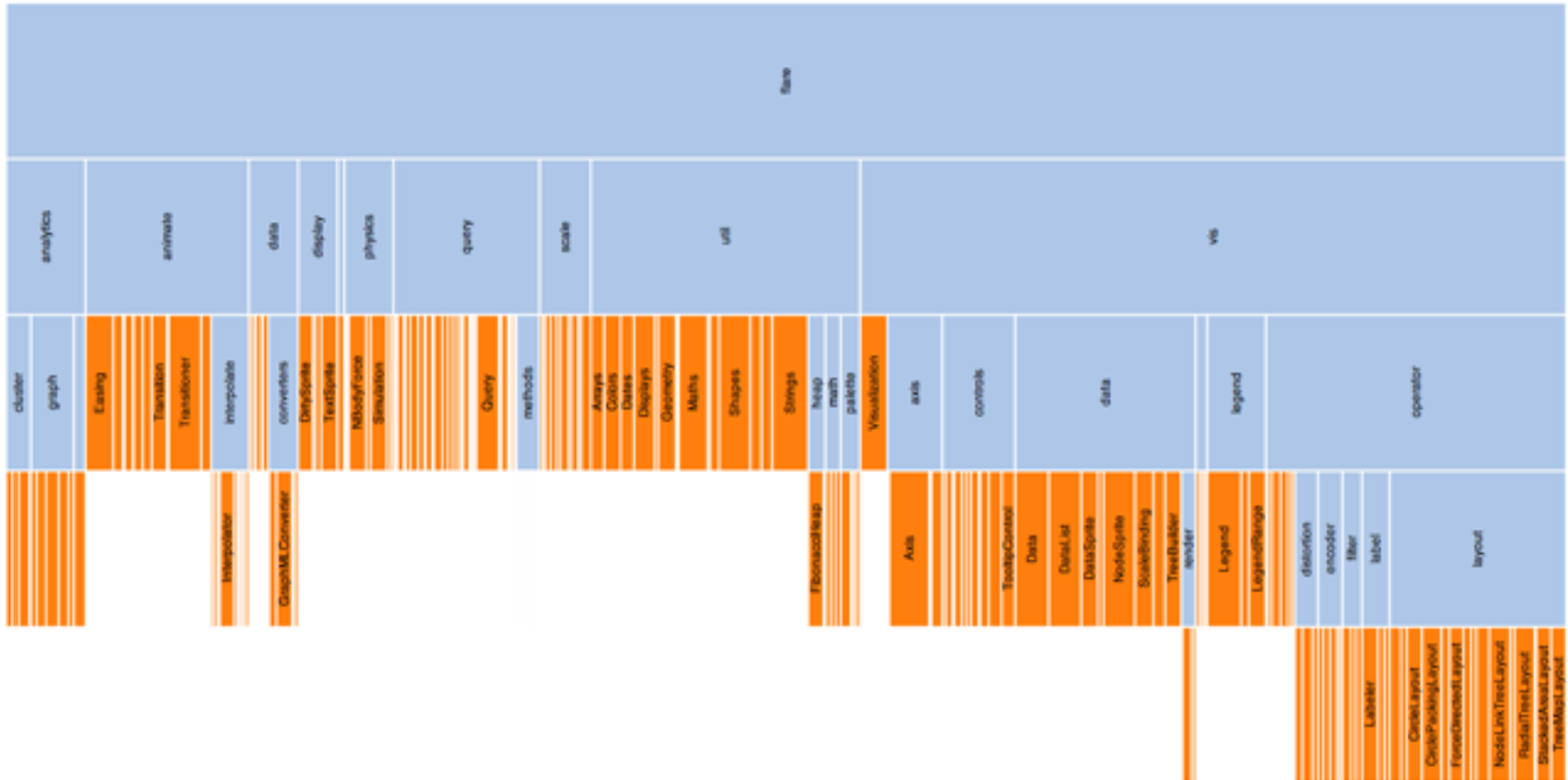
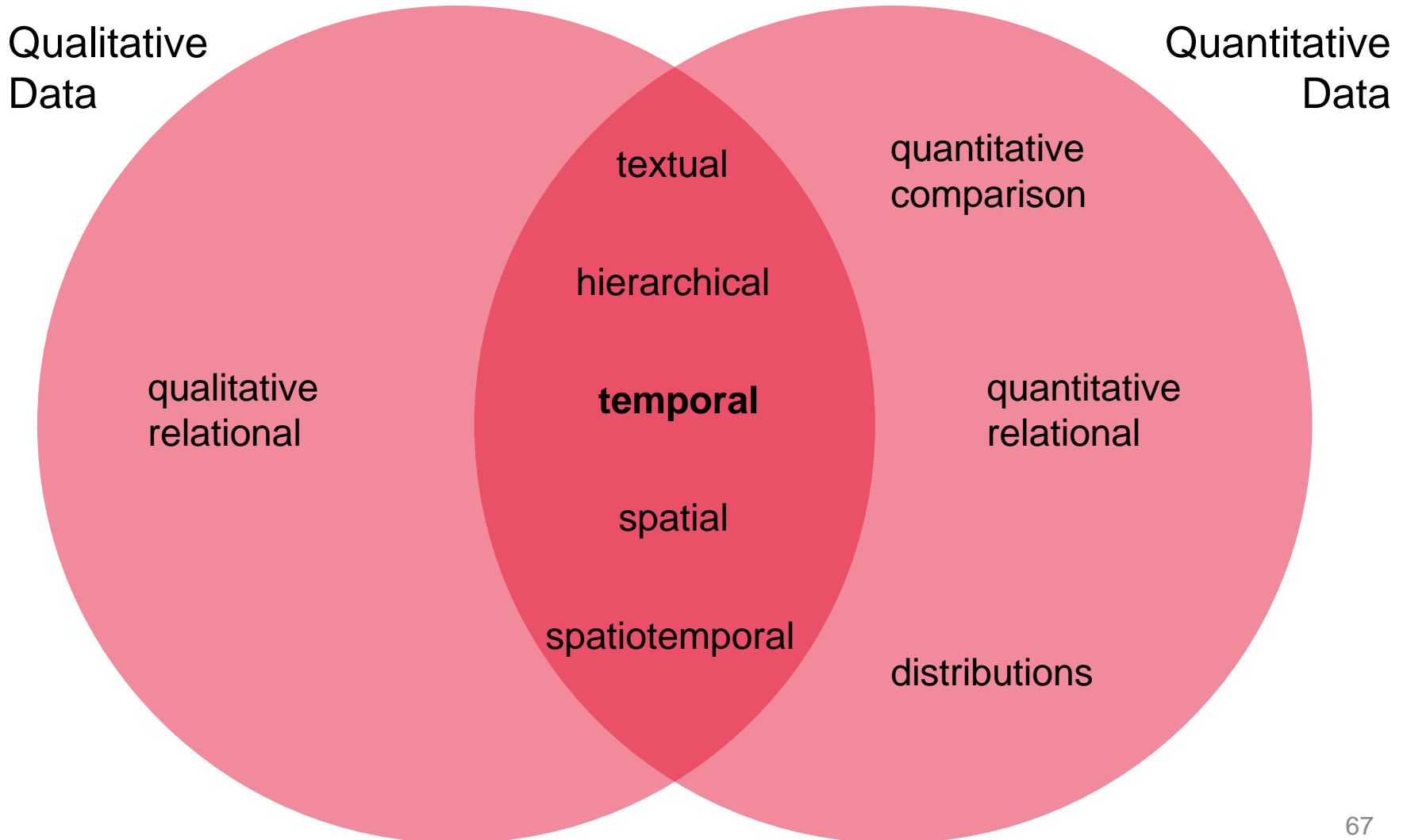


Image: <https://homes.cs.washington.edu/~jheer/files/zoo/>

# Temporal Structures





# Timeline of Space Exploration

## Timeline of Space Exploration

Info source: [www.wikipedia.org](http://www.wikipedia.org)

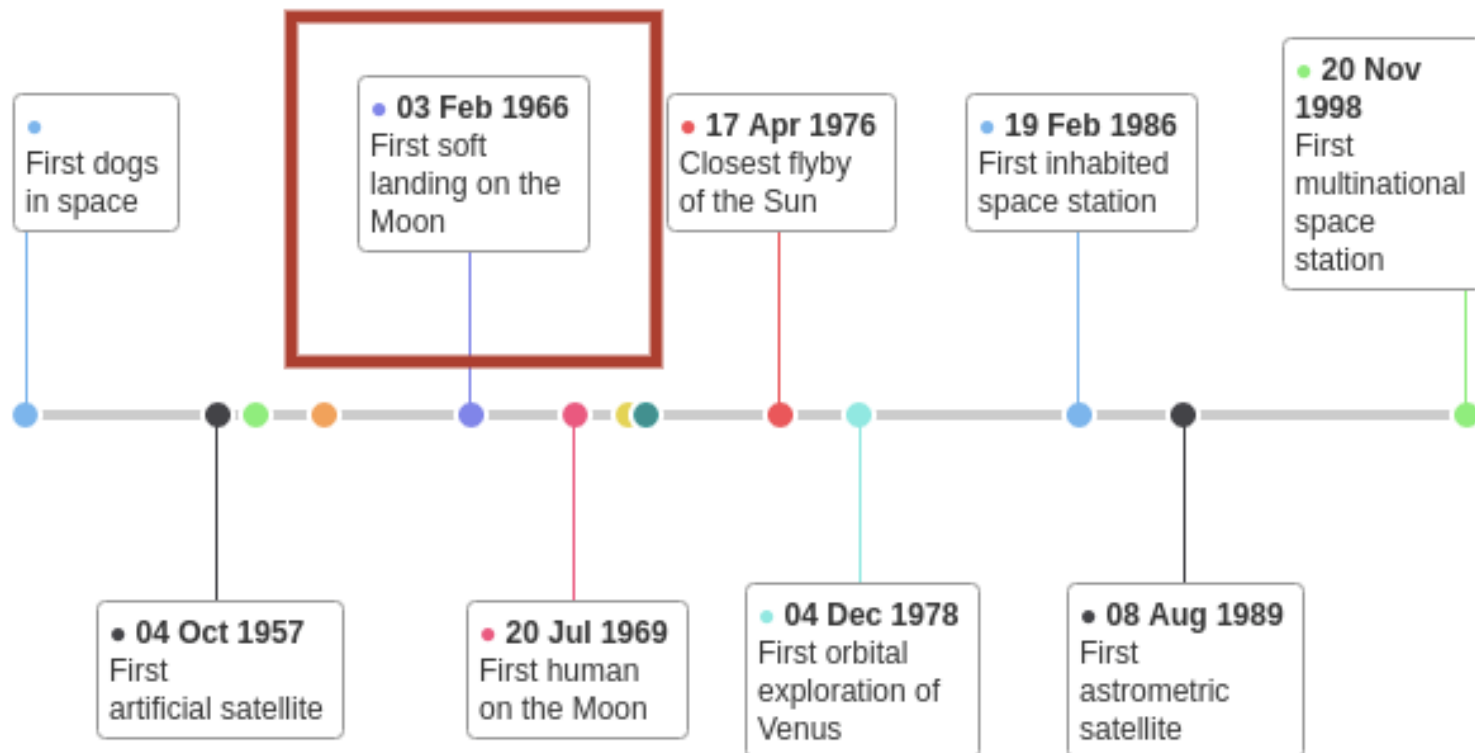


Image: <https://www.highcharts.com/>

# Timeline of 100 yrs of Rock Music (interact.)

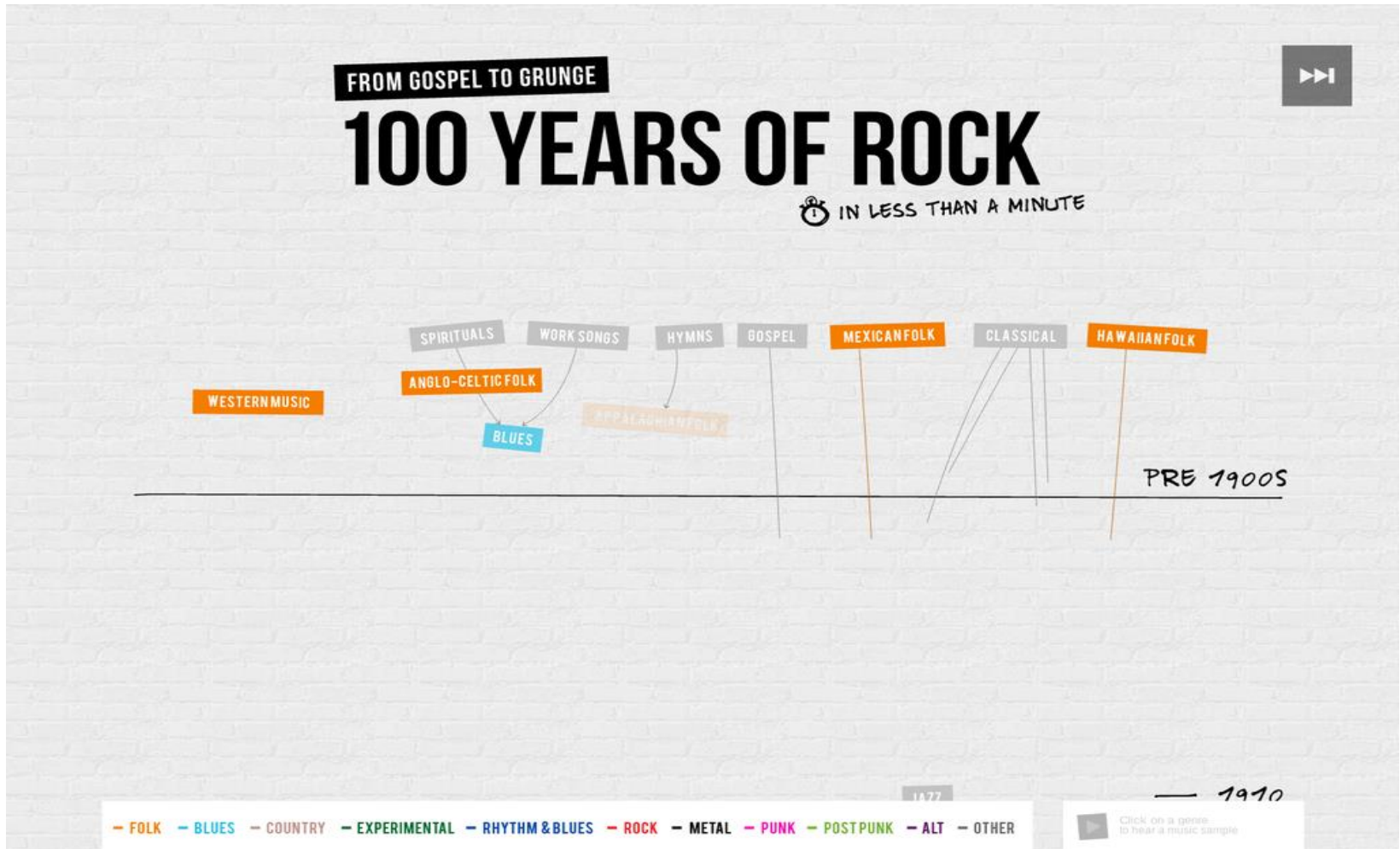
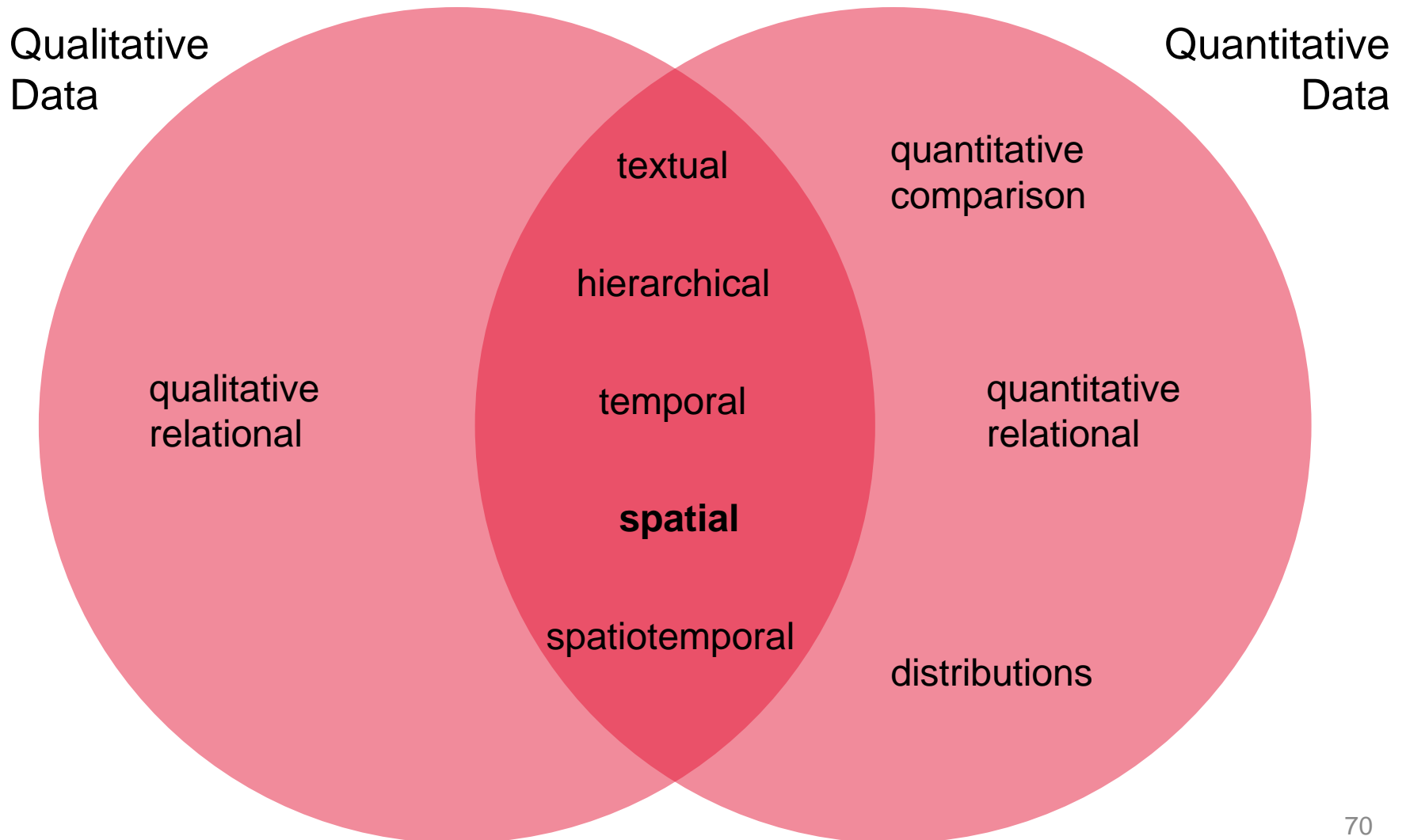


Image: <http://www.concerthotels.com/100-years-of-rock>

# Spatial Structures



# Heatmaps: Fandom of Coldplay (on Youtube)

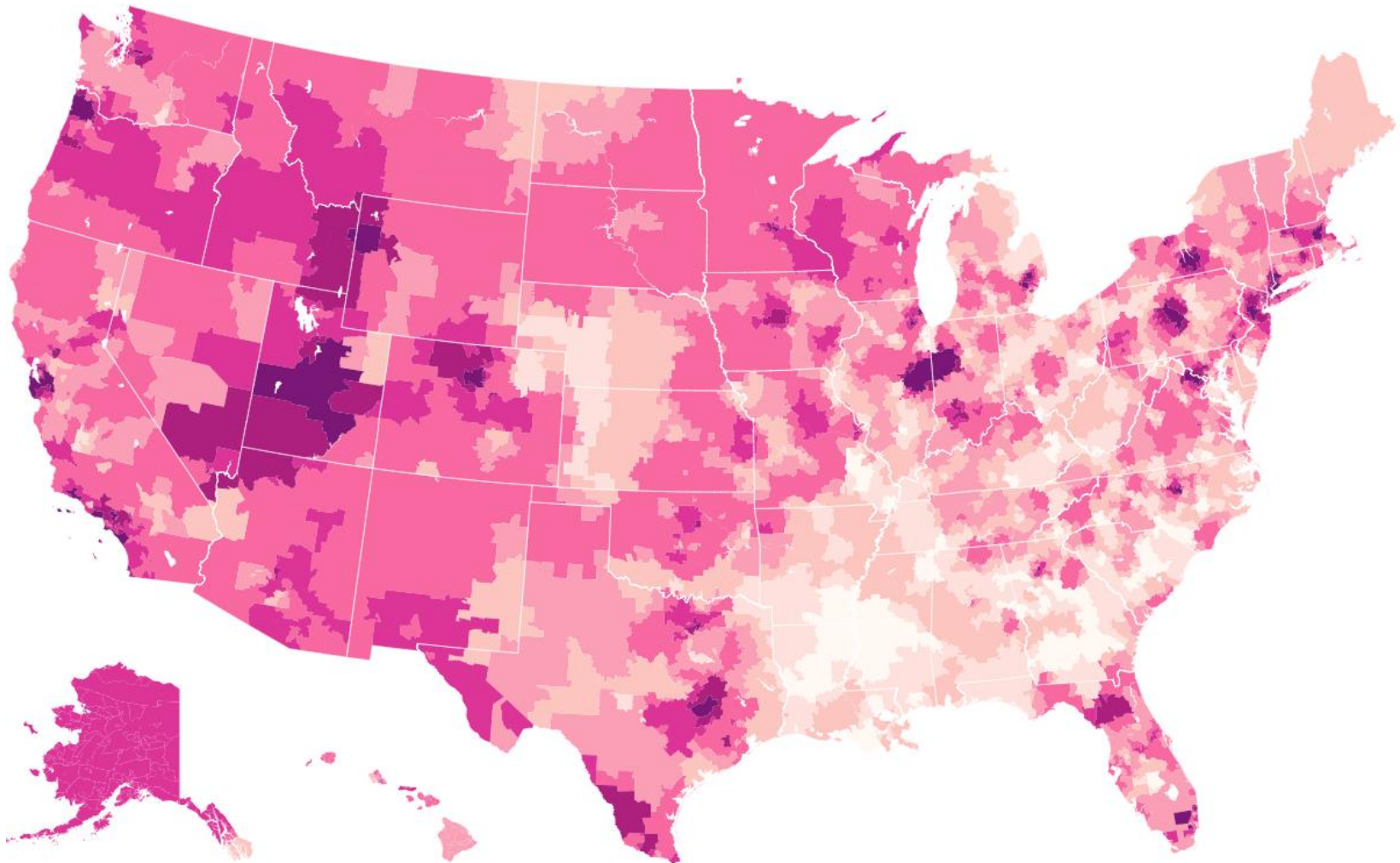


Image: <https://www.nytimes.com/interactive/2017/08/07/upshot/music-fandom-maps.html>

# Choropleth Map

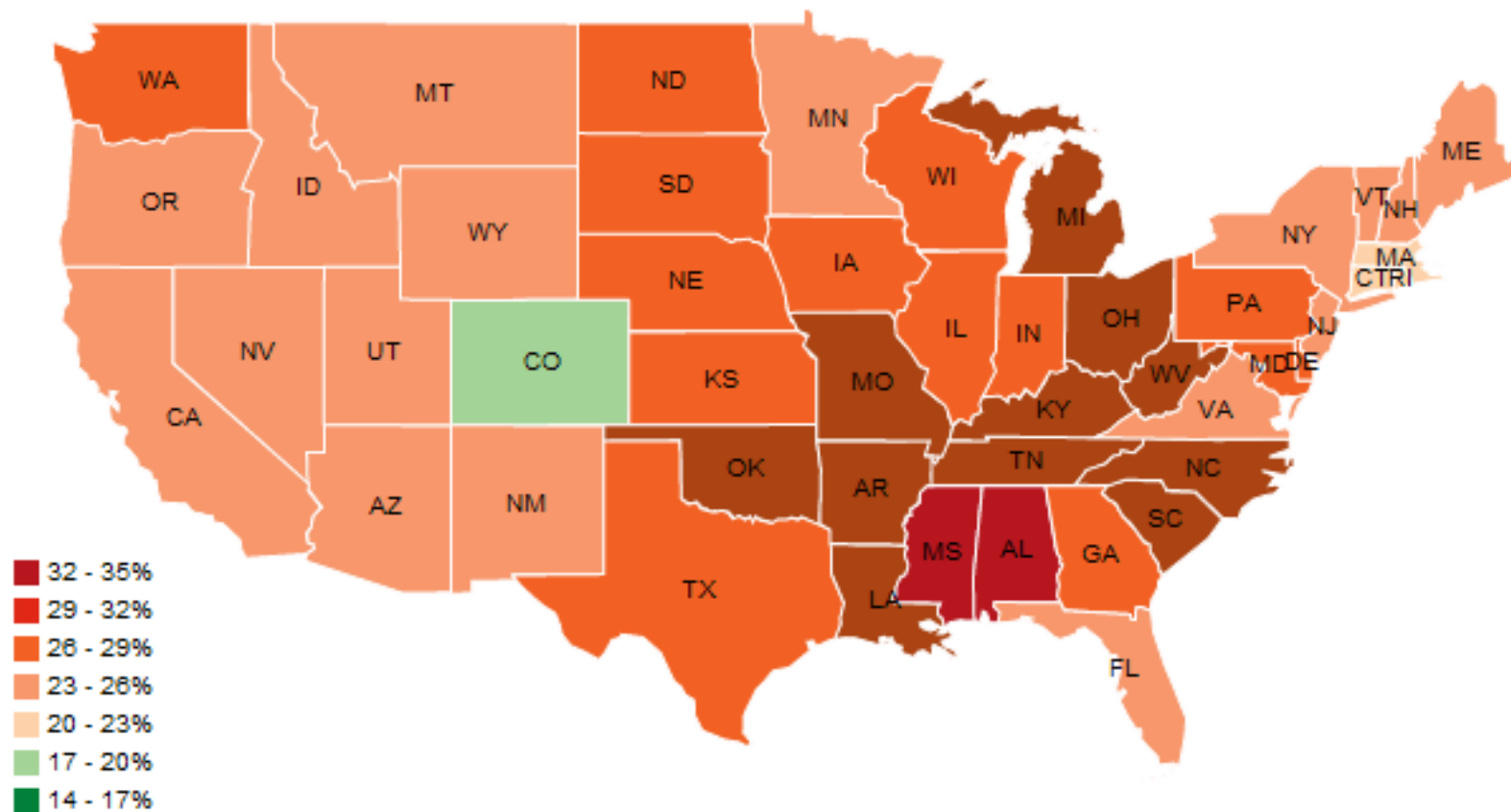


Image: <https://homes.cs.washington.edu/~jheer/files/zoo/>

# Graduated Symbol Map

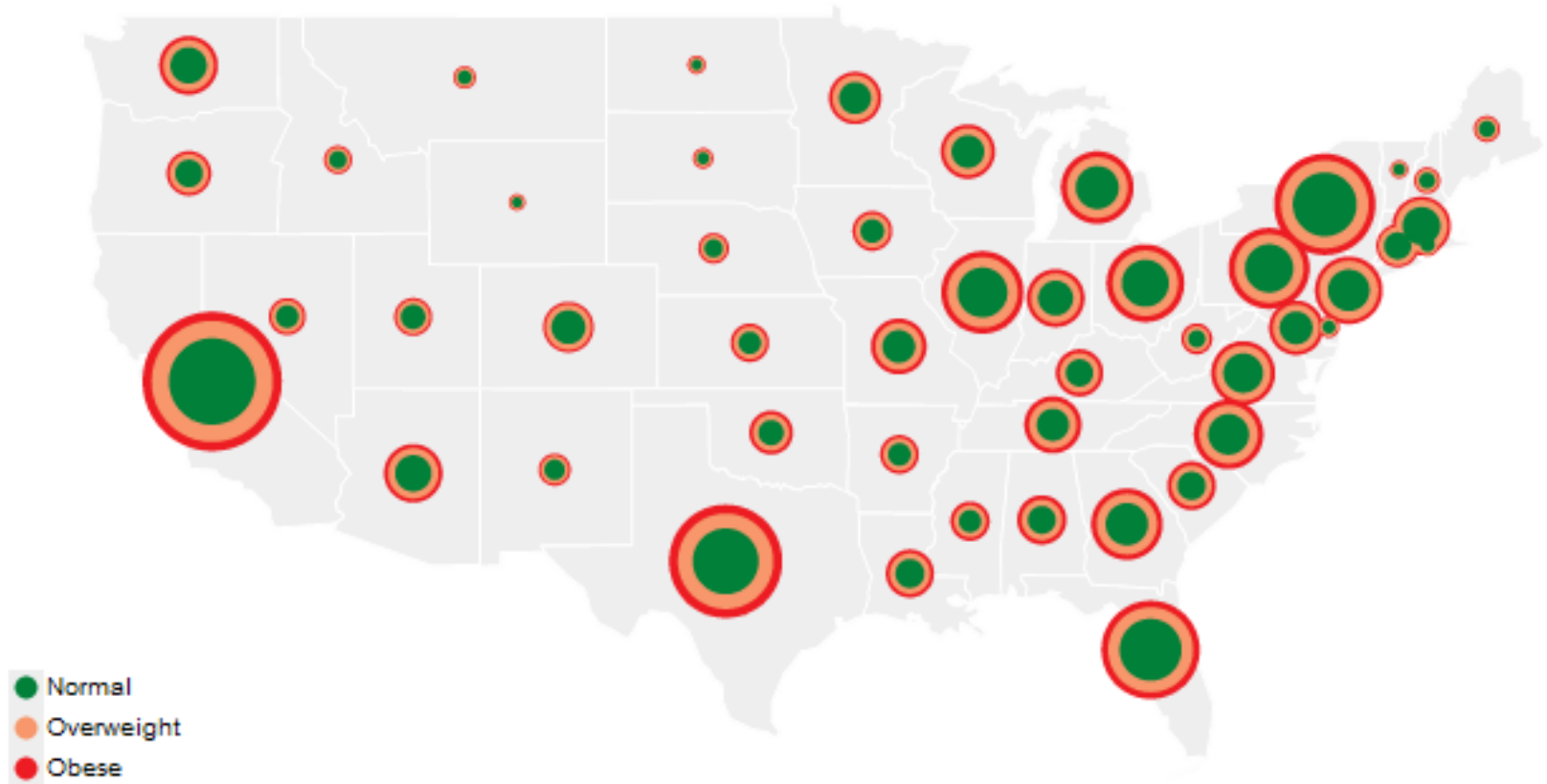


Image: <https://homes.cs.washington.edu/~jheer/files/zoo/>

# Cartograms

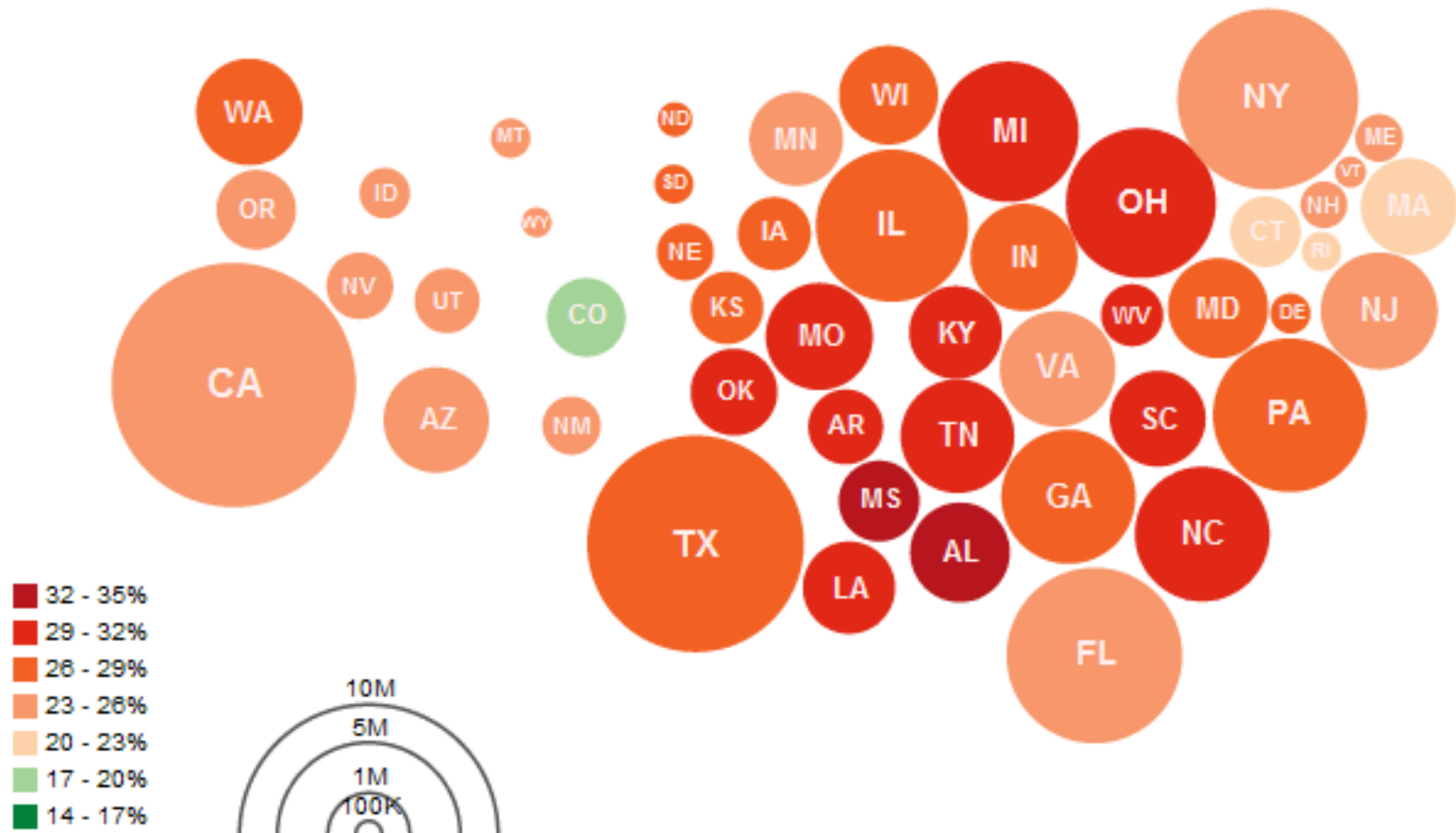


Image: <https://homes.cs.washington.edu/~jheer/files/zoo/>



# Examples: Wind Map (interactive)

**March 15, 2020**

9:42 pm EST

(time of forecast download)

top speed: **26.5 mph**

average: **7.7 mph**

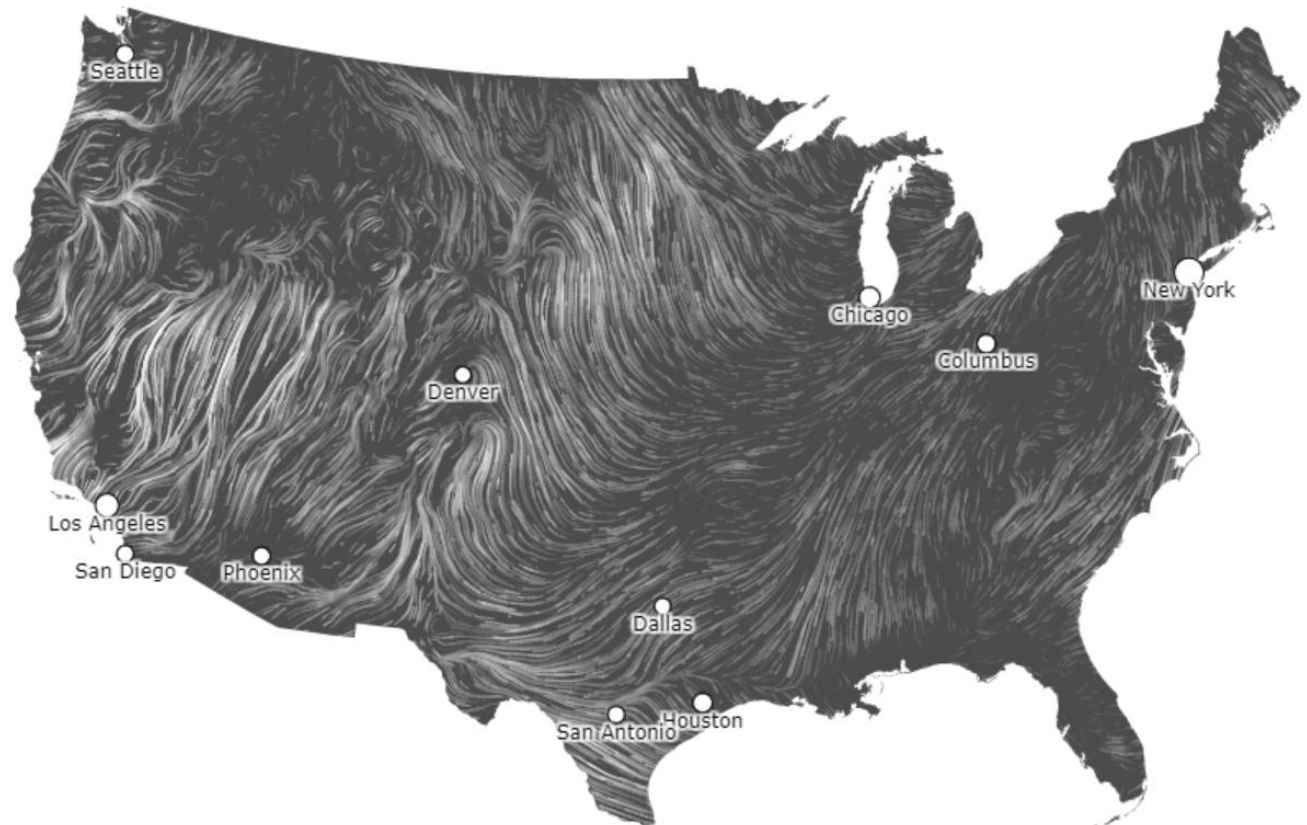
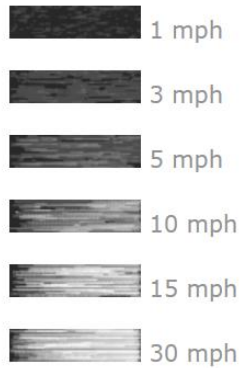
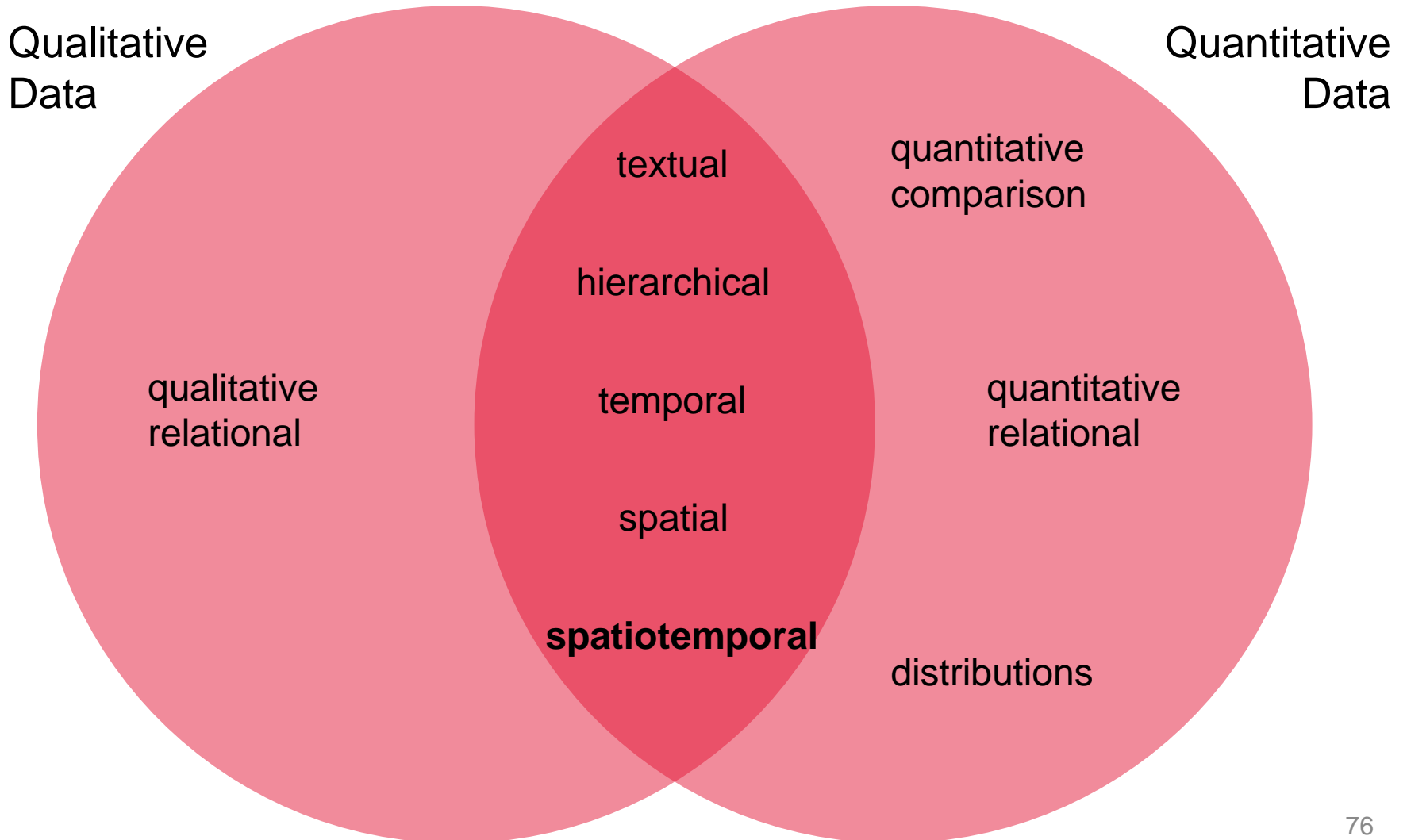


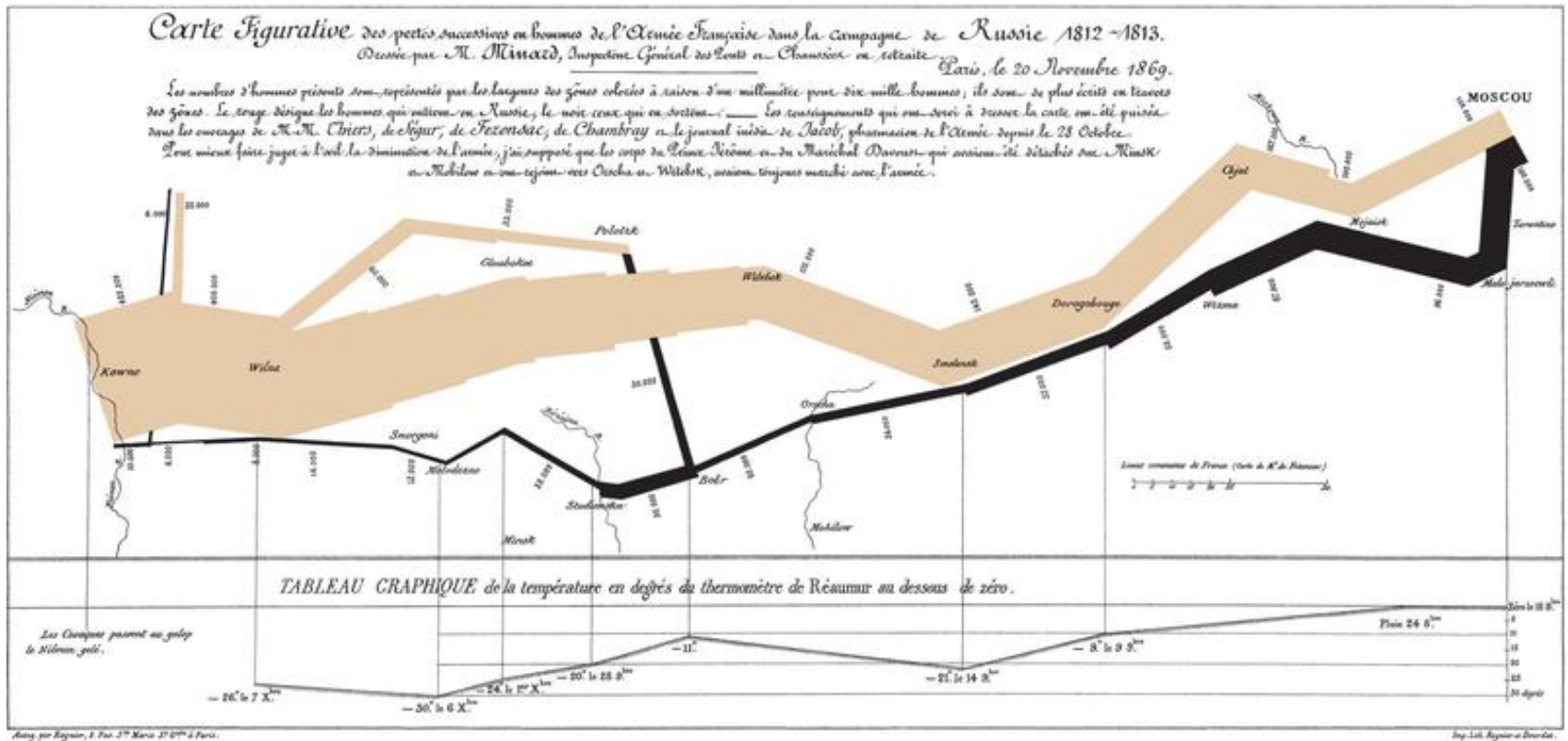
Image: <http://hint.fm/wind/>



# Spatiotemporal Structures



# Napoleon's Russian campaign of 1812



Charles Minard's map of **Napoleon's disastrous Russian campaign of 1812**. The graphic is notable for its representation in two dimensions of **six types of data**: the number of Napoleon's troops; distance; temperature; the latitude and longitude; direction of travel; and location relative to specific dates

# Hurricane Katrina Trajectory Over Time

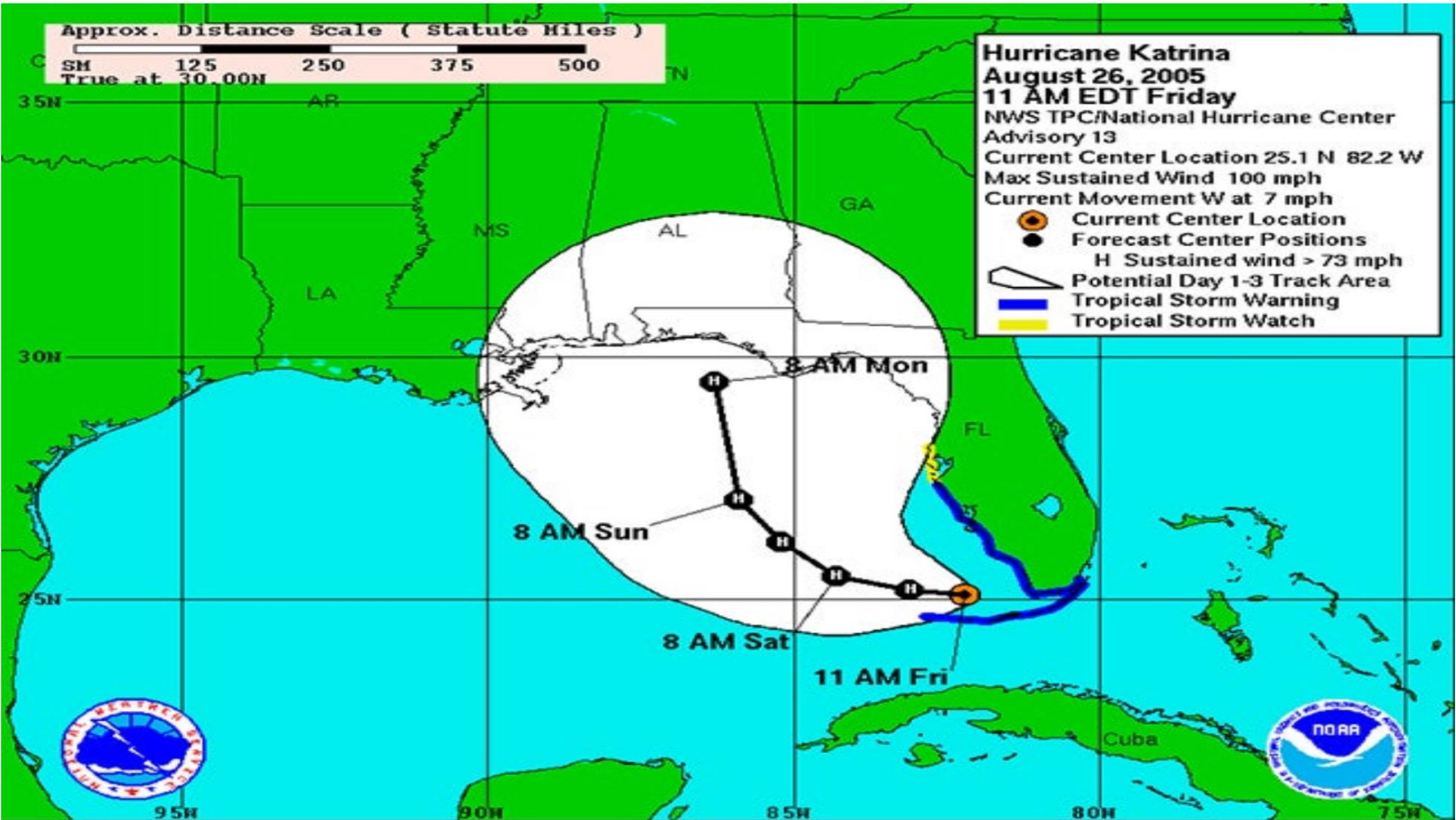
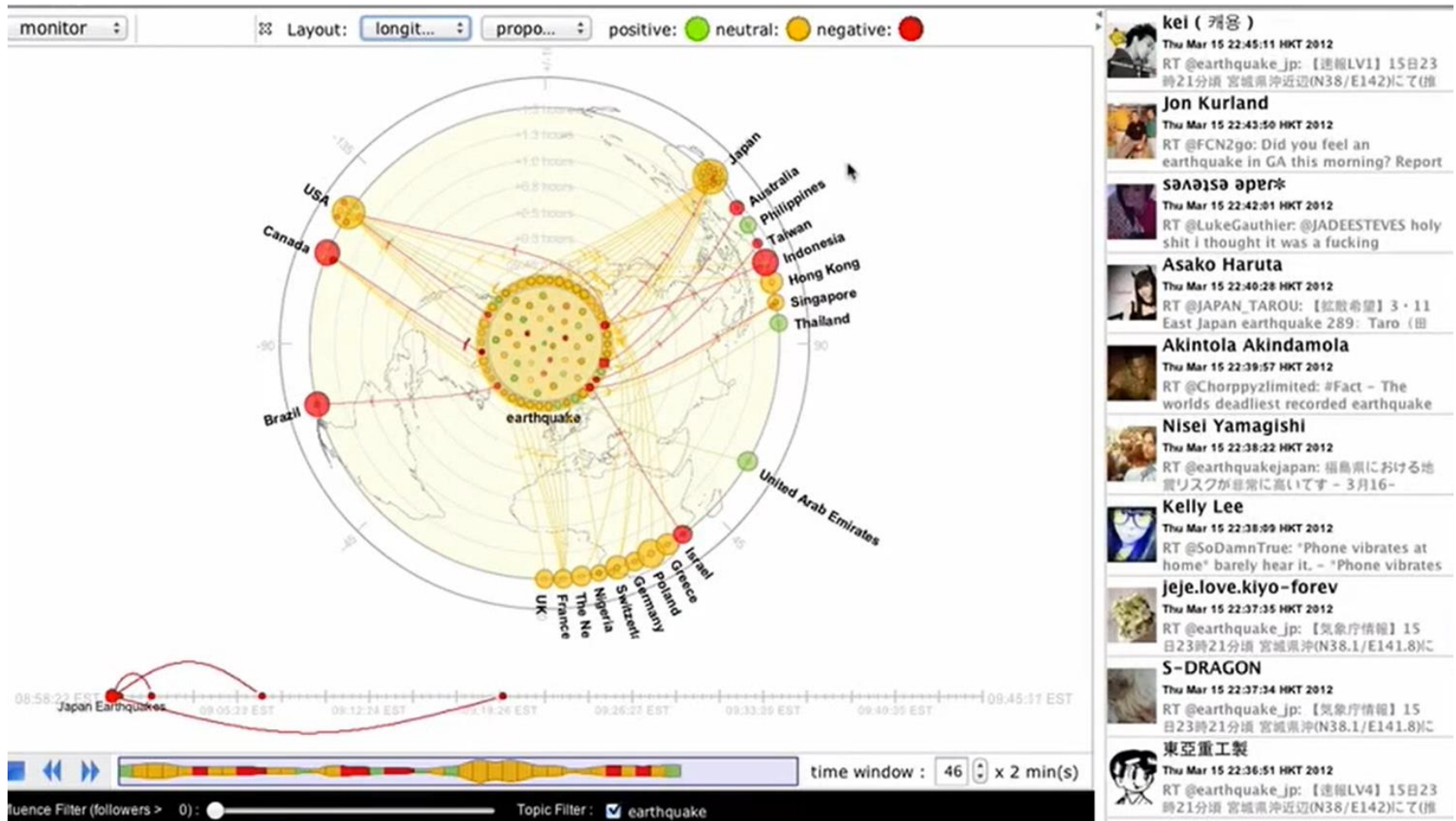


Image: <https://weather.com/storms/hurricane/news/hurricane-katrina-forecast-shift-aug26-2005>

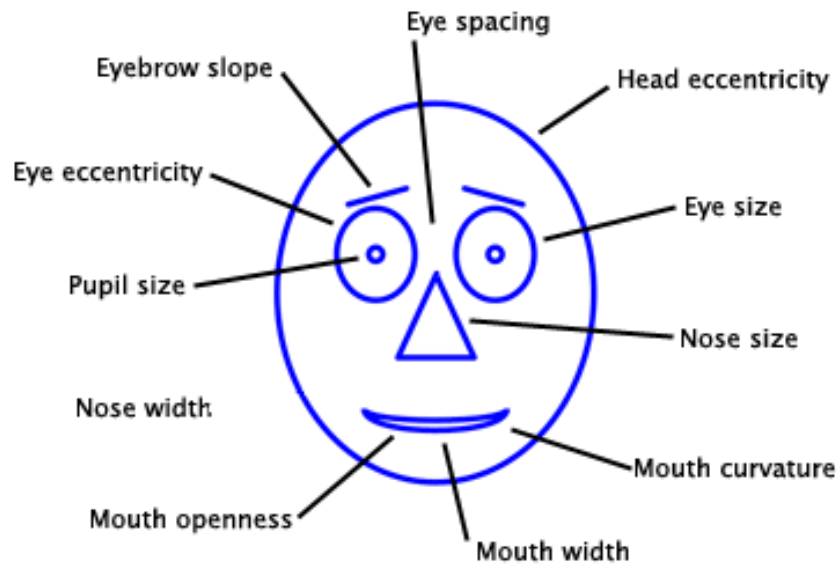
# Tracing Earthquake Discussions in Real Time



Image/video: <https://www.youtube.com/watch?v=ou8L0MzGvOU>

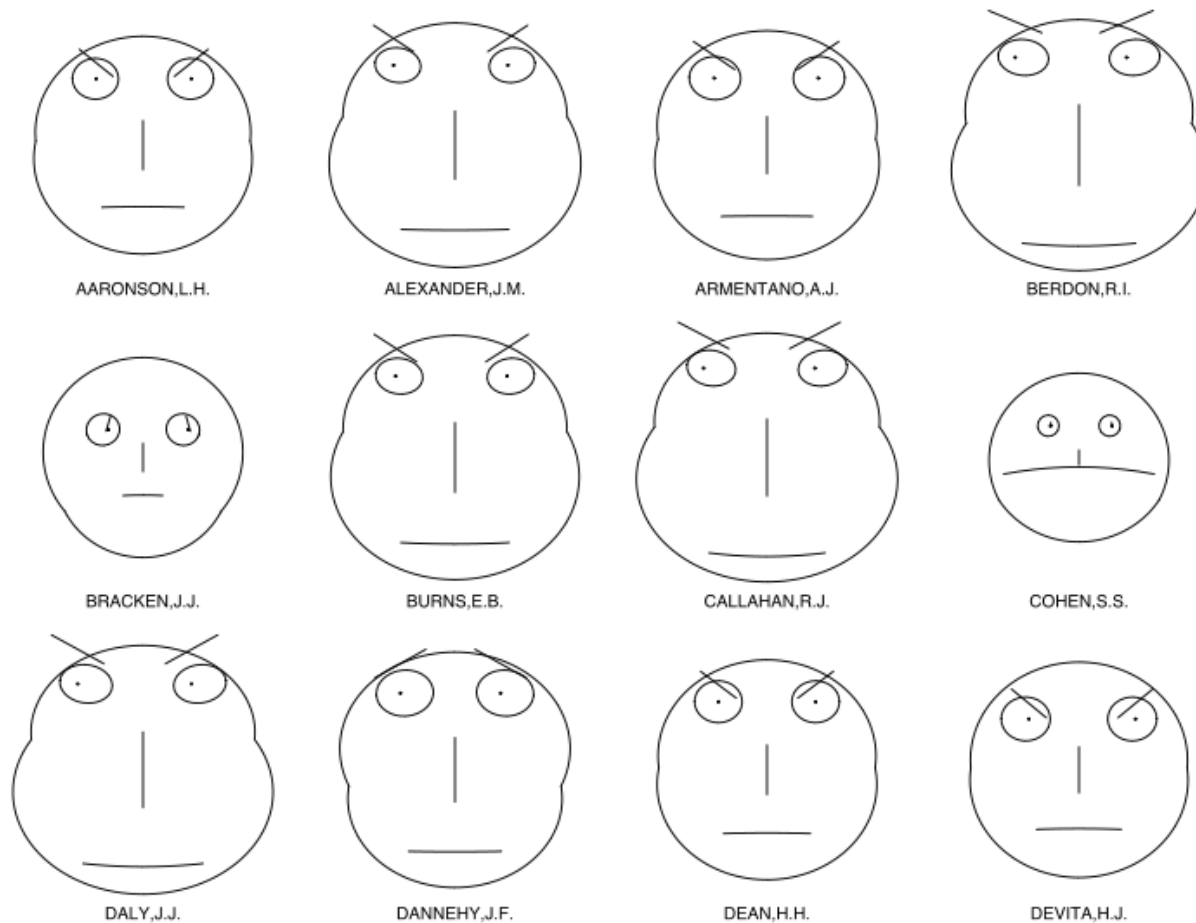
Other

# Chernoff Faces



a way to display  $n$  variables on a 2-D surface  
each variable is assigned one of  $k$  possible values

# Chernoff Faces: Example



Chernoff faces for lawyers' ratings of 12 judges

# Beyond digital visualizations



# Physical visualizations (data sculpture)

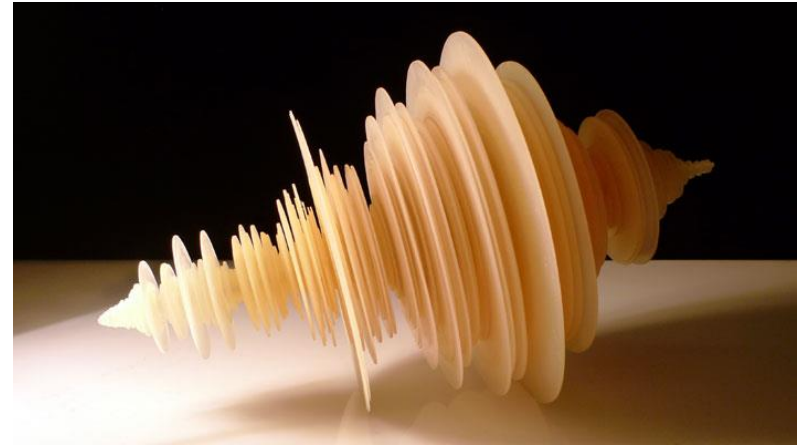
Keyboard Frequency Sculpture



A 3D bar chart on top of a keyboard which shows the frequency of each letter in the alphabet

Source: Michael Knuepfel

2011 – Tōhoku Japanese Earthquake Sculpture



A data sculpture by Luke Jerram that depicts nine minutes of seismographic readings during the 9.0 earthquake.

Source: Gizmodo

# Physical visualizations



Manifest Justice Exhibition, Los Angeles, May 2015

<http://www.afropunk.com/profiles/blogs/feature-manifestjustice-art-exhibit-in-los-angeles>

# Participatory visualization



<https://www.youtube.com/watch?v=hD5f8GuNuGQ>  
(what is privilege?)

# Resources

# Data Visualization Resources & Libraries

Data visualization catalog

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

Periodic table of visualization methods

[http://www.visual-literacy.org/periodic\\_table/periodic\\_table.html](http://www.visual-literacy.org/periodic_table/periodic_table.html)

Interactive dynamics for visual analysis (Taxonomy of Tools)

<http://queue.acm.org/detail.cfm?id=2146416>

HighCharts library

<https://www.highcharts.com/>

D3 library

<https://observablehq.com/@d3/gallery>