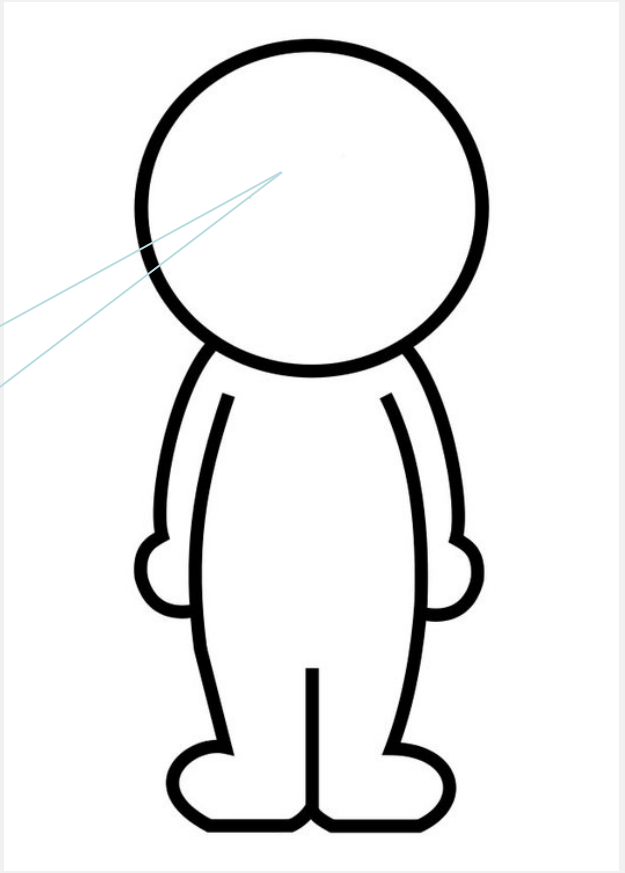
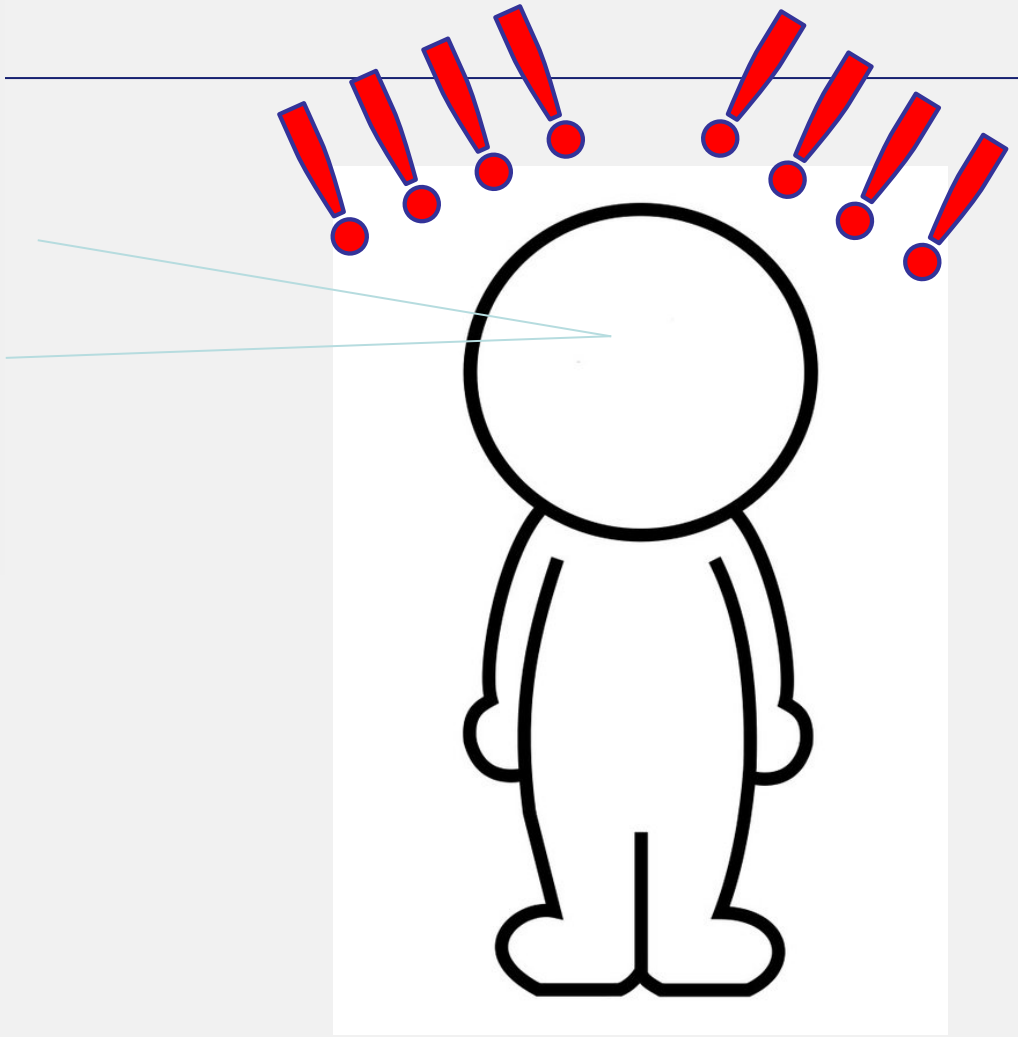
CATCH UP THE OLD STUFF....

In the past lecture there was a ball coming…





What's that (unconscious processing) that allowing sensation and perception?

Why optical illusions??

There is no just processing the light and a straight coding of the light.

There are biological effects (inhibition) and brain interpretation.

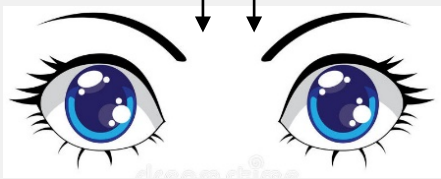
Brains considers also experiences, memories, and cognitive information

(unconscious processing)

How do we see complex patterns? conscious processing

Brain uses memories and says you need to start running, because there is a lion. Brain sees the lion, though it is hidden in the grass

Light



Photoreceptors receive stimuli

Electric signals go to brain

short-time (working) memory

A continuous exchange

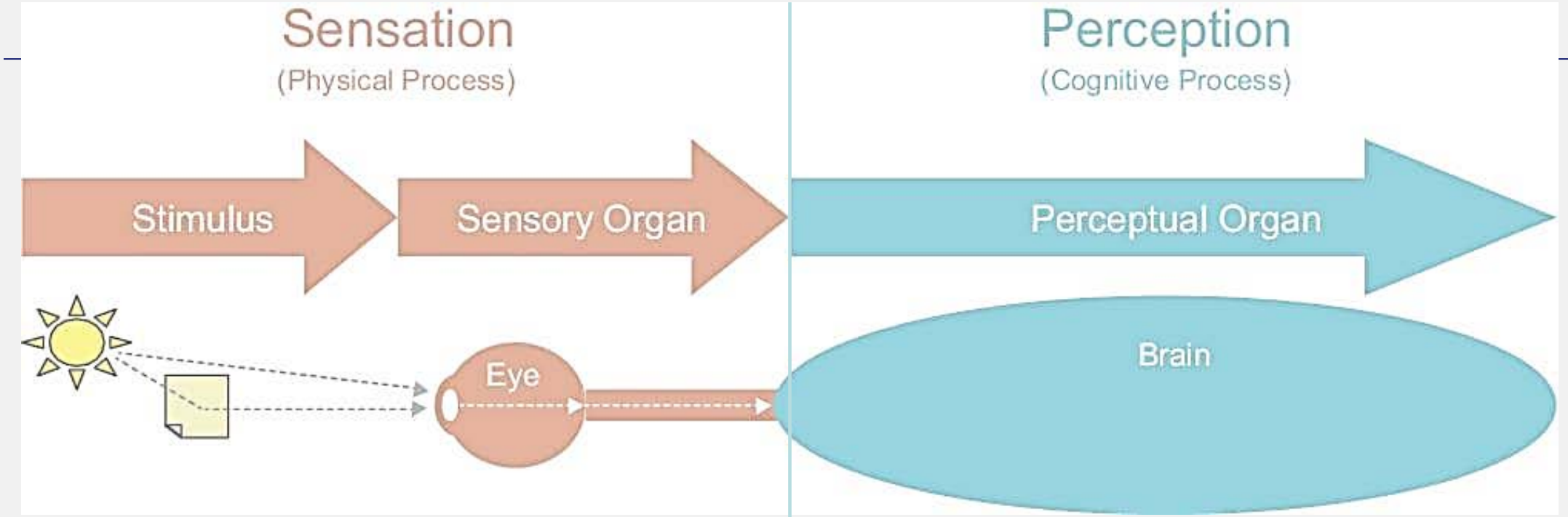
Long-time memory

Basic characteristics are extracted

Analysis of details (shapes, colors, edges)

Detection of patterns, object recognition

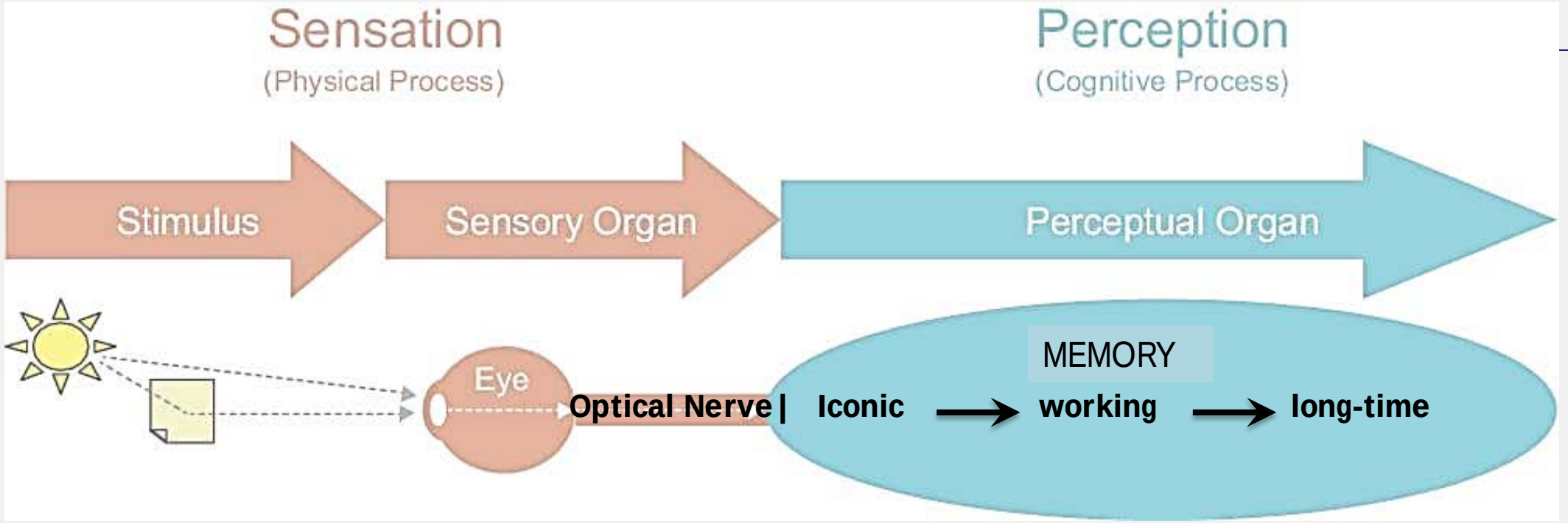
Experience



Sensations = physical detection of stimuli

Perceptions regard the interpretation of the sensations by exploiting cognitive approaches

Different sensations trigger different perceptions, perception trigger cognition



Memory actively builds world representations based on external sensations and on the past experiences.

Tomei, L. (2017). Psicologia della memoria in Aquilar, F., Pugliese, M. (2017). Condividere i ricordi. Psicoterapia cognitiva e funzioni della memoria. Franco Angeli Editore

Stimulus

Iconic Memory (visual sensory register – Stephen Few):

Stimuli stay there for 1 sec-1 min

Performs the uncoscious, *preattentive processing*

finds already known elements or most informative, high frequency, atomic elements: colors, edges, positions of points in space.

Patterns and elements which are further analized by the working memotry and then by the short-time memory

Visualizations should exploit preattentive stimuli to hit the iconic memory and the following memories!

GAME

I'm reading strings with numbers.

Trye to repeat in your mind the numbers without looking at the slide or writing them down

Example:

If I say "3-8-6", in your mind you repeat: "3-8-6"

I WON'T REPEAT THE NUMBERS.

READY????

Adults can store 7 ±2 elements

Miller, G.A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. Psychological Review, 63, 81–97.

The Working memory has a limited space!

We can't store numbers, but we can store pictures (positions of points)!

Could you repeat the third (short) sequence I said?

.....

As a cache, the working memory is emptied any time new data enters. To recall the numbers, we should think about them, to bring them in the long-term memory

Effective visualizations are visualizations that use preattentive attributes hitting the preattentive memory.

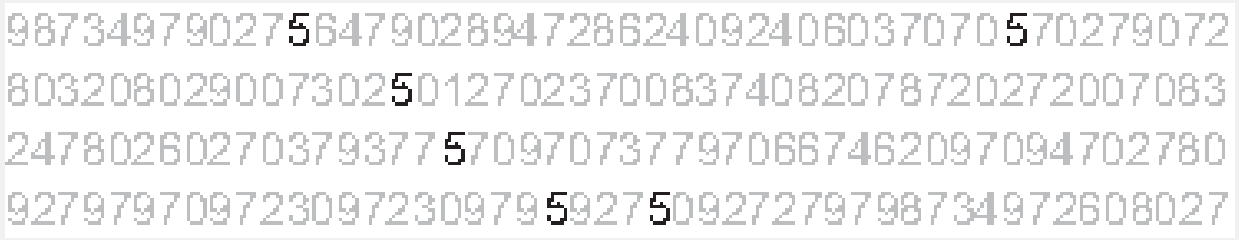
Long-term memory is important for the retrieved knowledge:

- I see a red color in a graph with the pre-attentive memory, the long-time memory tells me that color means fear
- The working memory recognizes the shape of a graph, and the long-term memory tells how to interpret the graph

PREATTENTIVE ATTRIBUTES

Quanti 5 sono contenuti nella sequenza qui sotto?

E qui?

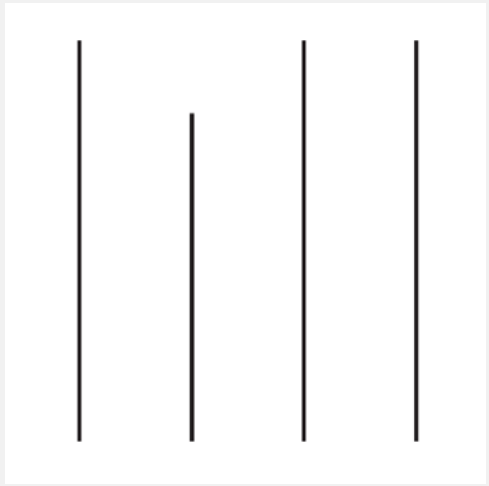


Colin Ware organization of pre-attentive attributes

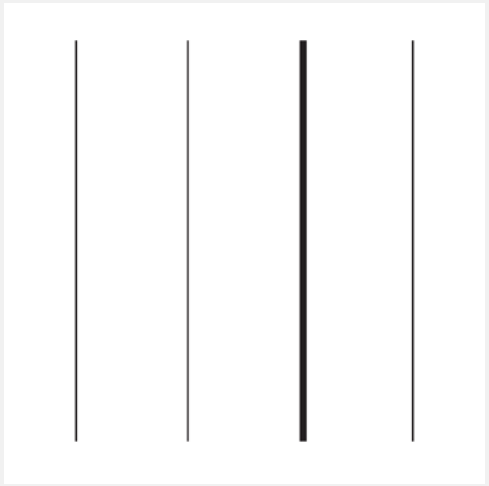
Type	Attribute (variations of)
Form	Length = distance along the dominant dimension Width = distance along the secondary dimension Orientation Size Shape Enclosure
Color	Hue Intensity
Spatial Position	2-D Position

FORM

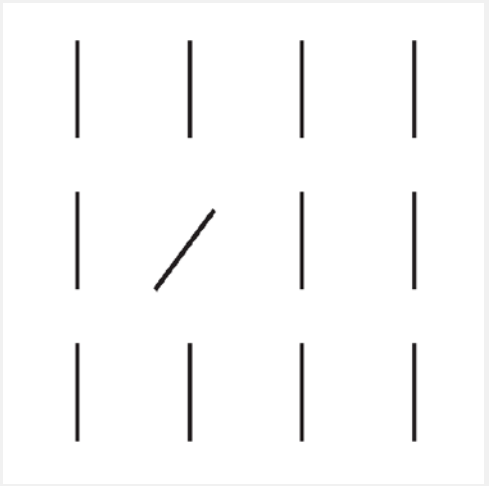
length

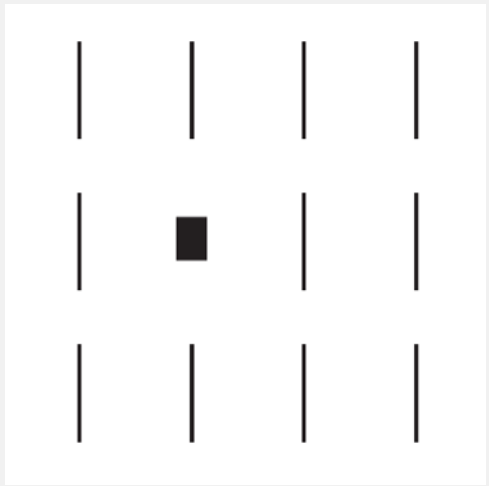


width

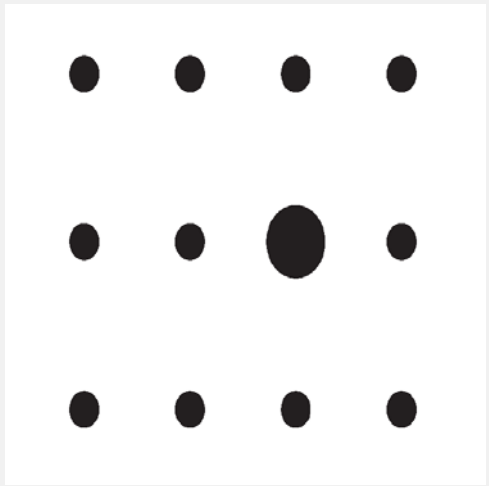


orientation

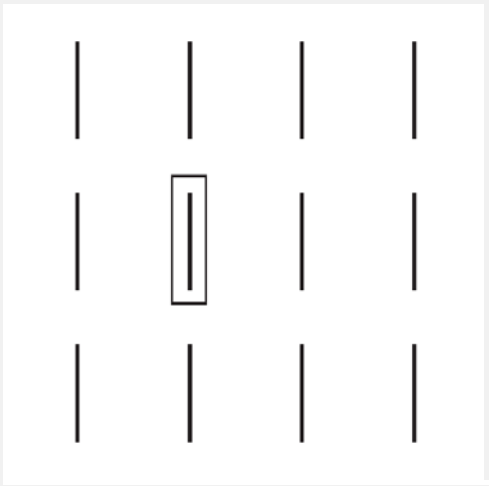




shape



size

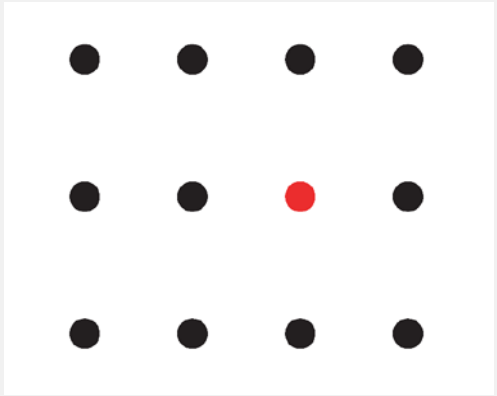


Enclosure

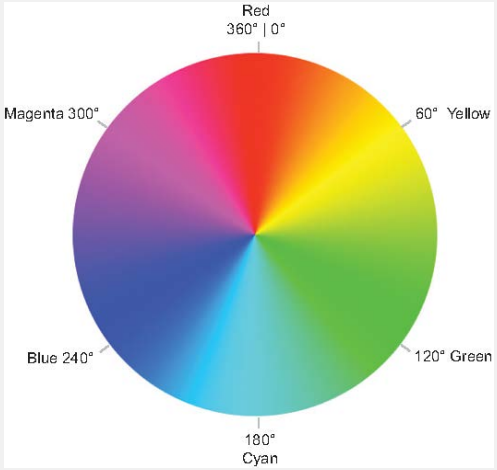
Colors

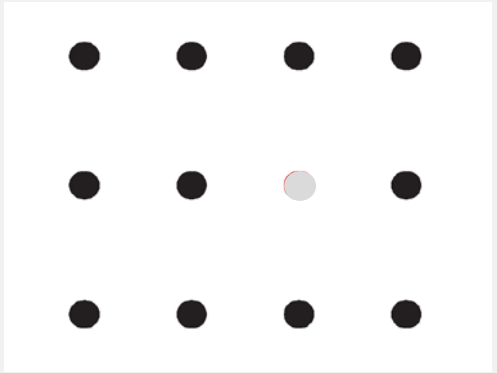
Hue is the color as we think about it

Intensity influences saturation and lightness



HUE





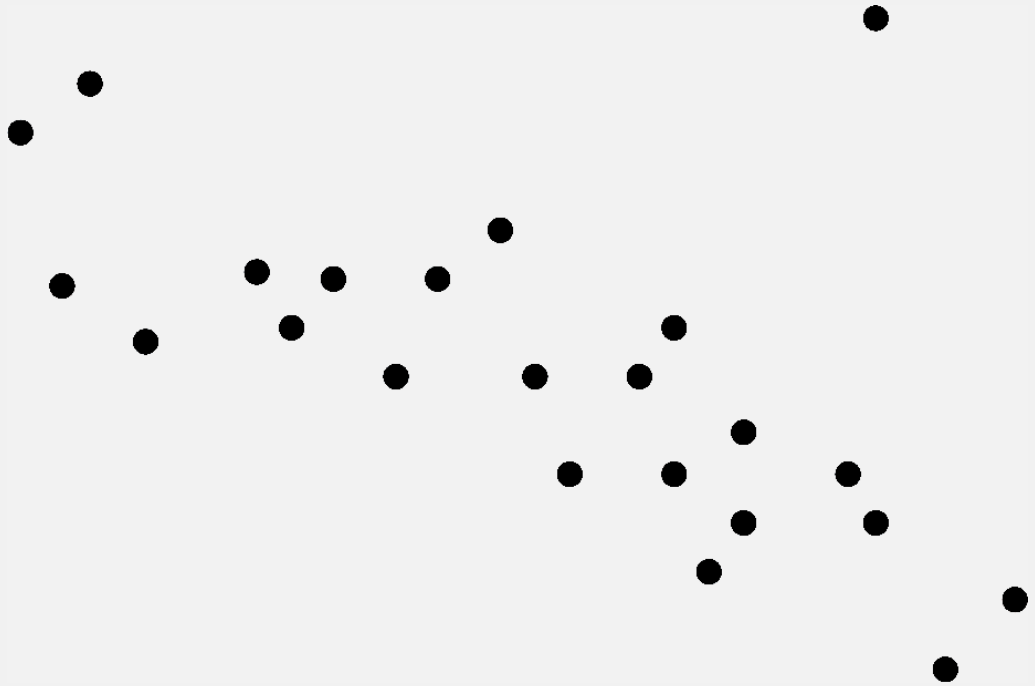
INTENSITY

saturation

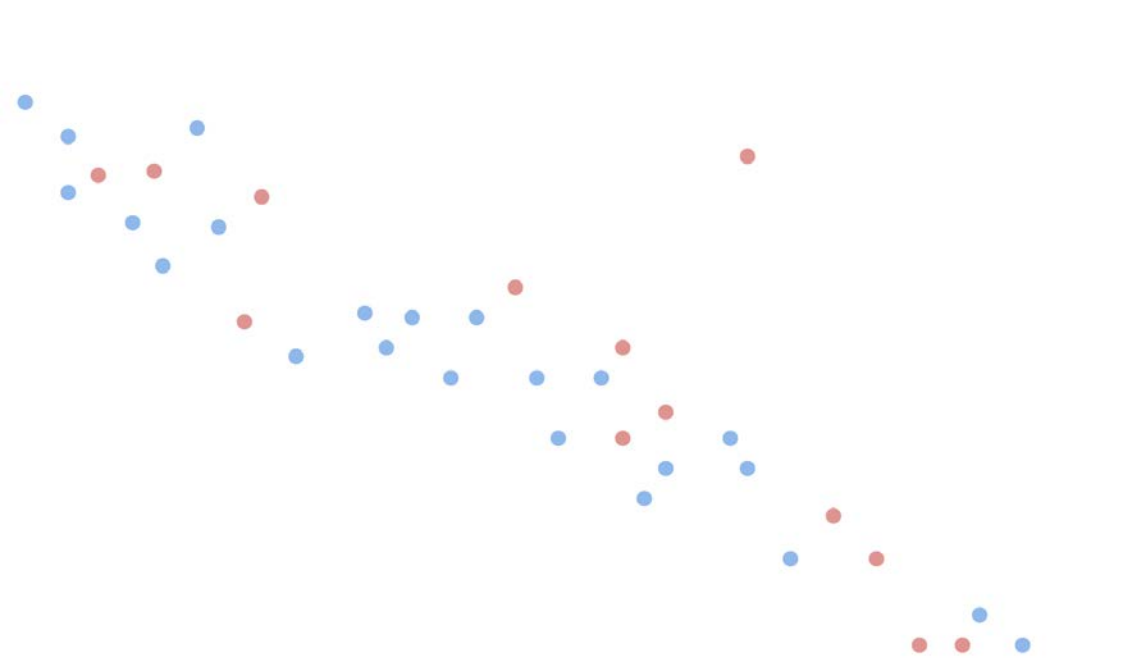
brightness

Position

We mainly see differences in 2D positions: horizontal differences in position and vertical differences

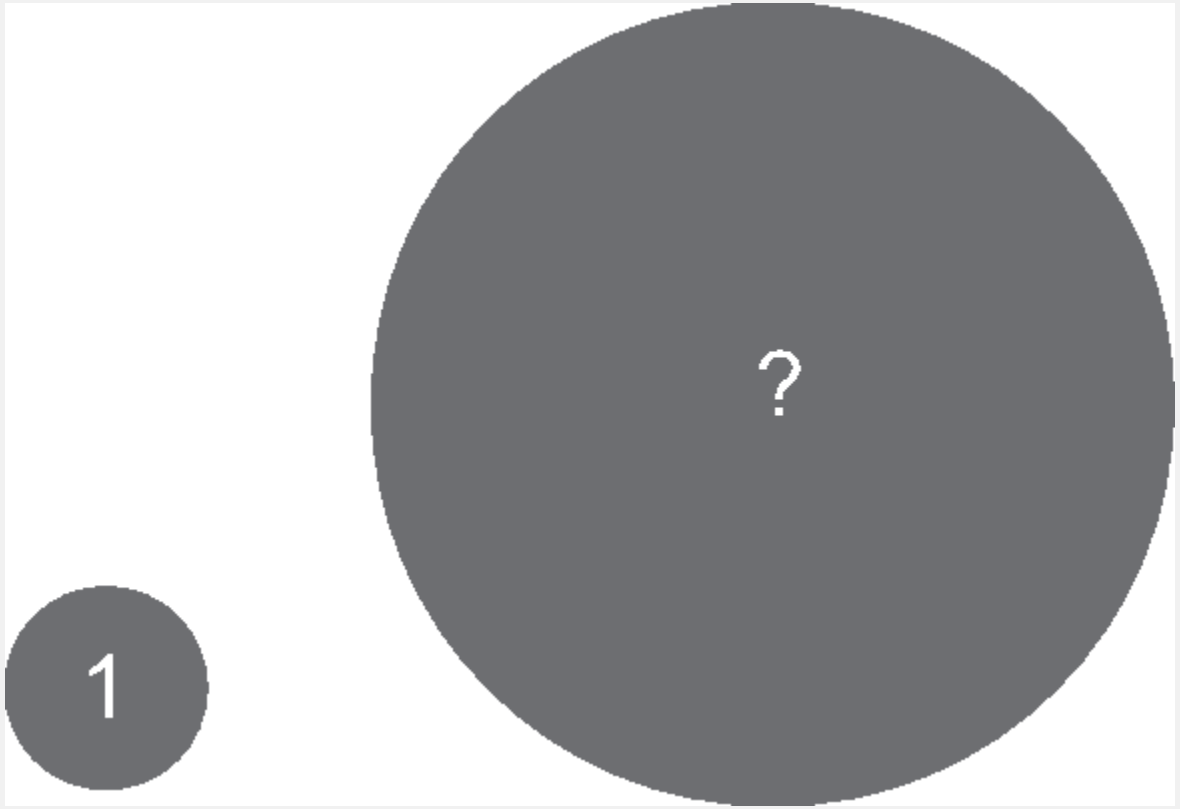


Type	Attribute (variations of)	Quantitative/Categorical Perception
Form	Length	Quantitative
	Width	Quantitative BUT LIMITED
	Orientation	Quantitative (ONLY TRENDS)
	Size (Area)	Quantitative BUT LIMITED
	Shape	Categorical
	Enclosure	Categorical
Color	Hue	Categorical
	Intensity	Quantitative BUT LIMITED
Spatial Position	2-D Position	Quantitative (!!!! Best one)



Colors let me perceive two categories

Position le me perceive higher(lower values)



MIND THE OVERALL PICTURE!

"[…] It is easy to spot a hawk in the clear sky

It is easy to spot a hawk in a sky full of pigeons

It is NOT easy to spot a hawk in a sky full of different kind of birds […]"

Pre-attentive memory is small, for each pre-attentive attributes, it can recognize a limited number of variations.

8 different hues,

4 different sizes,

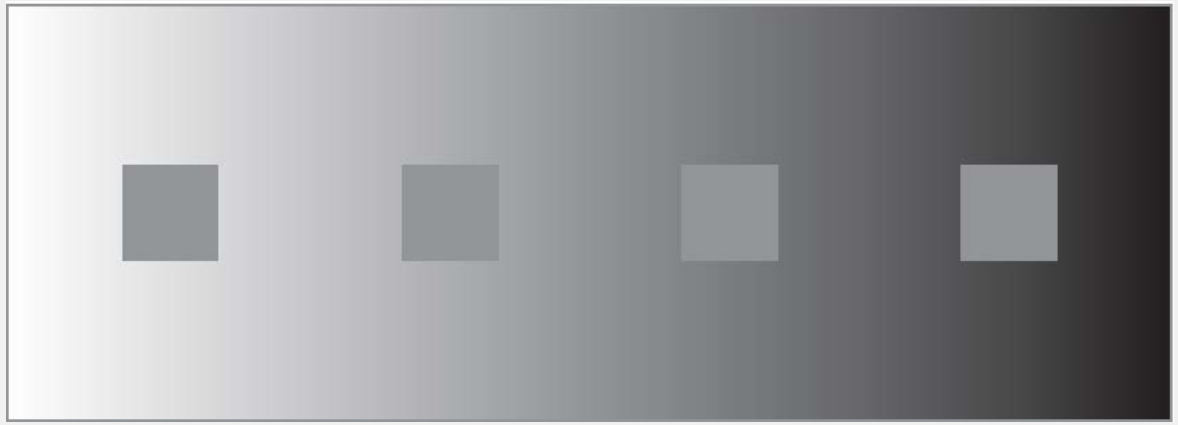
4 different orientations …

Mind the context!

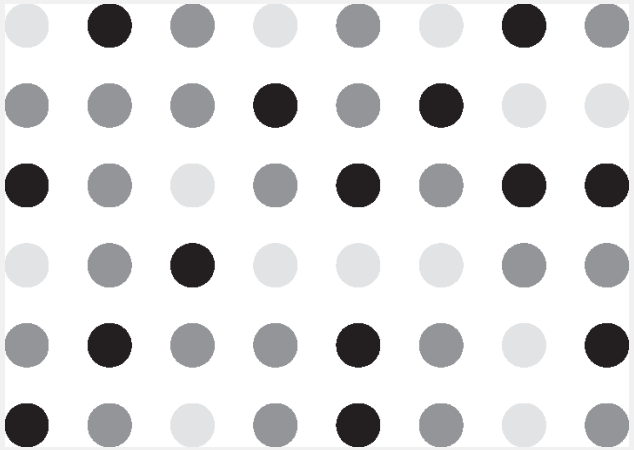
The context influences the way the output is perceived

Black text works well here (grey background)

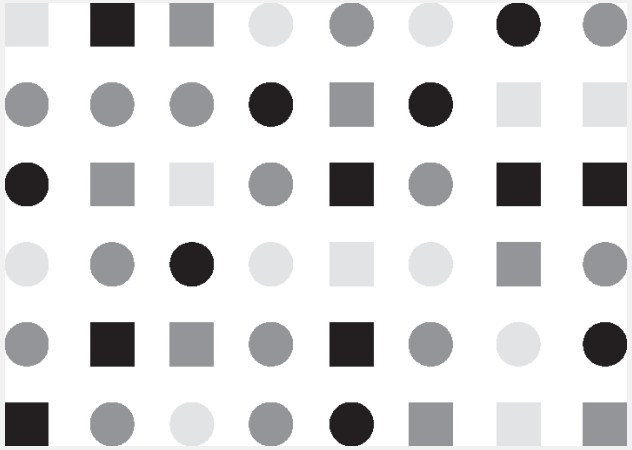
Black text do not work well here (dark blue background)



Two attributes alone work well but using them simultaneously may create overload.



One attribute (intensity), three categories/quantities



Two attributes (shape+intensity), six categories

but picking up the brightest categories is more difficult;

readers get annoyed

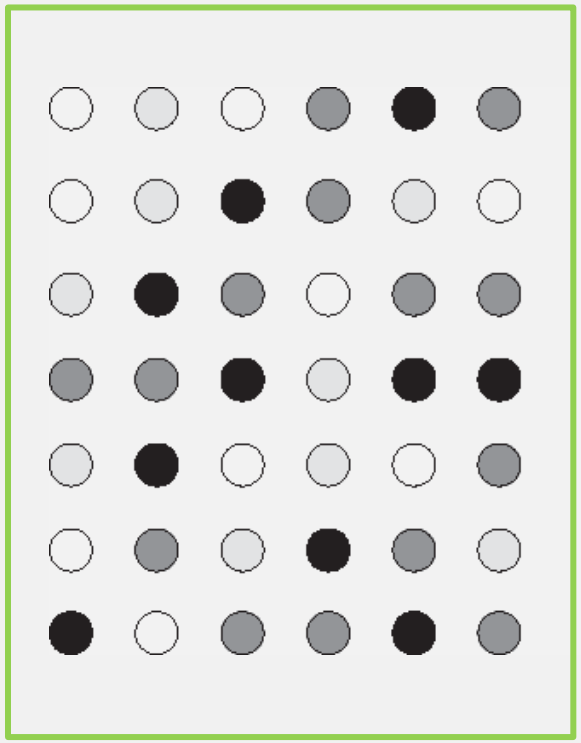
Line-plot using different colors and different markers

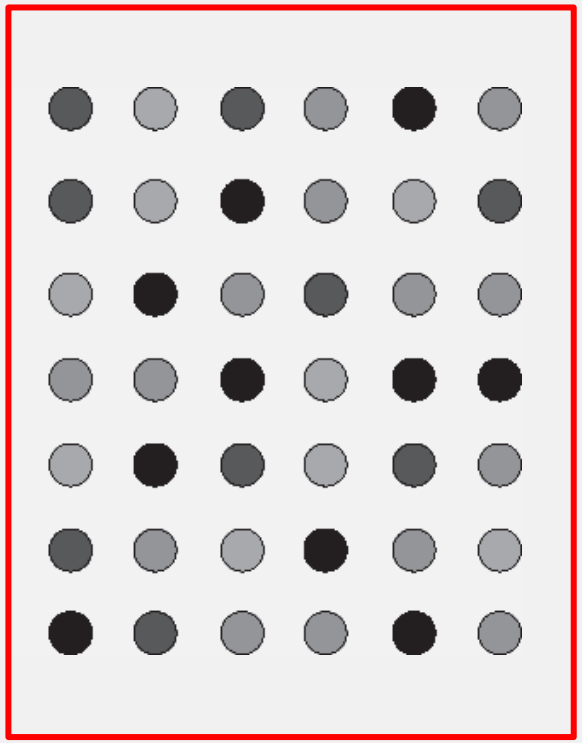
Shapes and colors are used together to discriminate among categories

Gupta, A.; Wang, H.; Ganapathiraju, M. Learning structure in gene expression data using deep architectures, with an application to gene clustering. 2015 IEEE International Conference on Bioinformatics and Biomedicine (BIBM), 2015, pp. 1328–1335. doi:10.1109/BIBM.2015.7359871.

PICK ATTRIBUTES for which the range is big enough

Differences between different categories/values must reflect in farthest possible differences in the attributes





Hues that are seen as different are

Gray

Blue

Orange

Green

Pink

Brown

Purple

Yellow

Red

Colors

Represent different things depending on the cultural background.

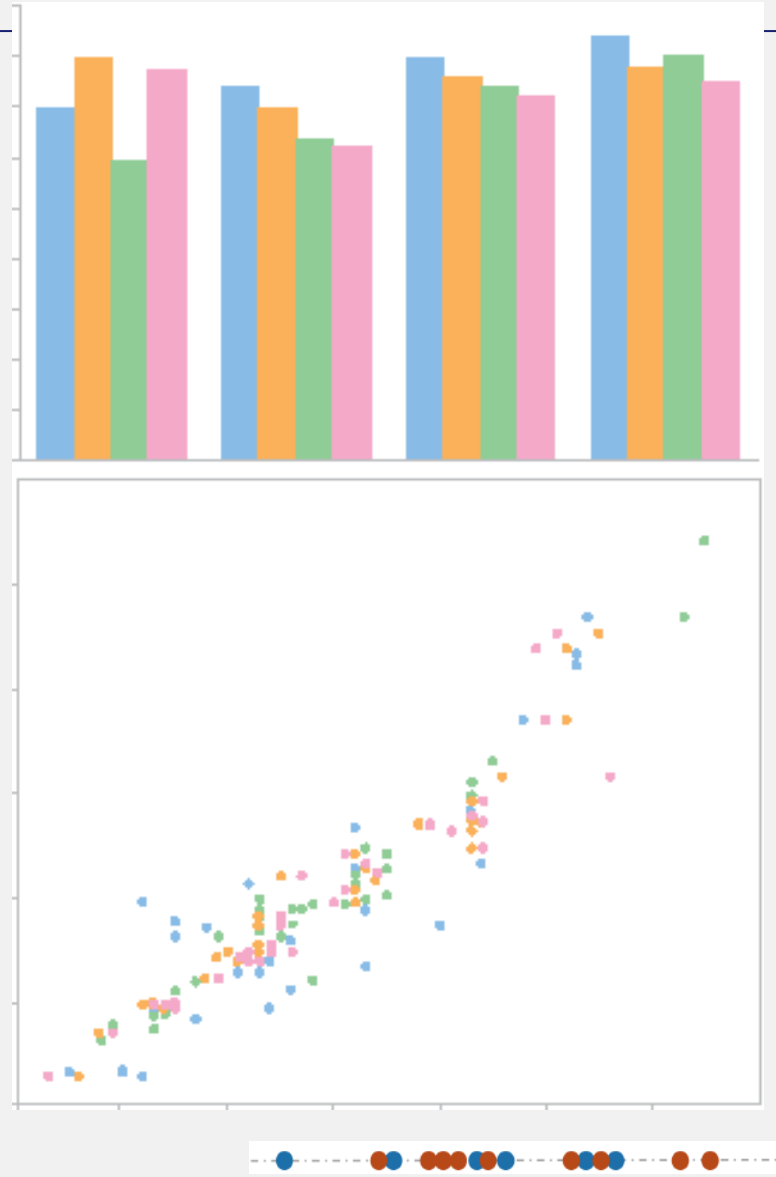
Bright, saturated colors are strong and exciting, attracting attention.

Natural colors (generally not fully saturated) are more neutral and soothing.

Use saturated colors to highlight some information.

Use not saturated colors if you want to color tables or for graphs where all the info have similar importancy and nothing need to prevail.

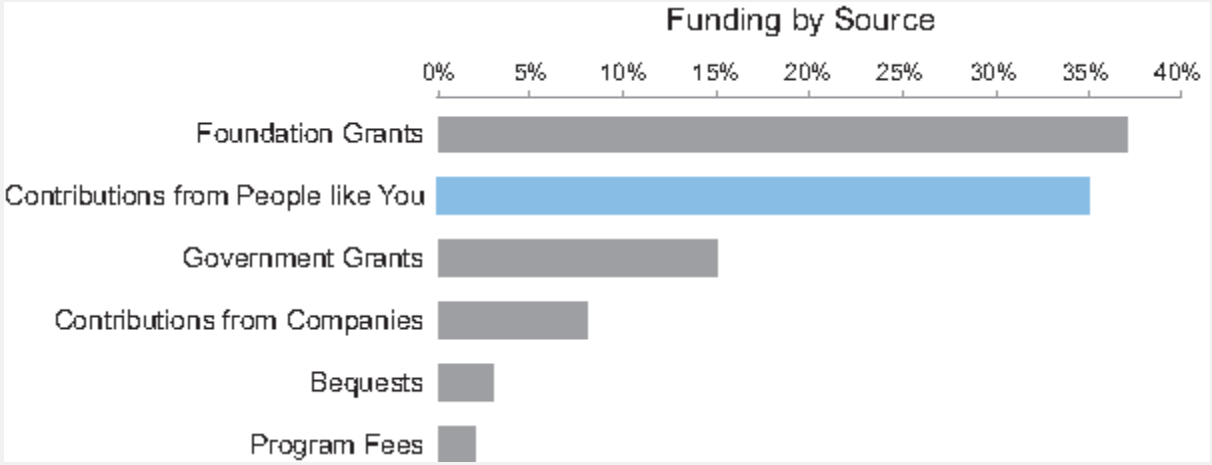
The ability of distinguishing colors diminish with the size of colored objects



Rule of Thumb: whenever you have N categories to be represented, chose a (colorblind safe!!) palette and prepare three version of it:

- one with **low saturated** (yet distinguishable!!) colors for **bigger shapes** (e.g. bars, treemaps)
- one with the same colors, but **darker** for **small objects** (e.g. points in scatterplot)
- one with the same **saturated** colors for infos to be highlighted.

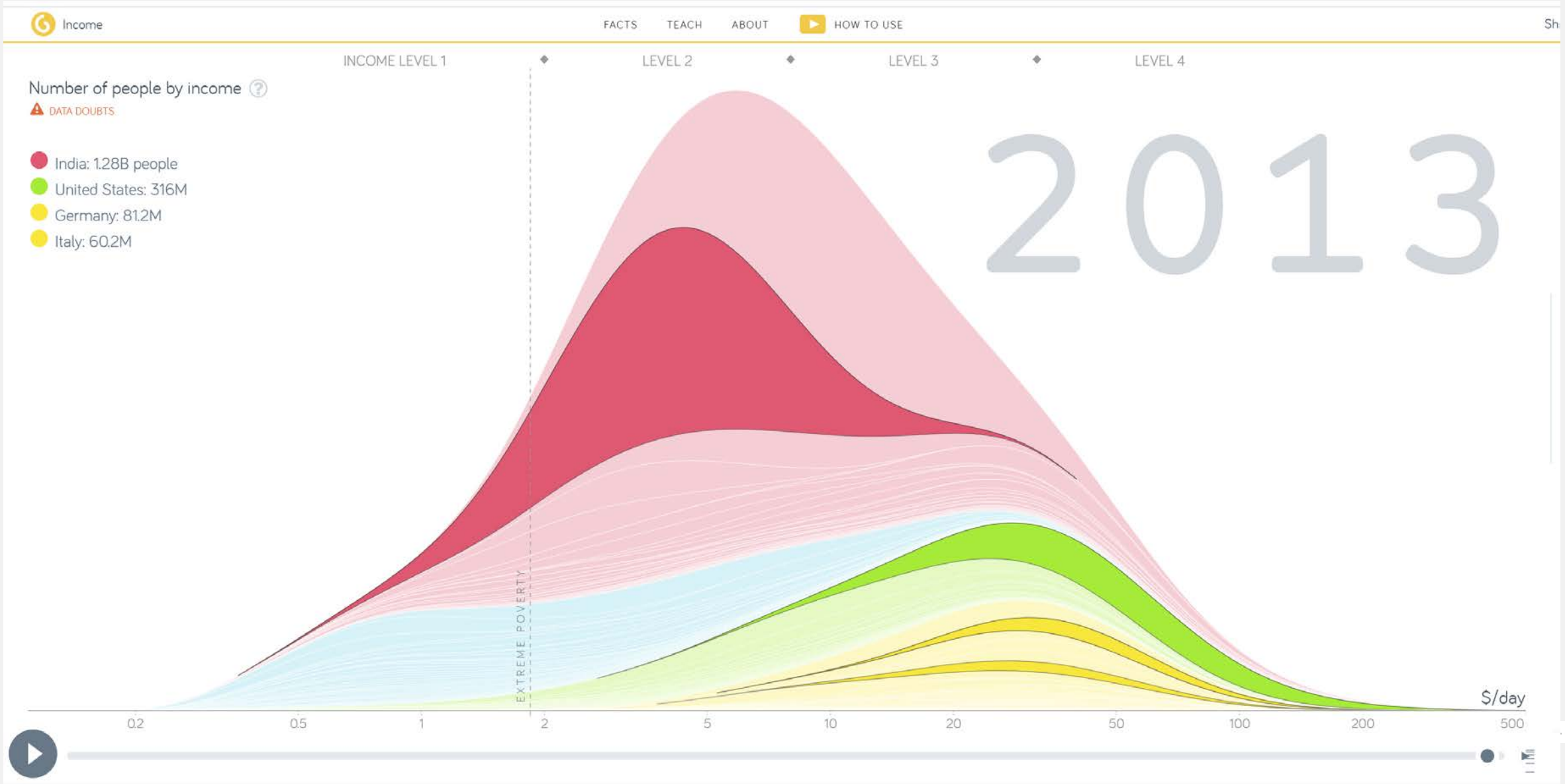
https://colorbrewer2.org/



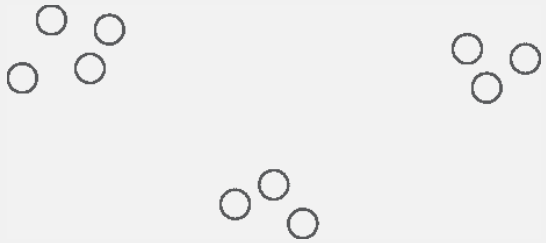
In Times Square you are lost… nothing and everything attract you. Everything is important but nothing stand out clear.

Sensation and Perception like contrast and (color) differences.
BUT too many variations delete the importance of each other.

GapMinder website: colors show different geopraphical areas



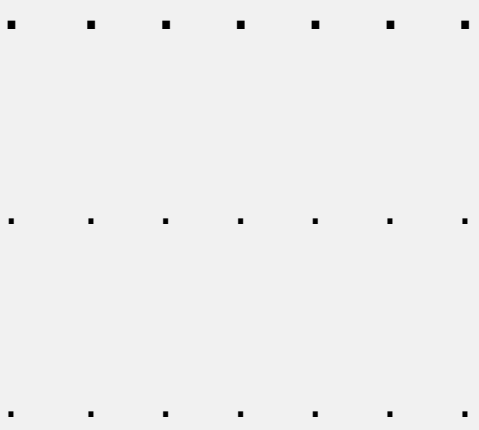
GESTALT PRINCIPLES explain pattern perception



Proximity principle: elements close to each other are perceived as belonging to the same group.

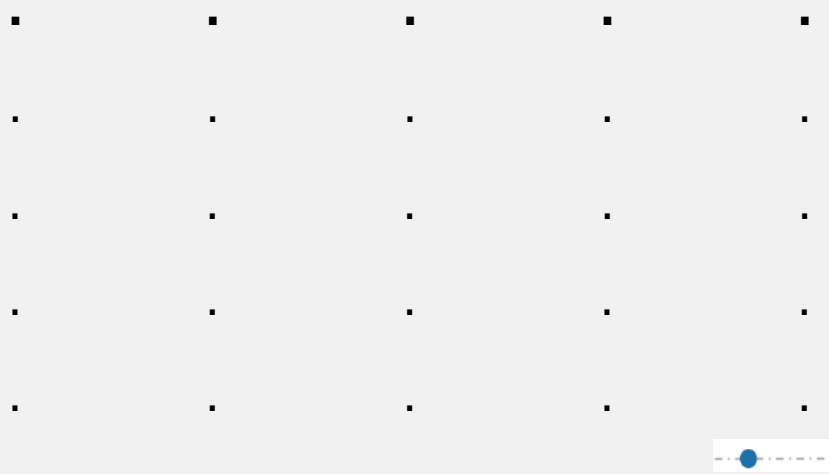
Users that each row is a group;

They scan the table row by row

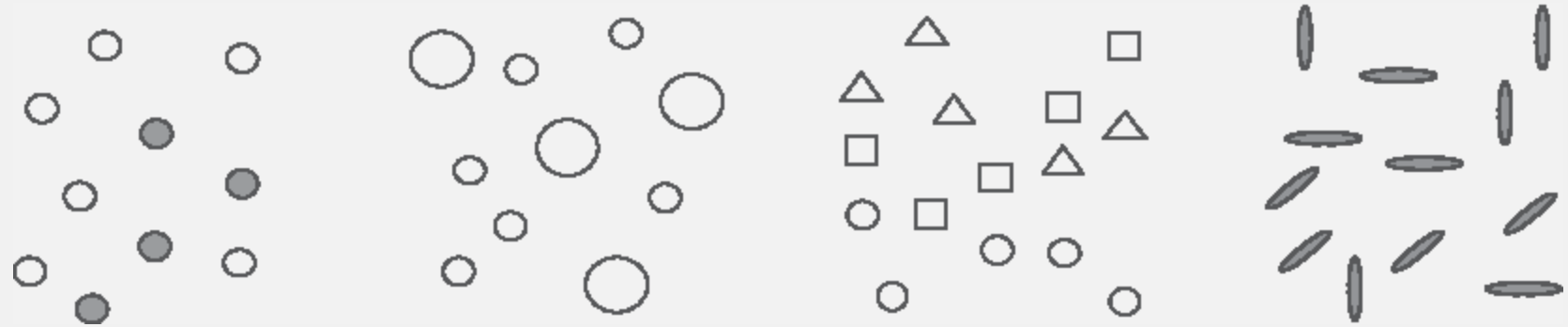


Users that each column is a group;

They scan the table column by column



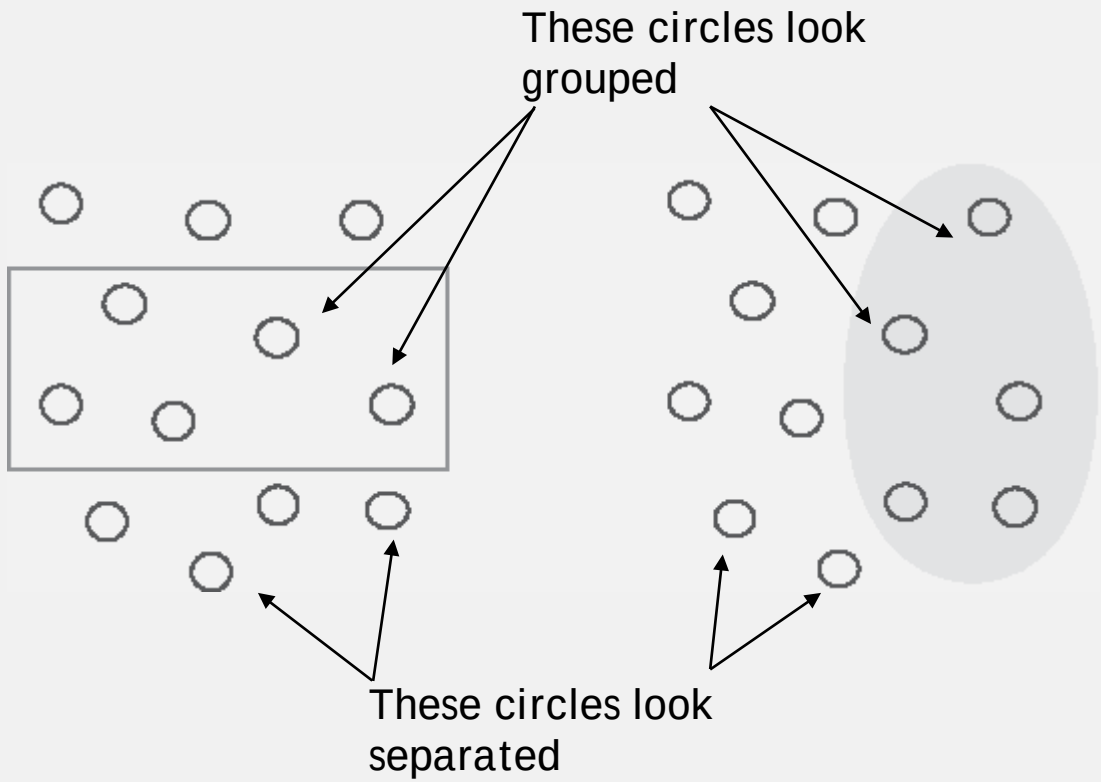
Similarity principle: (as we said) similar object (in color, size, shape, ...) are grouped

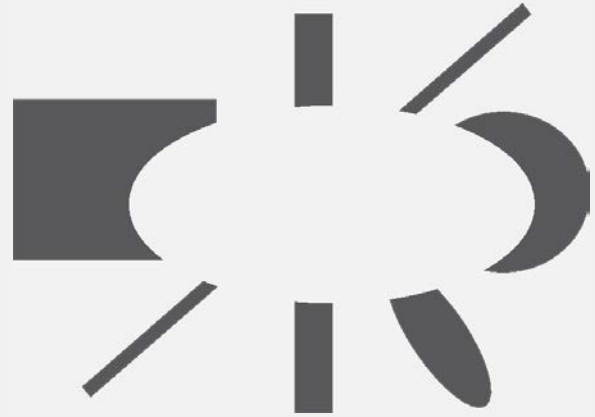


But avoid using too many categories!!!

In tables use differing colors in columns (rows) if you want to orient reader to focus on column (rows)

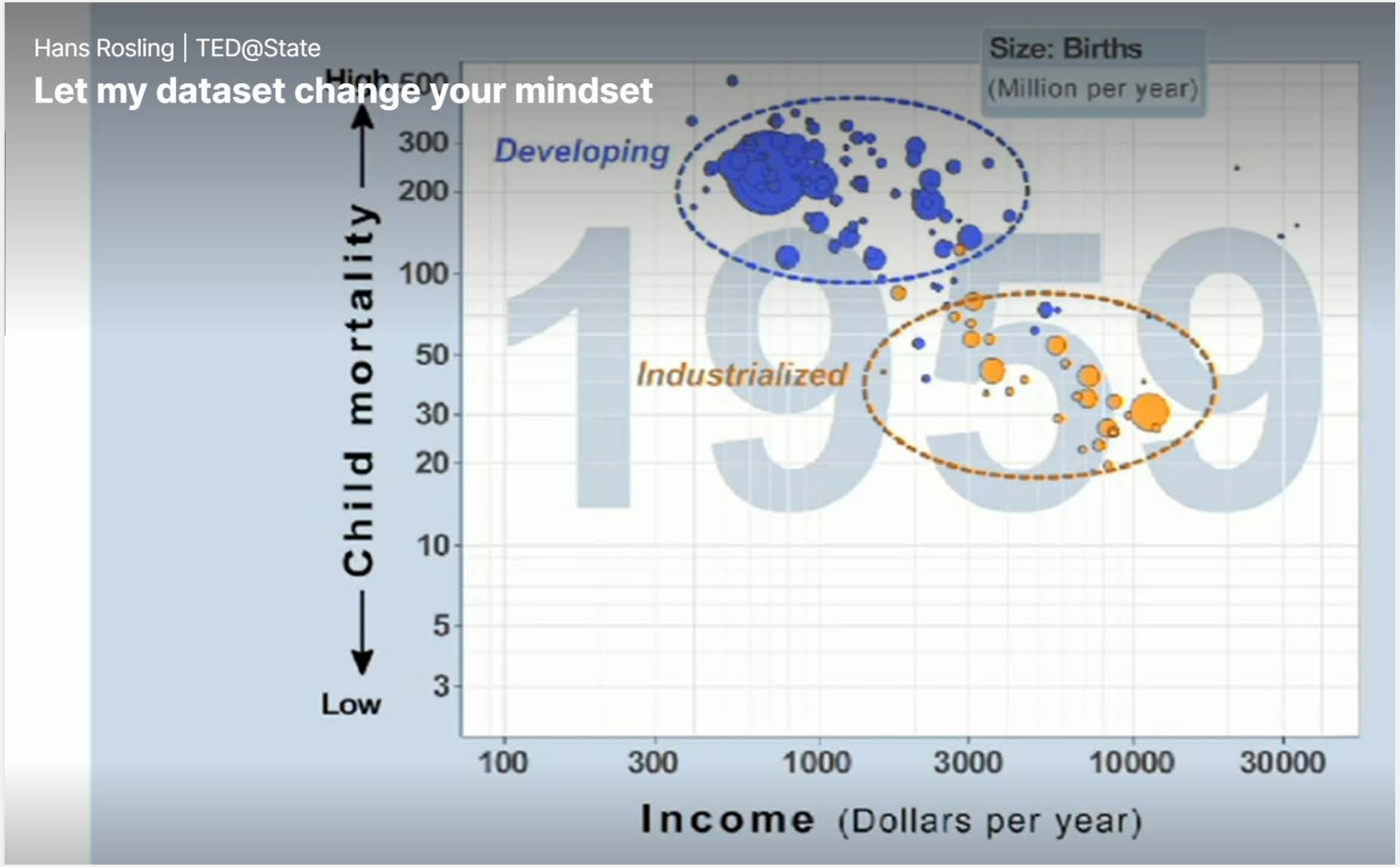
Principle of enclosure: objects that are enclosed in a way that forms a boundary around them are grouped



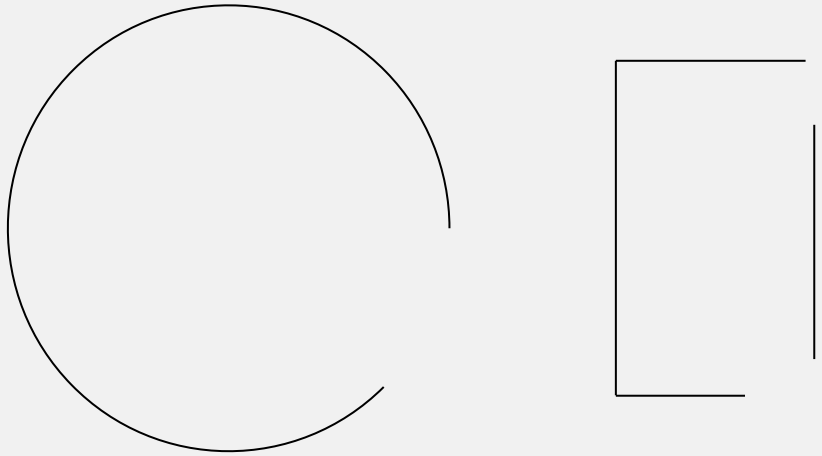


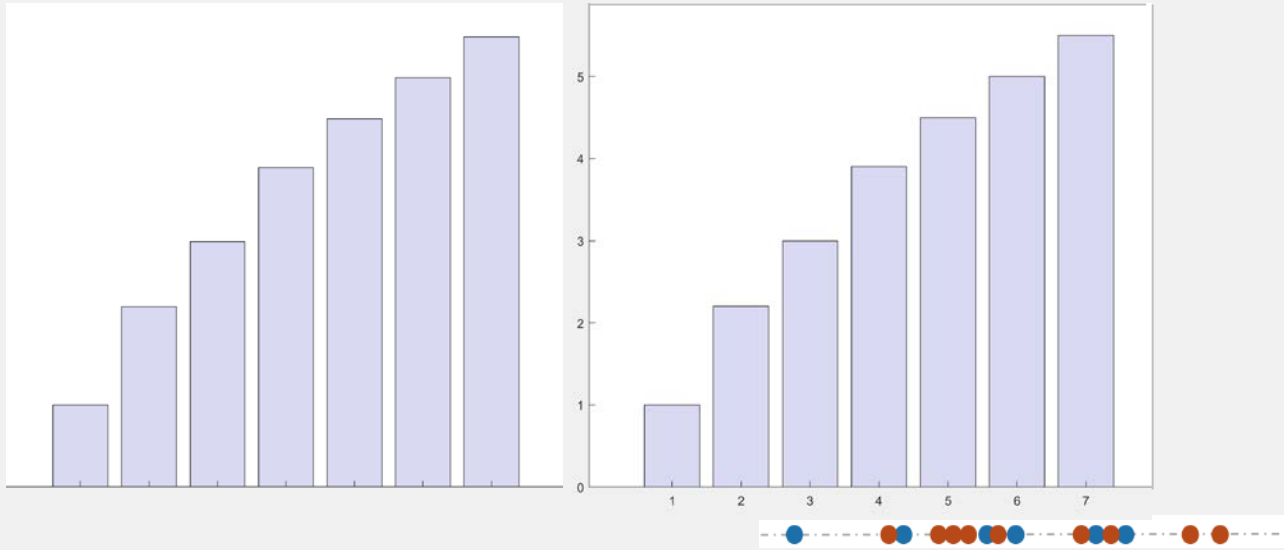
It looks like points in the middle are together and form an ellipsis

An example from Hans Rosling (TED'S TALKS): "let my dataset change your mindset"

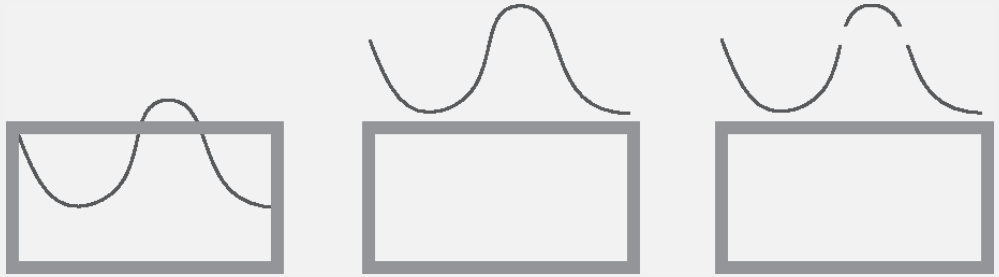


Principle of closure: human fill the gaps and close open lines





Principle of continuity: aligned objects are perceived as belonging to the same part



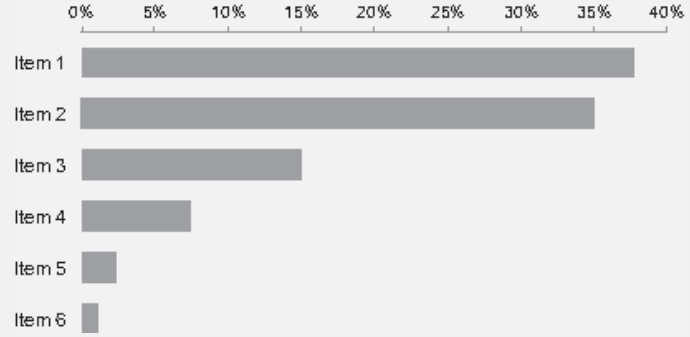
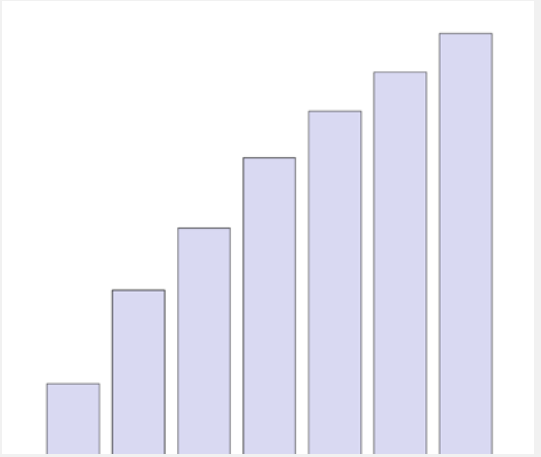
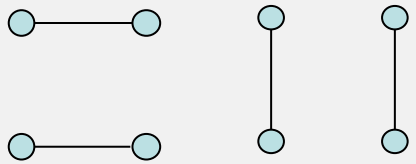


Table A.23: Household financial stress—C10 ‡

	Household comparisons					
	Adult low paid		Other		All households	
	'000s	%	'000s	%	'000s	%
Family finances: optimists						
Poor or very poor	20	1.6	44	1.2	64	1.3
Just getting along	285	23.8	720	19.0	1,005	20.1
Reasonably comfortable	645	53.9	2,039	53.7	2,684	53.8
Prosperous or v comfort	246	20.6	991	26.1	1,237	24.8
Total	1,196	100.0	3,793	100.0	4,990	100.0
Family finances: pessimists						
Poor or very poor	46	3.8	104	2.8	150	3.0
Just getting along	401	33.5	1,054	27.8	1,454	29.1
Reasonably comfortable	645	53.9	2,097	55.3	2,742	55.0
Prosperous or v comfort	105	8.8	539	14.2	644	12.9
Total	1,196	100.0	3,793	100.0	4,990	100.0
Episodes of financial hardship						
Three or more	135	11.3	295	7.8	430	8.7
Two	115	9.7	282	7.5	397	8.0
One	160	13.4	509	13.5	668	13.5
None	781	65.6	2,691	71.3	3,472	69.9
Total	1,191	100.0	3,776	100.0	4,967	100.0
How easily raise $2000 in one week						
Could not raise it	244	20.4	481	12.7	725	14.6
Have to do something drastic	194	16.2	399	10.5	593	11.9
Raise it, but some sacrifices	321	26.8	949	25.1	1,270	25.5
Easily raise it	436	36.5	1,956	51.7	2,393	48.0
Total	1,196	100.0	3,785	100.0	4,981	100.0



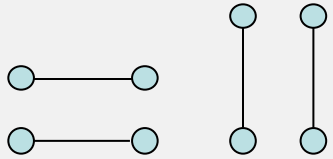
Principle of connection: objects connected by lines are viewed as part of the same group



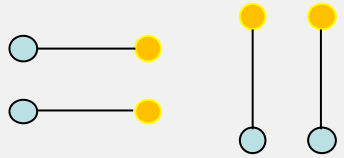
Points are equally spaced but those connected are perceived as grouped

Connection is more powerful than proximity or similarity but less powerful than enclosure

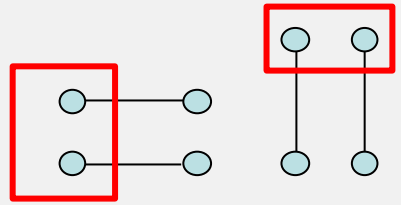
proximity

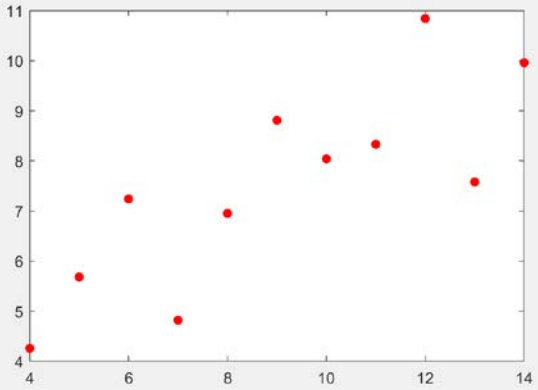


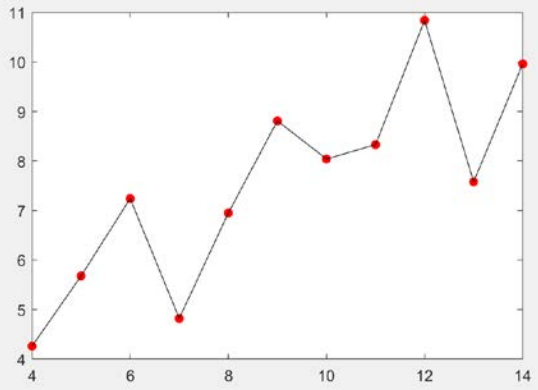
similarity



enclosure

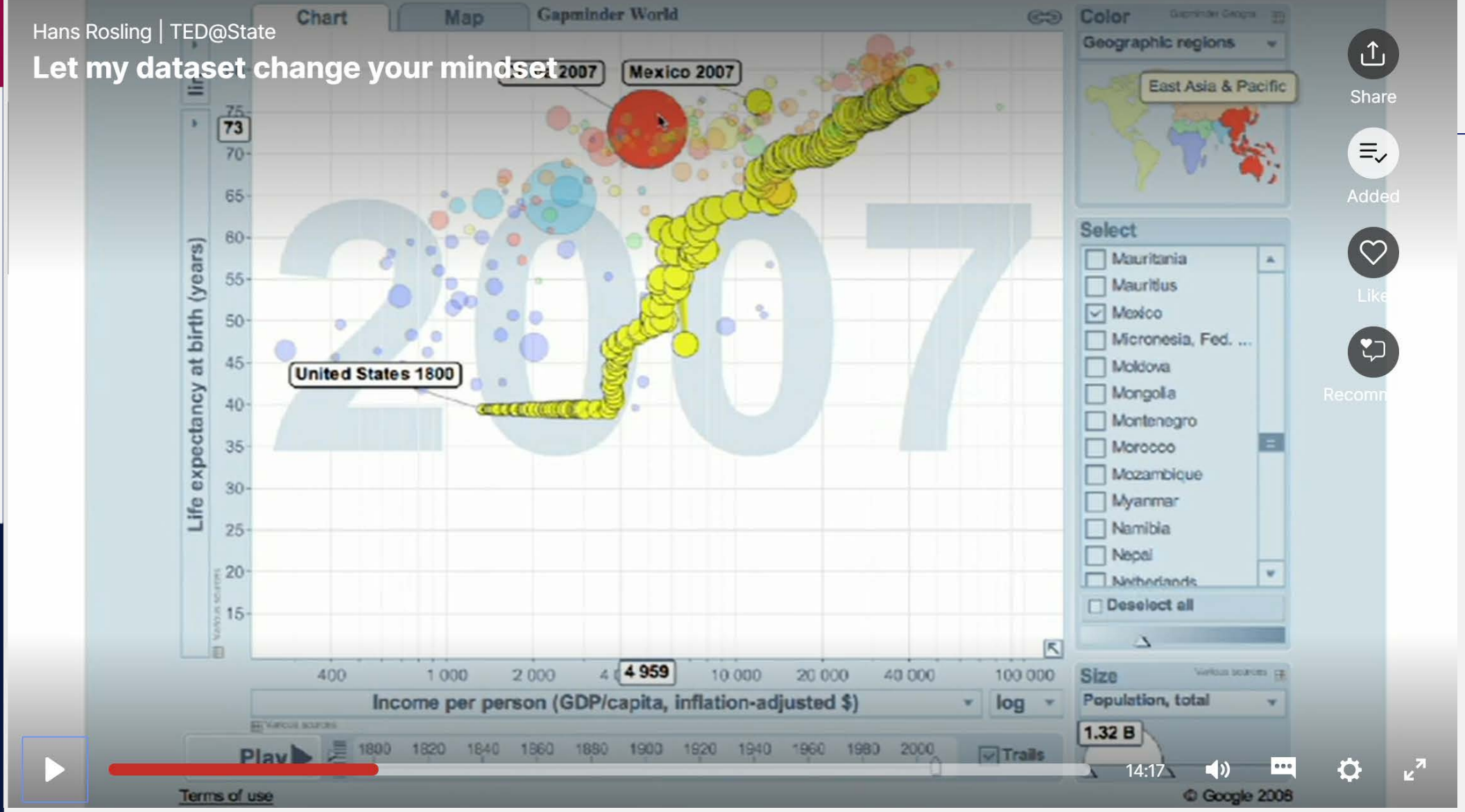






Point connection with lines in plots let us identify the trend and see patterns

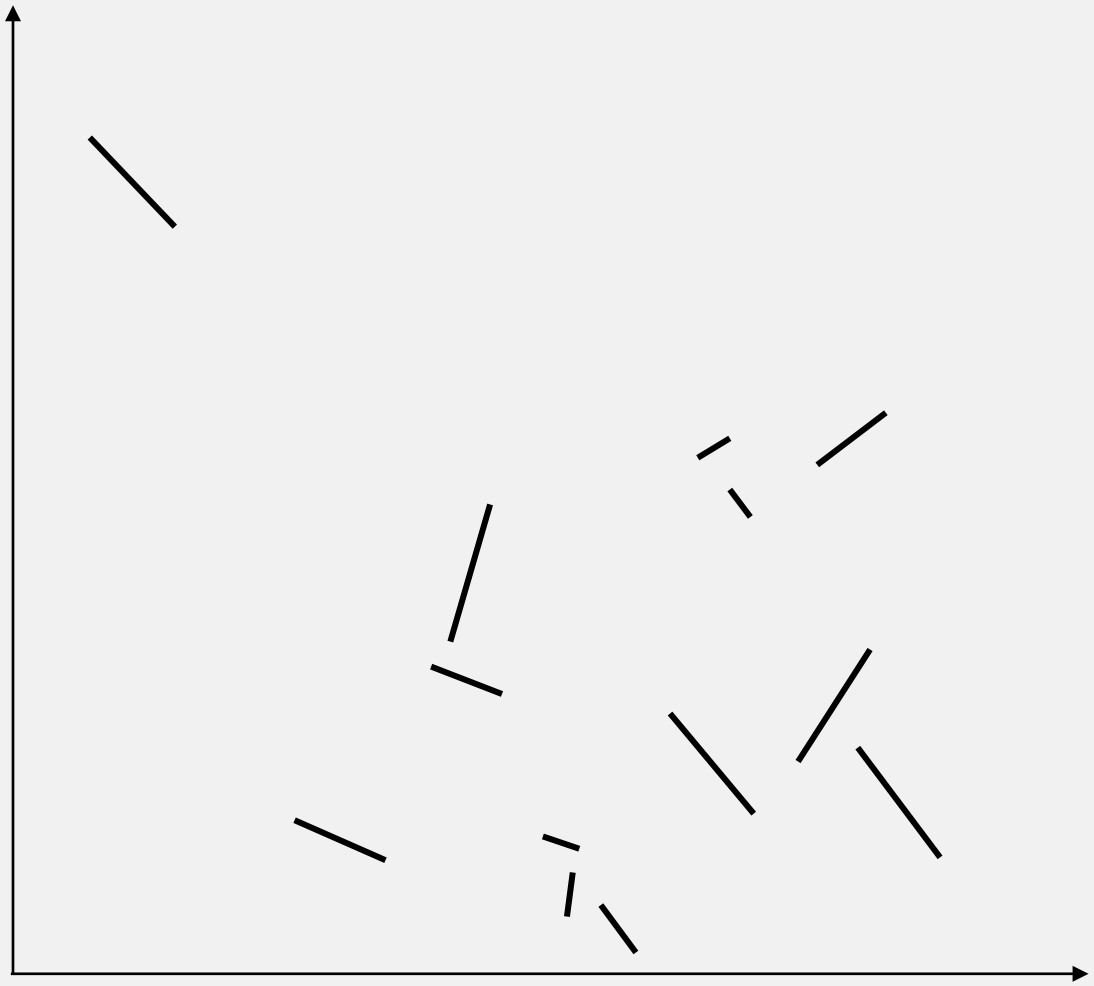
Hans Rosling (TED'S TALKS): "let my dataset change your mindset"

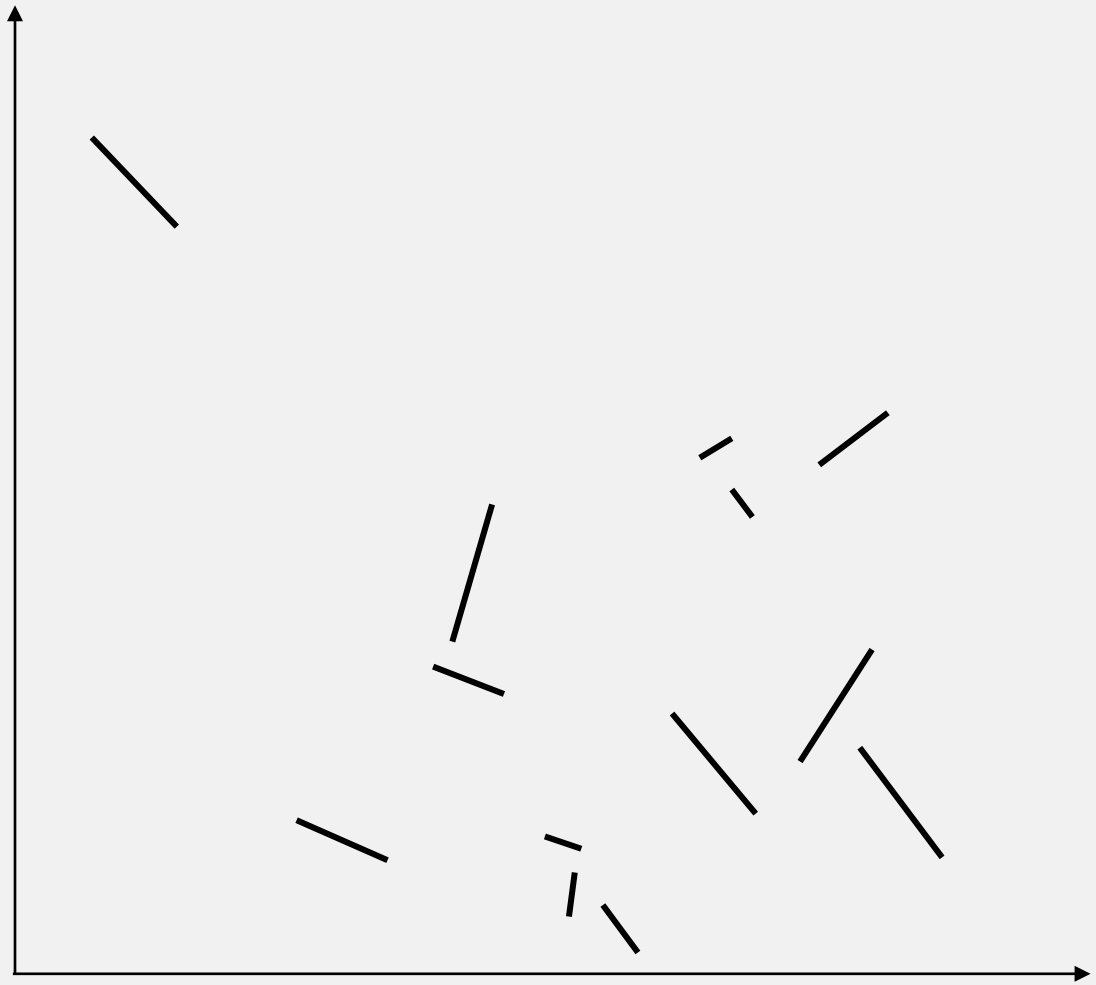


Bubbles are connected to show trends,
Keeping all bubbles allows to show also the

Another example:

what do you perceive in the following plot?



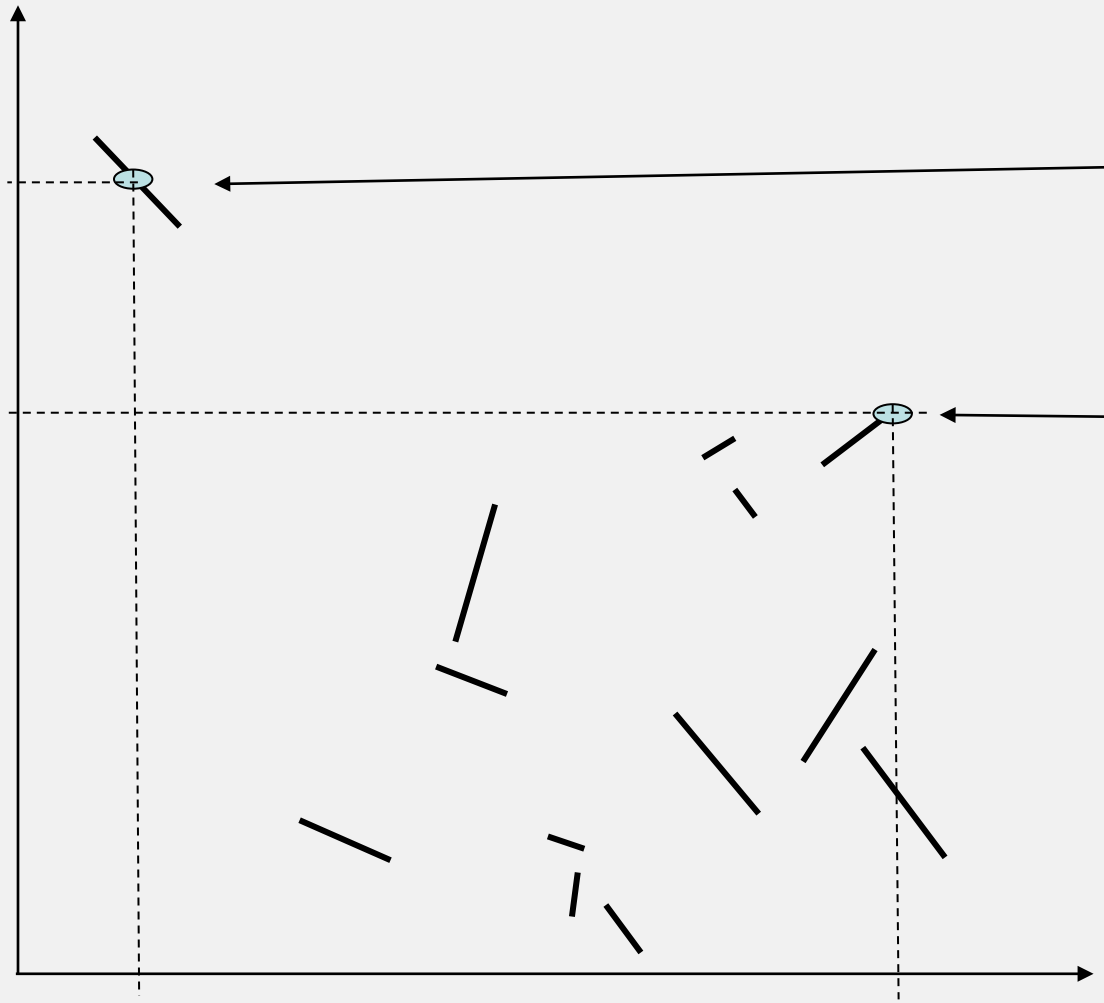


Are there categories?

How do you group segments?

- Orientation:
  - Orientation does not allow to divide into categories (colors or shapes on the segments would)
  - different orientations may allow showing trends
- Length
  - Length allows “sizing” each input (we perceive it as related to the strength of the point)

Position: which is the precise position of the points??



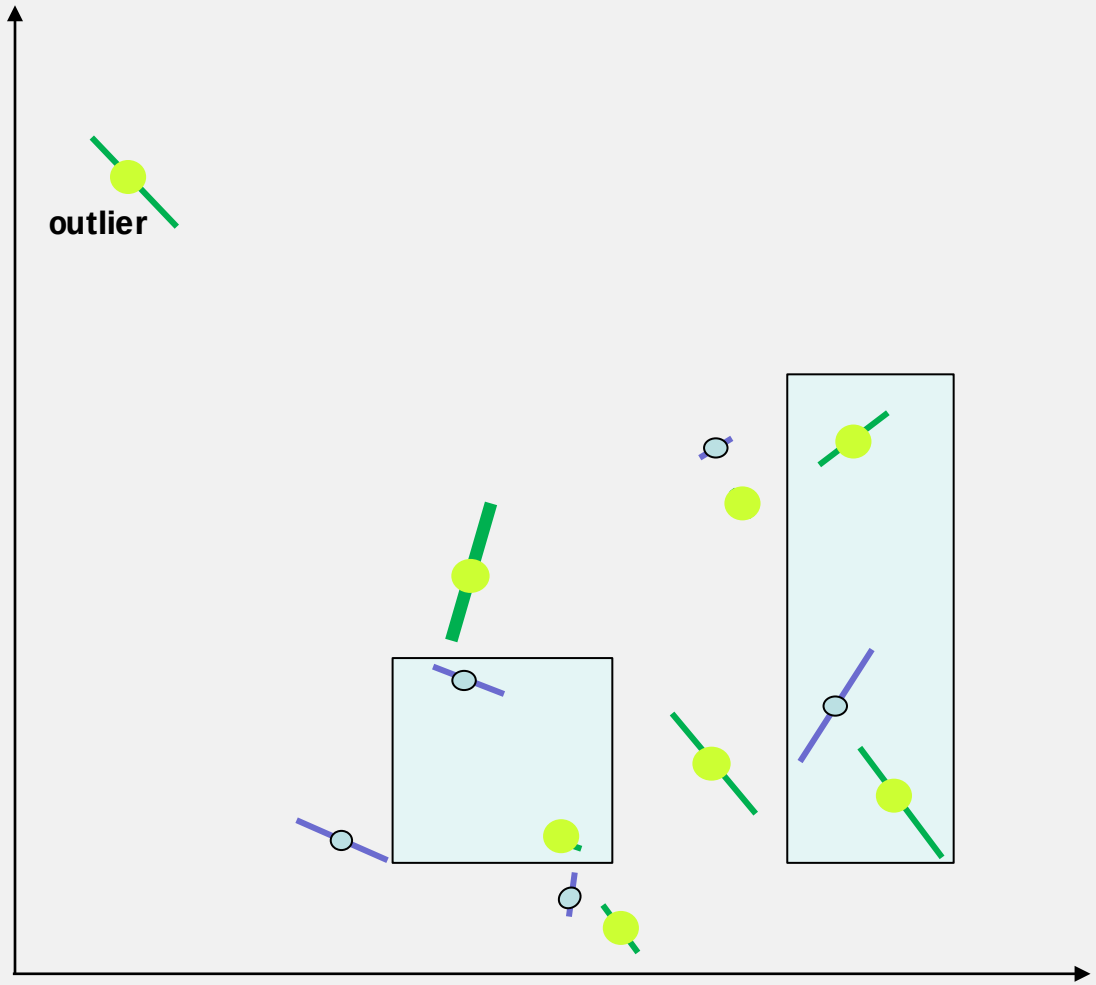
Where would you place the center on the x, y axis?

- At Center of the segment

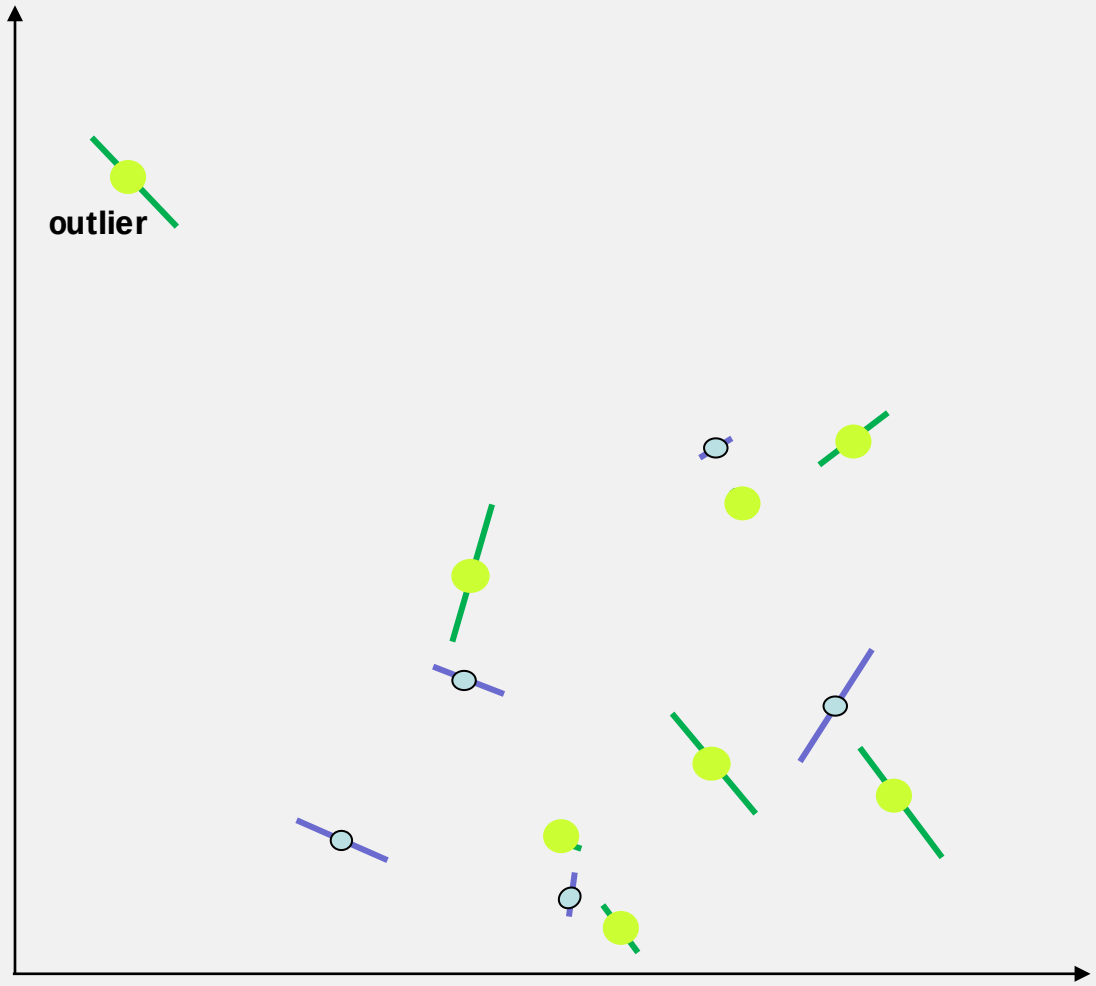
At one end of the segment (physics memories)

- the position of the segment is at the extremes of the segment or at the center???
- Extremes of the segments if you recall physics lectures (but you are implicitly searching for an arrow)

The gestalt principles



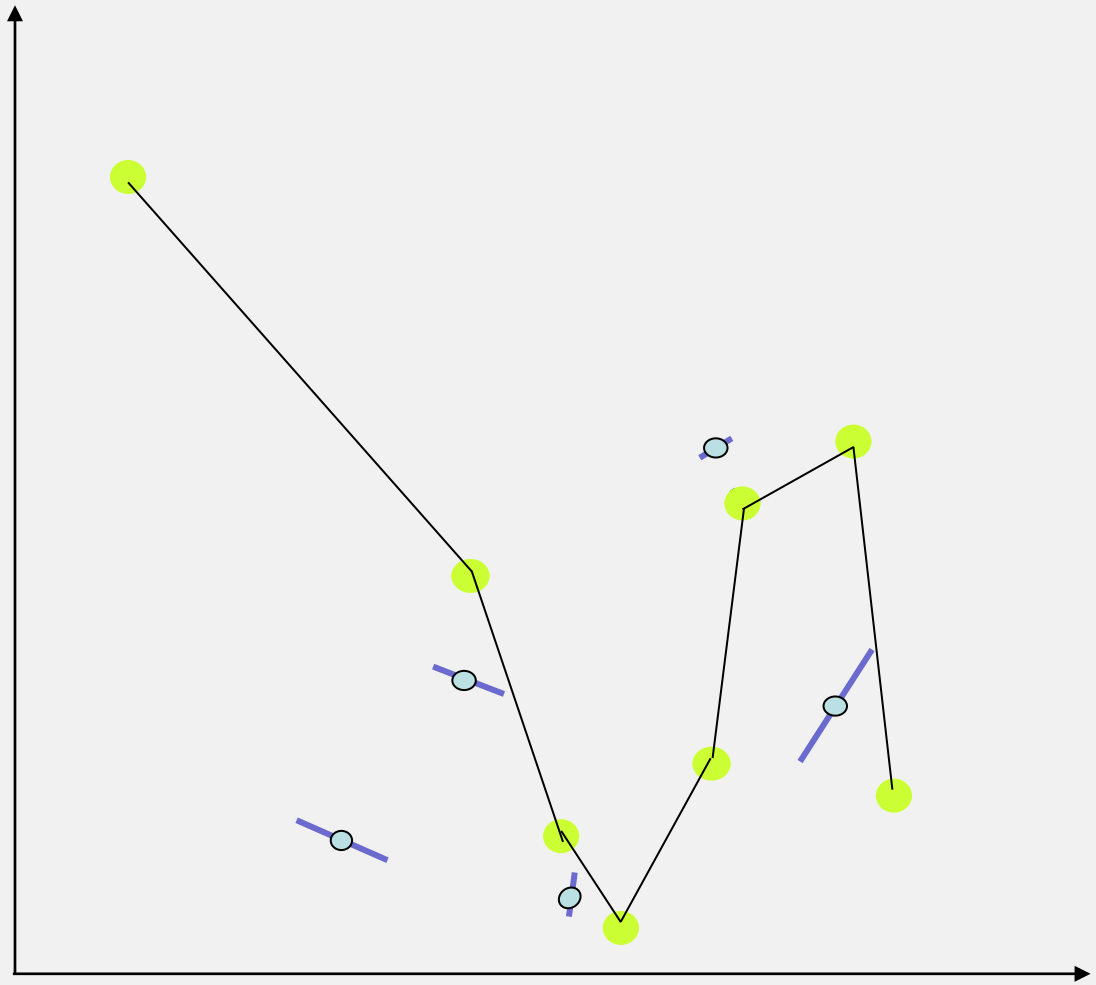
- Similarity in Colors and shapes discriminate categories
- Enclosure allows grouping certain elements
- Differences in proximities (Position) helps identifying outliers and further communicates measurements



otherwise

- Proximity further drills down connections

  (though enclosure is stronger)



- Connection helps viewing the pattern of change

Information Design

exploits knowledge about human perception to create **Infographics (information+graphics):** information (data) visualizations combining integrating text, (scientific) data visualizations, and images to tell a whole story and show results, inform, entertain, persuade the audience.

(Cool Infographics)

EVERYTHING MUST E CONSIDERED: TEXT

Why should we be interested in Visualization? ...

The visual system has its own rules. We can see patterns presented in certain ways, but if they are presented in other ways, they become invisible...

When data is presented in certain ways, the patterns can be readily perceived.

If we can understand how perception works our knowledge can be translated into rules for displaying information.

Following perception-based rules, we can present our data in such a way that the important and informative patterns stand out.

If we disobey the rules, our data will be incommprehensible or misleading

Colin Ware, «Information Visualization: Perception for Design» (2004)

COLORS....

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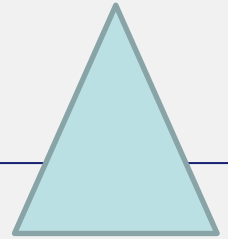
SHAPES



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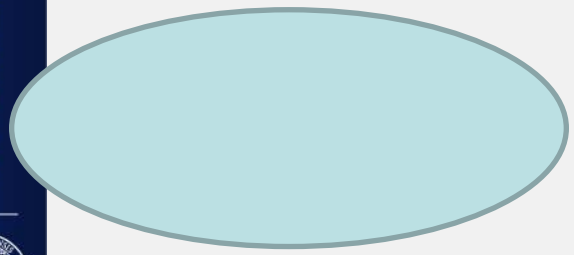

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Colin Ware, «Information Visualization: Perception for Design» (2004)

‘‘Of all methods for analyzing and communicating statistical information, well-designed data graphics are usually the simplest and at the same time the most powerful’’ (Edward Tufte)

For humans, visualization is one of the most natural ways for understanding things.

Good (???) interactive visualization: StockTouch App on iPad.

U.S. Stocks from 9 market sectors.

In each market sector companies are organized in a spiral pattern, from largest company (in the middle of the square) to smallest (on the borders of the square).

Each stock is color-coded based on its stock price performance over the (user-selected) period.

The shades of green (red) show stock prices that have increases (decreased).

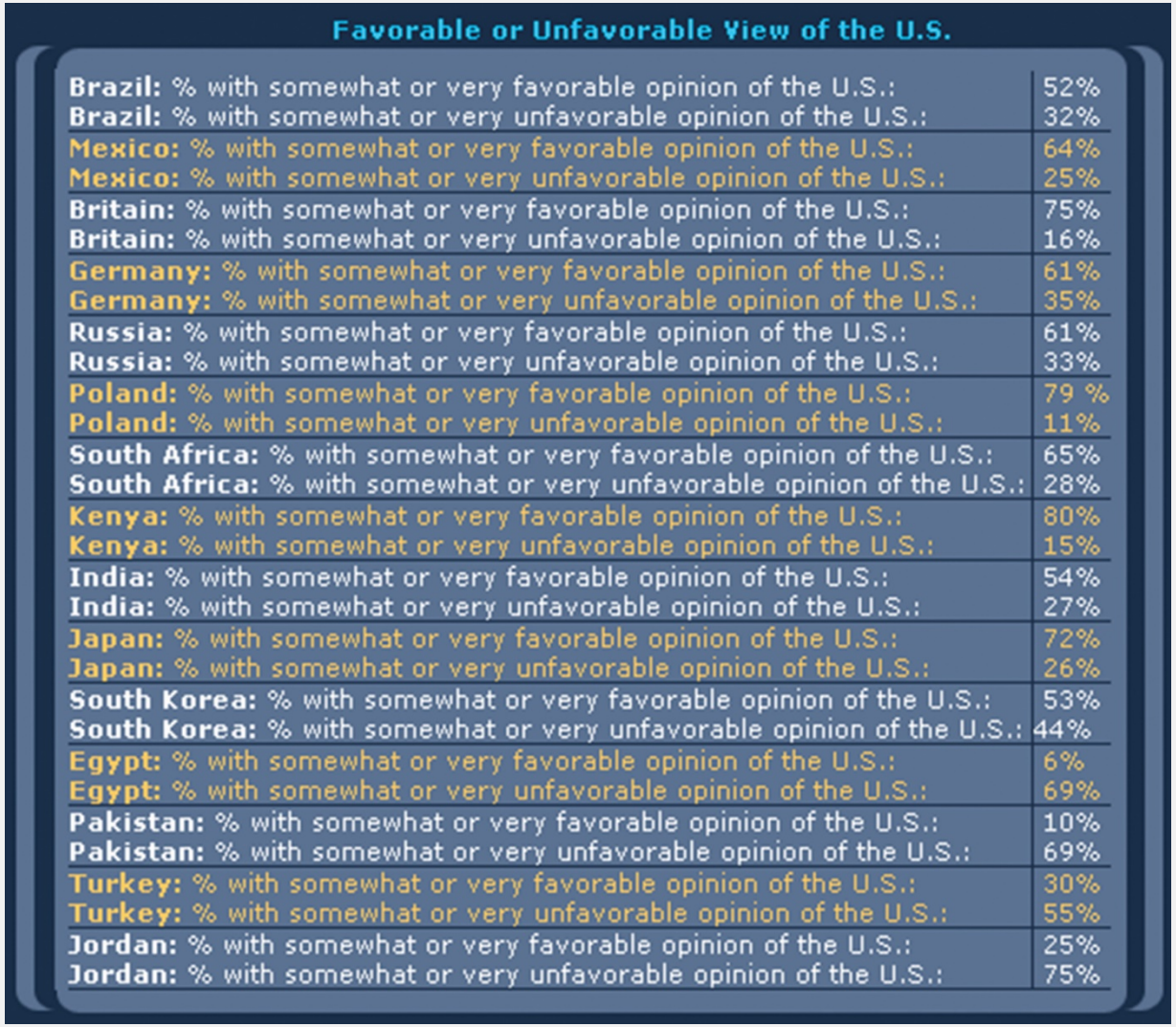
Touching a squares shows plots describing the company stock prices.

Though it seems messy it is considered one of the best tools for Business people.

Unfortunately there is no rule.

‘‘the aim of good data graphics is to display data accurately and clearly’’

MISLEADING GRAPHS

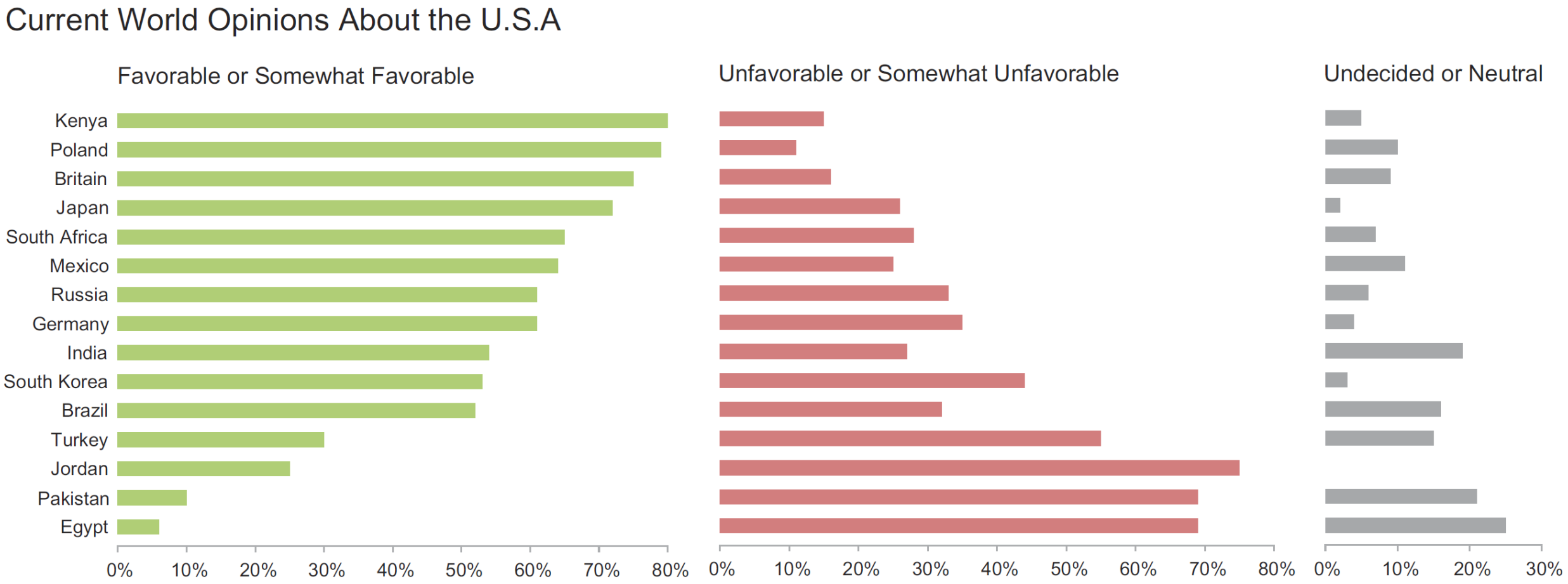


Favorable or Unfavorable View of the U.S.

Brazil: % with somewhat or very favorable opinion of the U.S.:	52%
Brazil: % with somewhat or very unfavorable opinion of the U.S.:	32%
Mexico: % with somewhat or very favorable opinion of the U.S.:	64%
Mexico: % with somewhat or very unfavorable opinion of the U.S.:	25%
Britain: % with somewhat or very favorable opinion of the U.S.:	75%
Britain: % with somewhat or very unfavorable opinion of the U.S.:	16%
Germany: % with somewhat or very favorable opinion of the U.S.:	61%
Germany: % with somewhat or very unfavorable opinion of the U.S.:	35%
Russia: % with somewhat or very favorable opinion of the U.S.:	61%
Russia: % with somewhat or very unfavorable opinion of the U.S.:	33%
Poland: % with somewhat or very favorable opinion of the U.S.:	79 %
Poland: % with somewhat or very unfavorable opinion of the U.S.:	11%
South Africa: % with somewhat or very favorable opinion of the U.S.:	65%
South Africa: % with somewhat or very unfavorable opinion of the U.S.:	28%
Kenya: % with somewhat or very favorable opinion of the U.S.:	80%
Kenya: % with somewhat or very unfavorable opinion of the U.S.:	15%
India: % with somewhat or very favorable opinion of the U.S.:	54%
India: % with somewhat or very unfavorable opinion of the U.S.:	27%
Japan: % with somewhat or very favorable opinion of the U.S.:	72%
Japan: % with somewhat or very unfavorable opinion of the U.S.:	26%
South Korea: % with somewhat or very favorable opinion of the U.S.:	53%
South Korea: % with somewhat or very unfavorable opinion of the U.S.:	44%
Egypt: % with somewhat or very favorable opinion of the U.S.:	6%
Egypt: % with somewhat or very unfavorable opinion of the U.S.:	69%
Pakistan: % with somewhat or very favorable opinion of the U.S.:	10%
Pakistan: % with somewhat or very unfavorable opinion of the U.S.:	69%
Turkey: % with somewhat or very favorable opinion of the U.S.:	30%
Turkey: % with somewhat or very unfavorable opinion of the U.S.:	55%
Jordan: % with somewhat or very favorable opinion of the U.S.:	25%
Jordan: % with somewhat or very unfavorable opinion of the U.S.:	75%

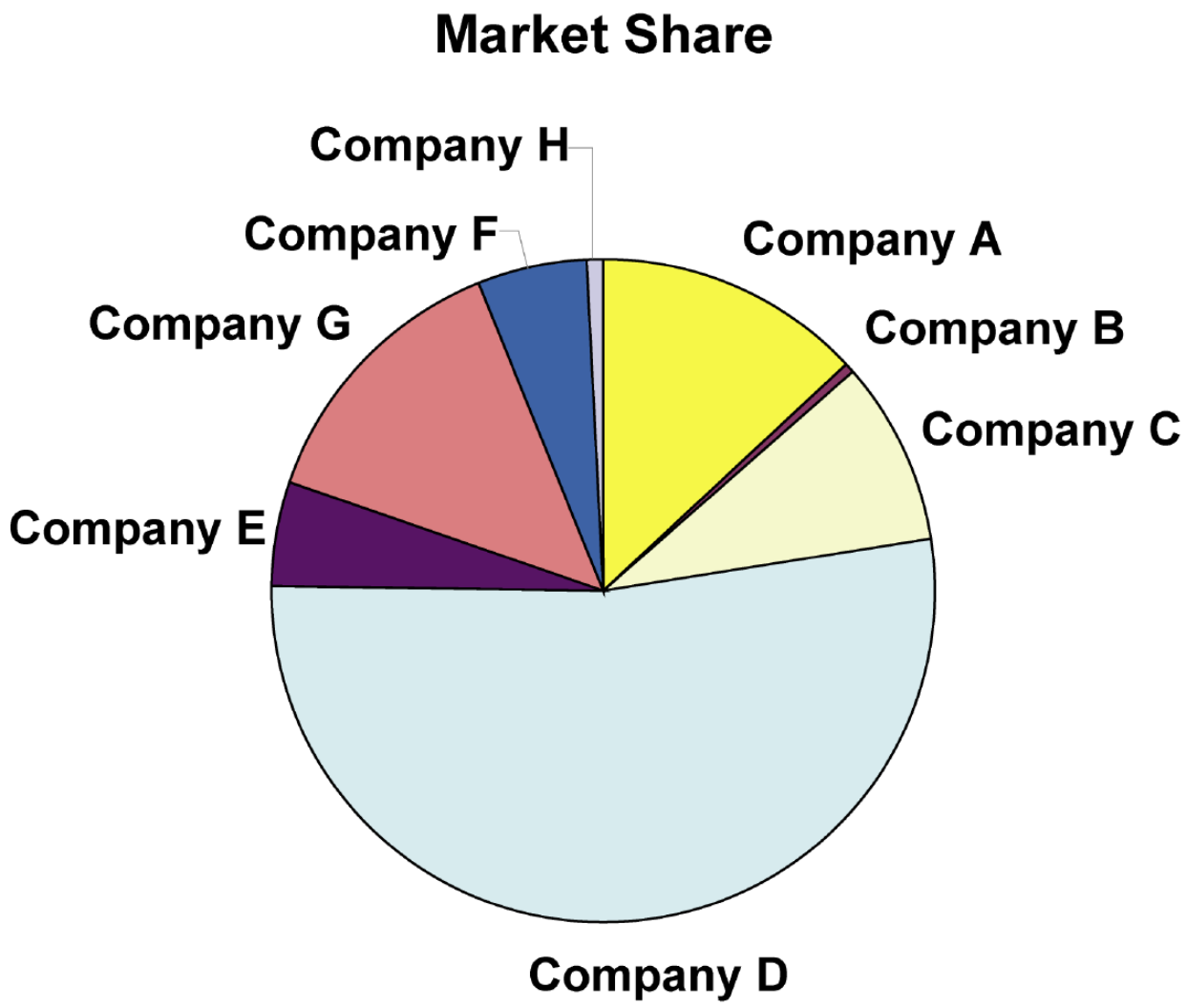
Opinions w.r.t. United States after 11th of September 2001

Much better in this way!



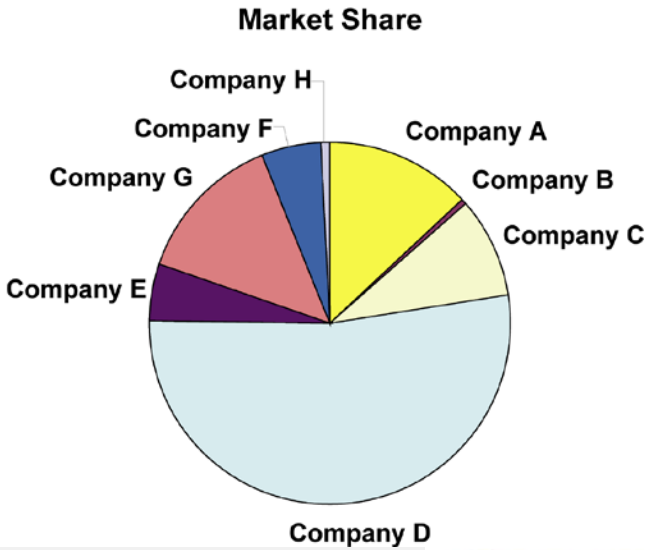
Source: 2004 study conducted by the Pew Research Center, as reported by the PBS television program NOW.

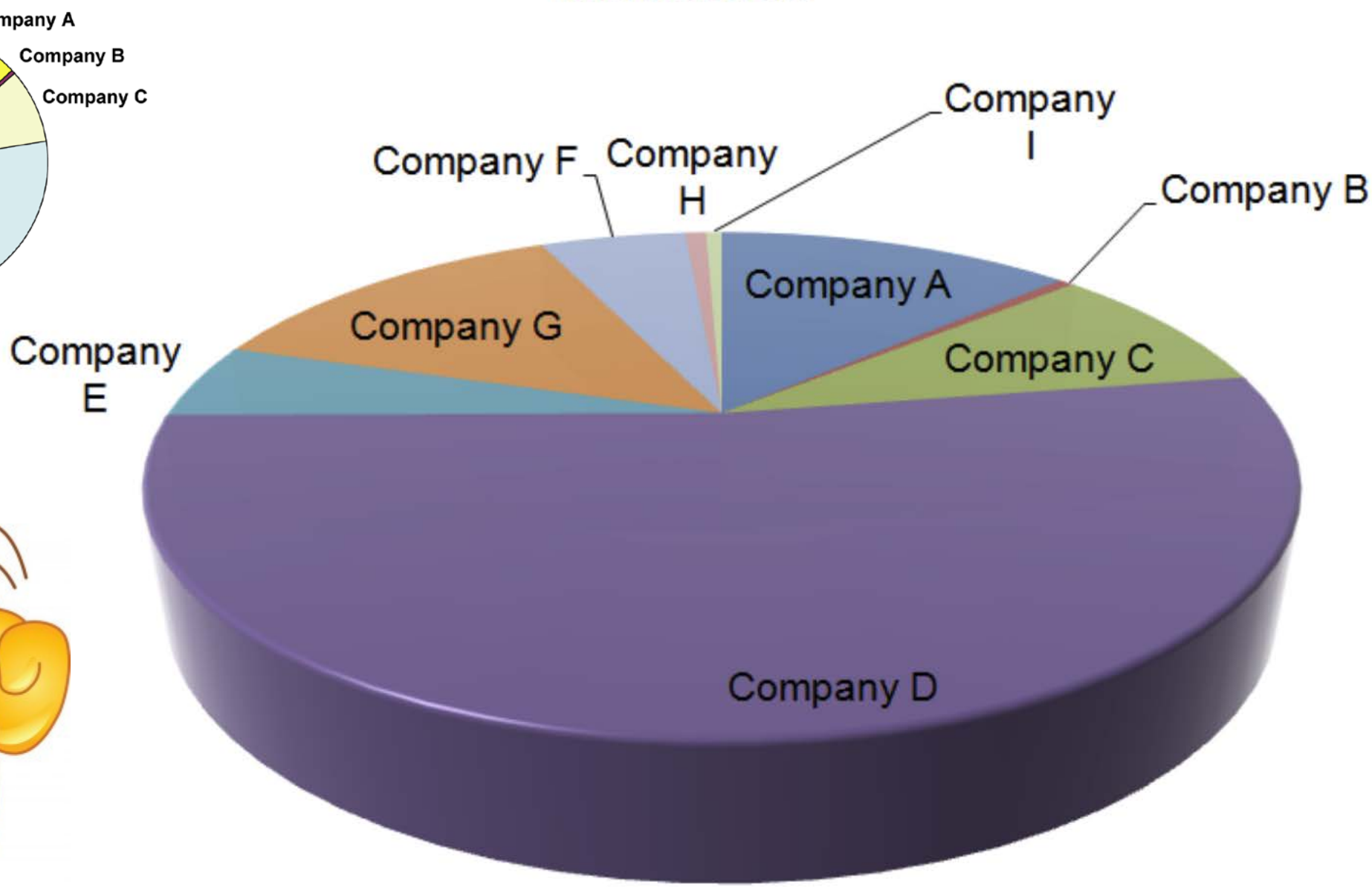
OUR COMPANY IS G: BETTER OR WORSE THAN A?

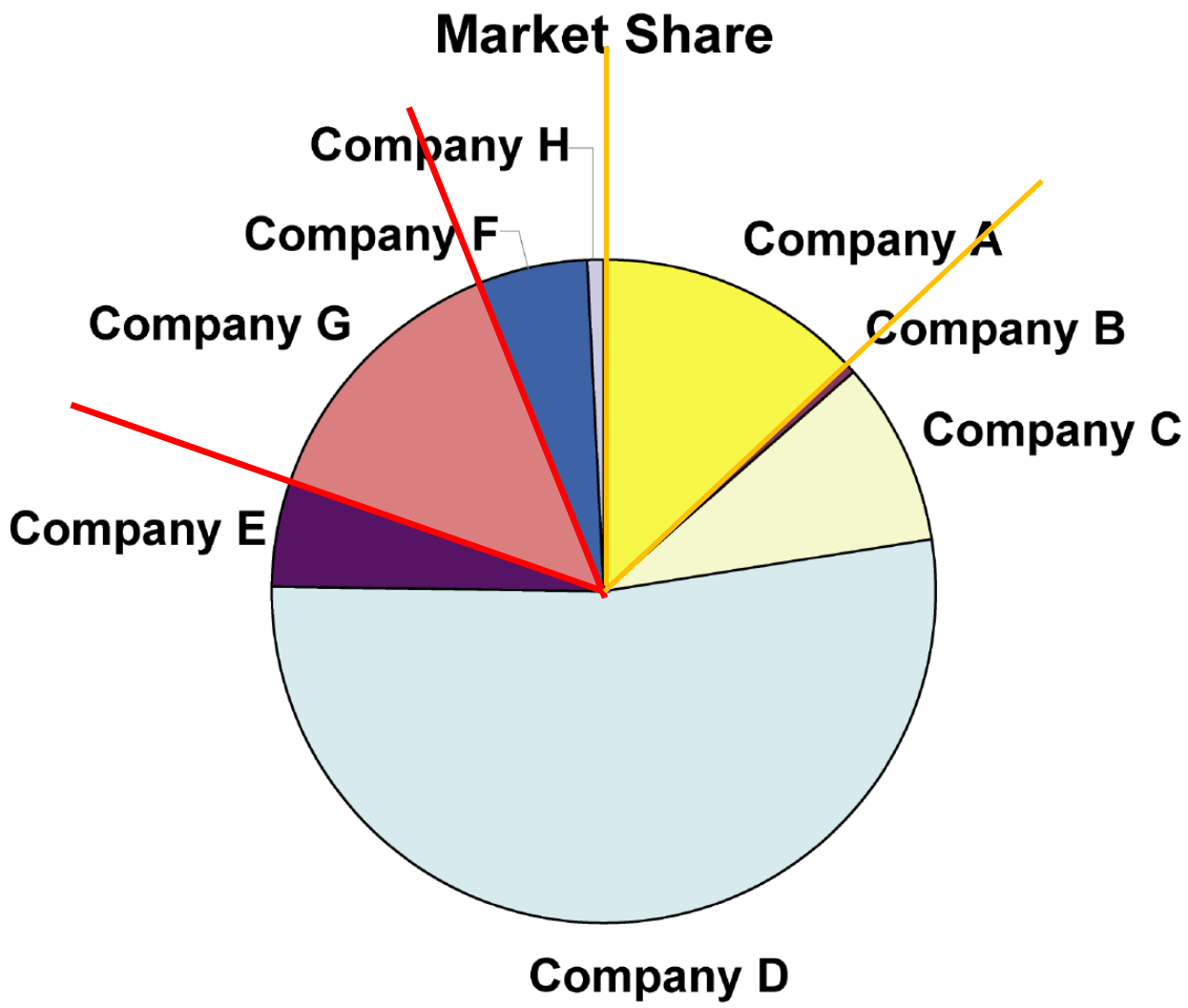


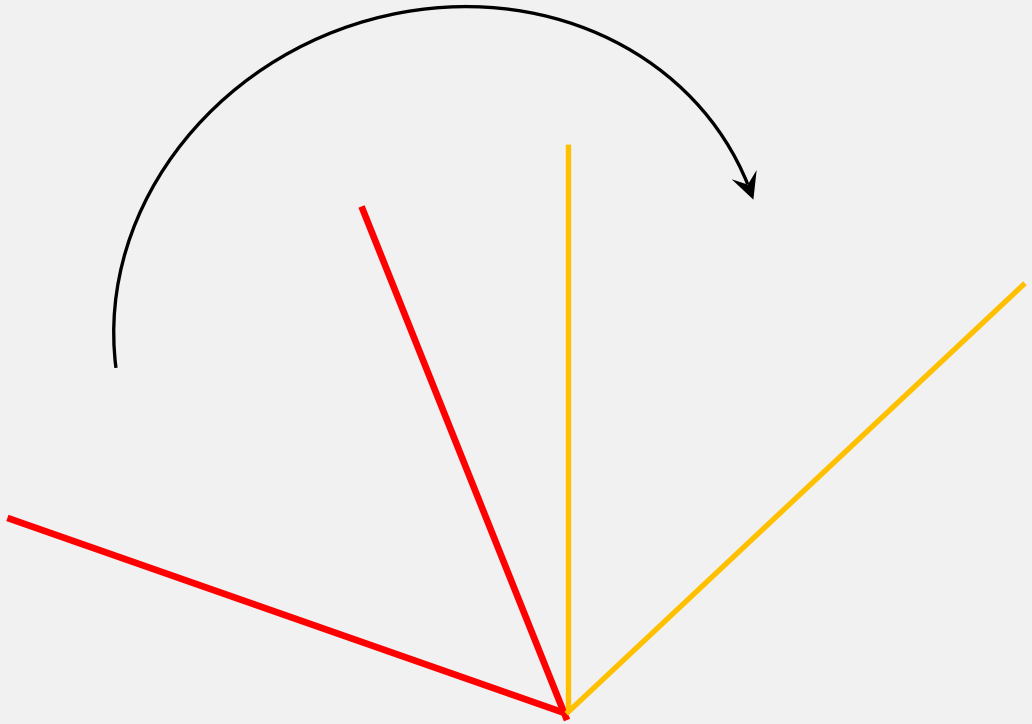
mmmmm…. Is just that there is not enough dimension…

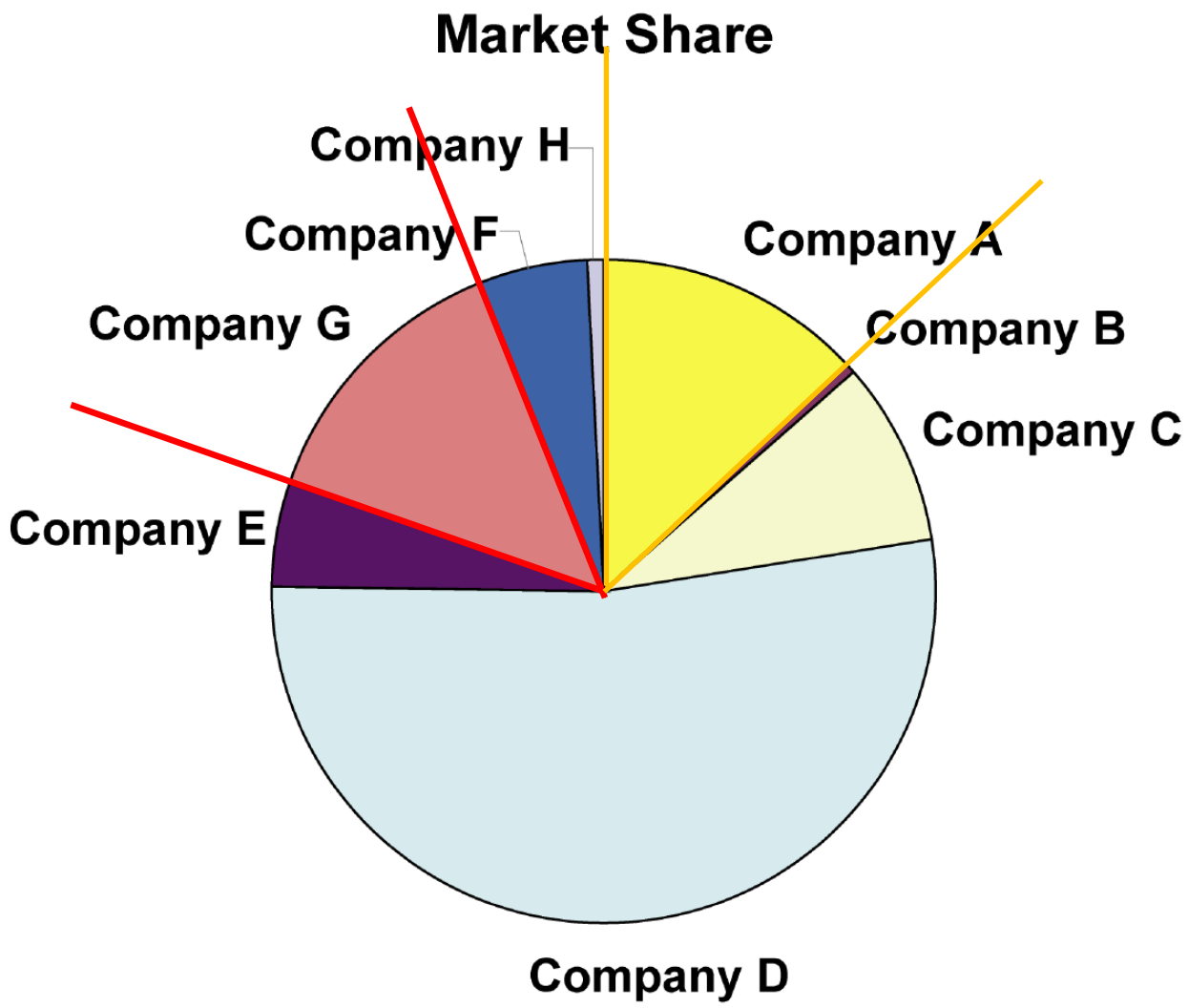
Let's go in 3D

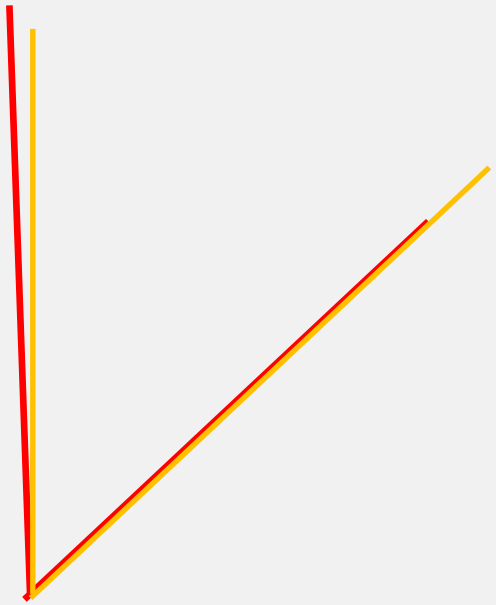






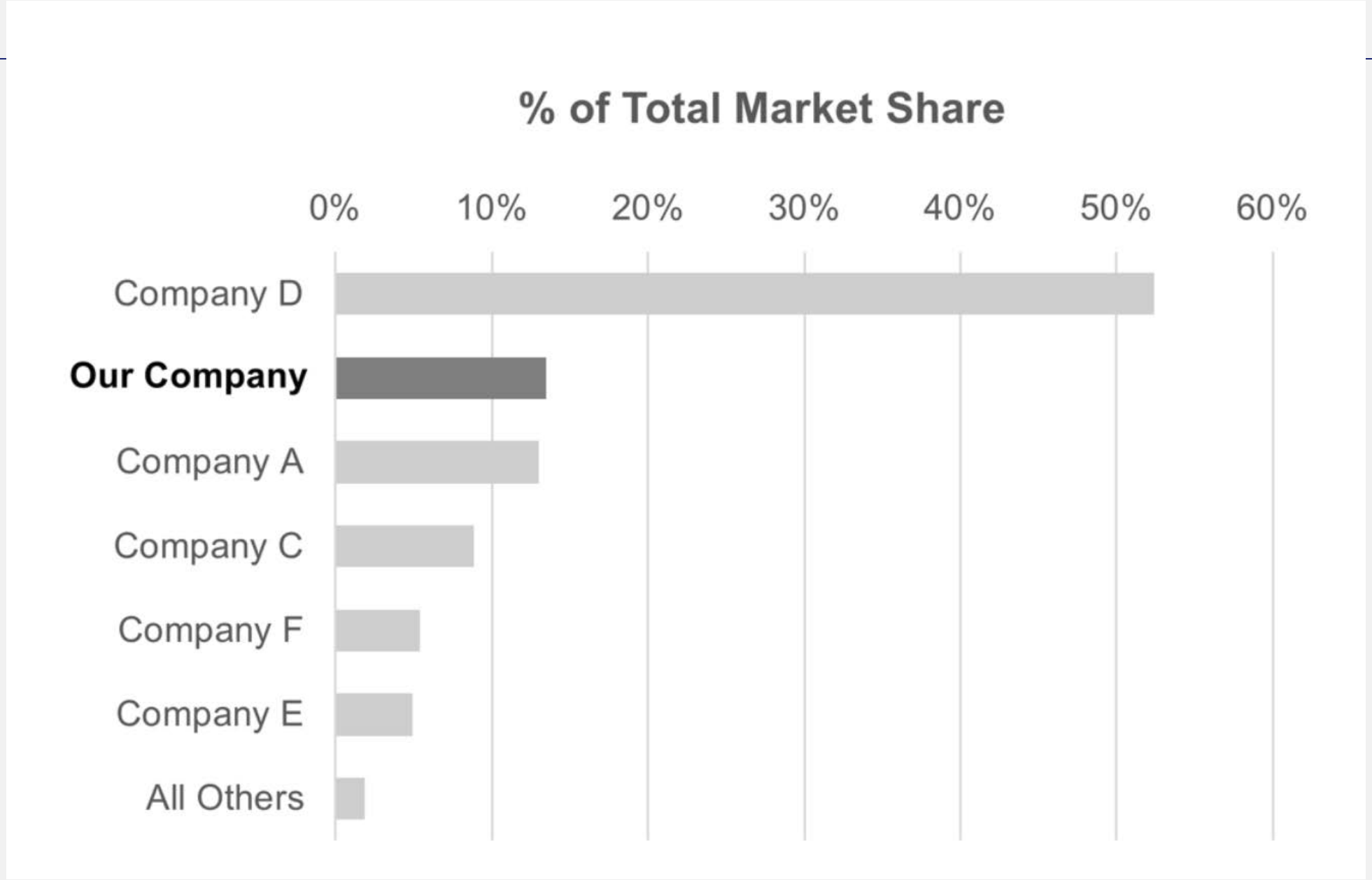




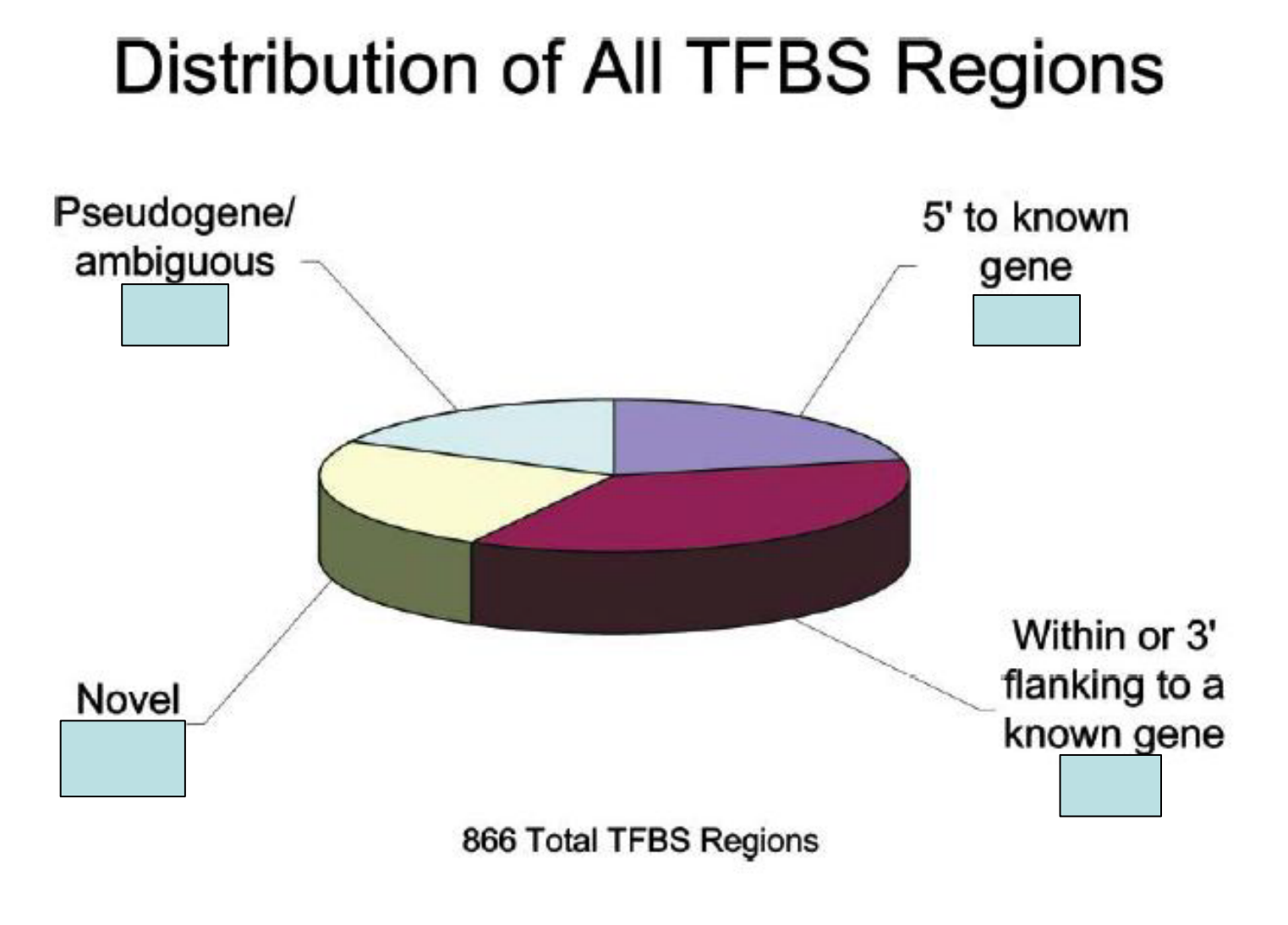


WE ARE BETTER!!!!!!

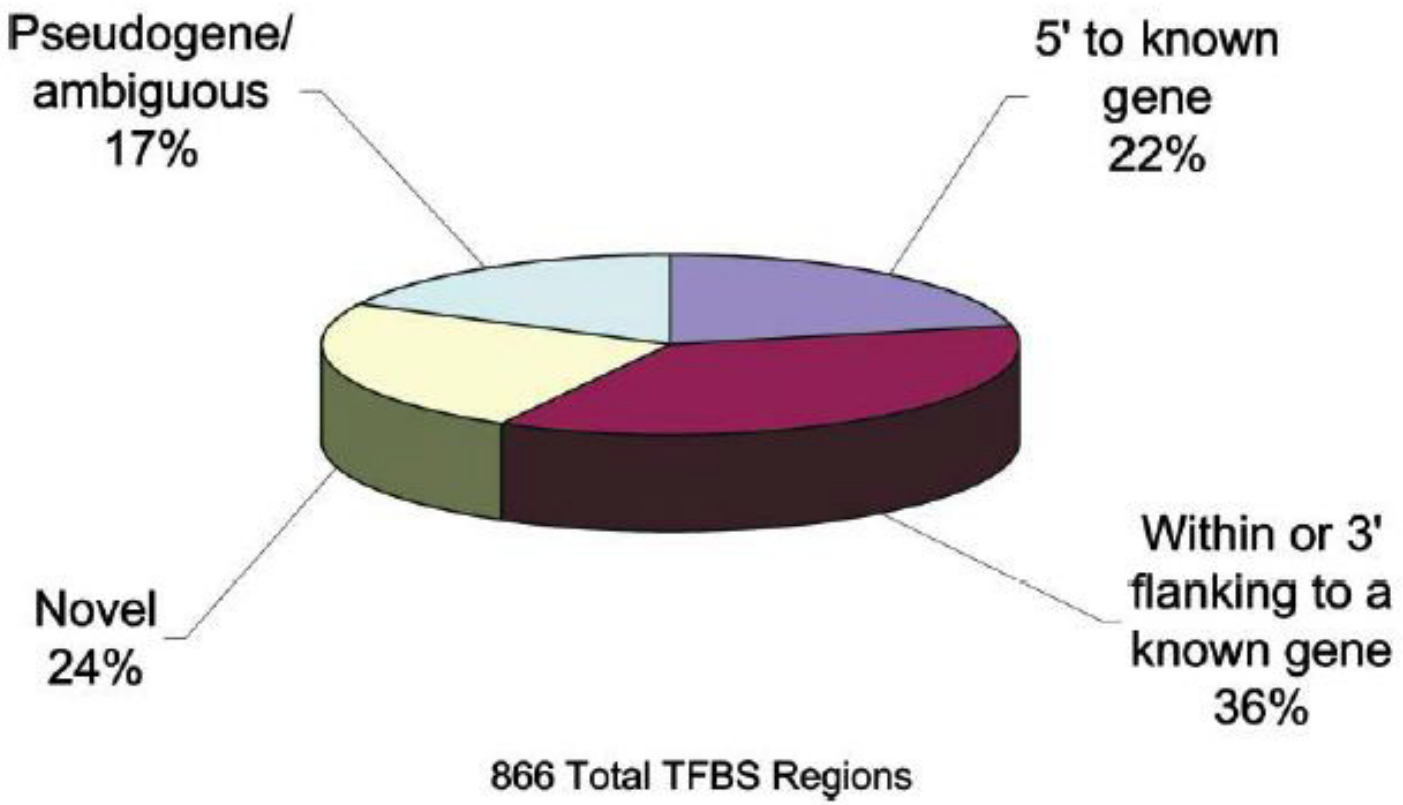
I'm tired but we are better!!



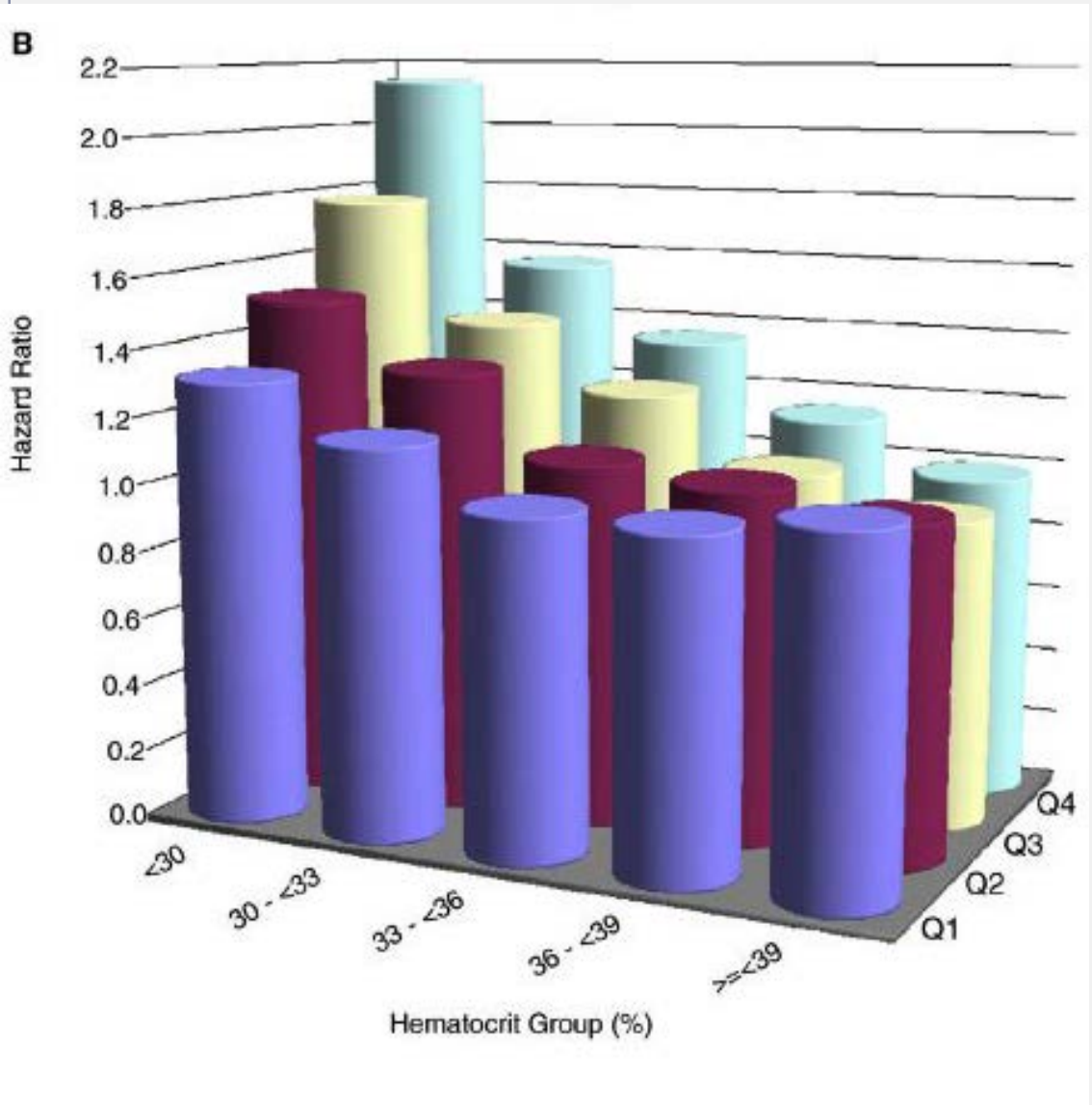
HOW MUCH ARE THE RATES HERE???

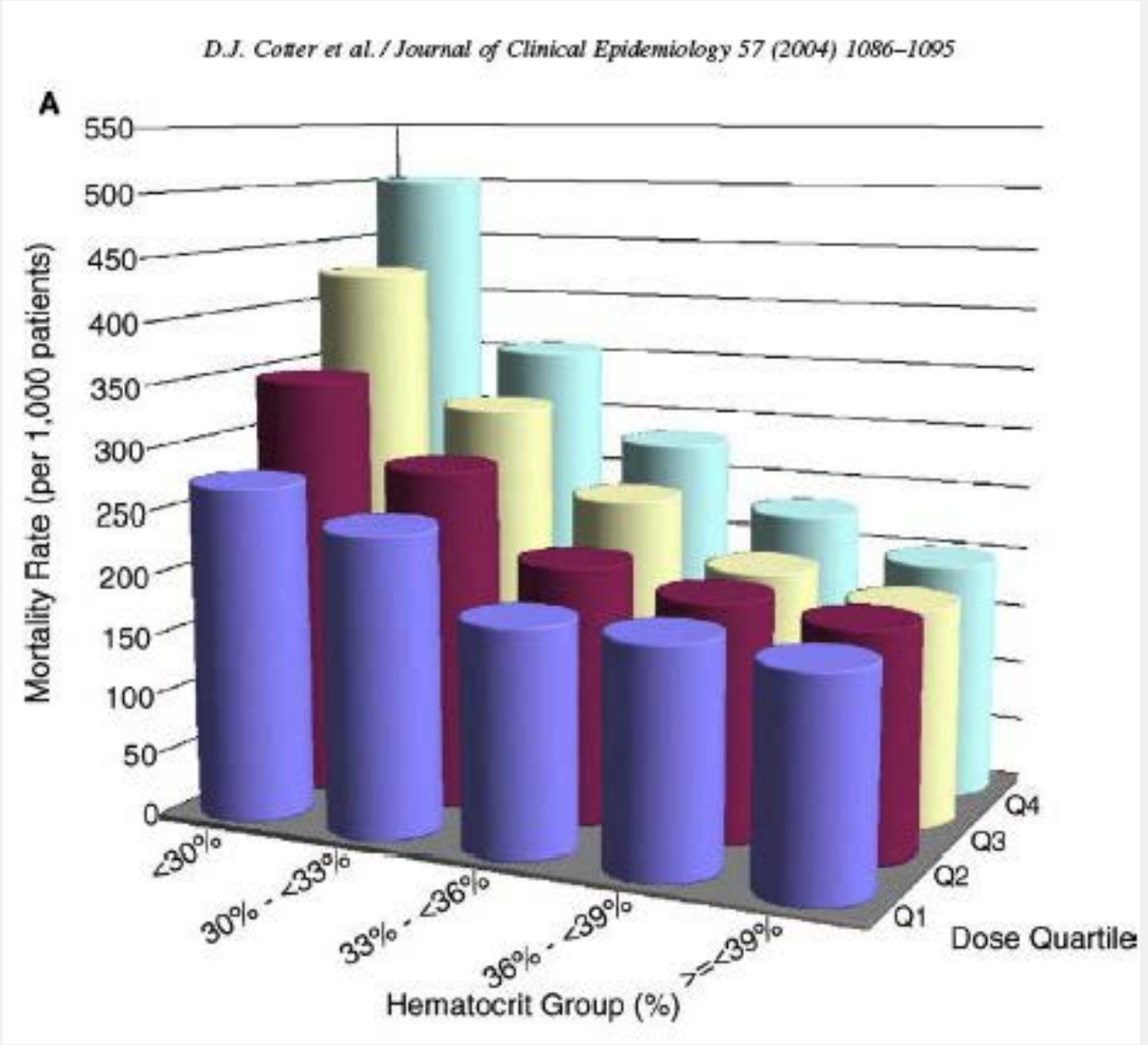


Distribution of All TFBS Regions



3D is almost never good: if there's a difference you hardly see it





“The birth of a word”

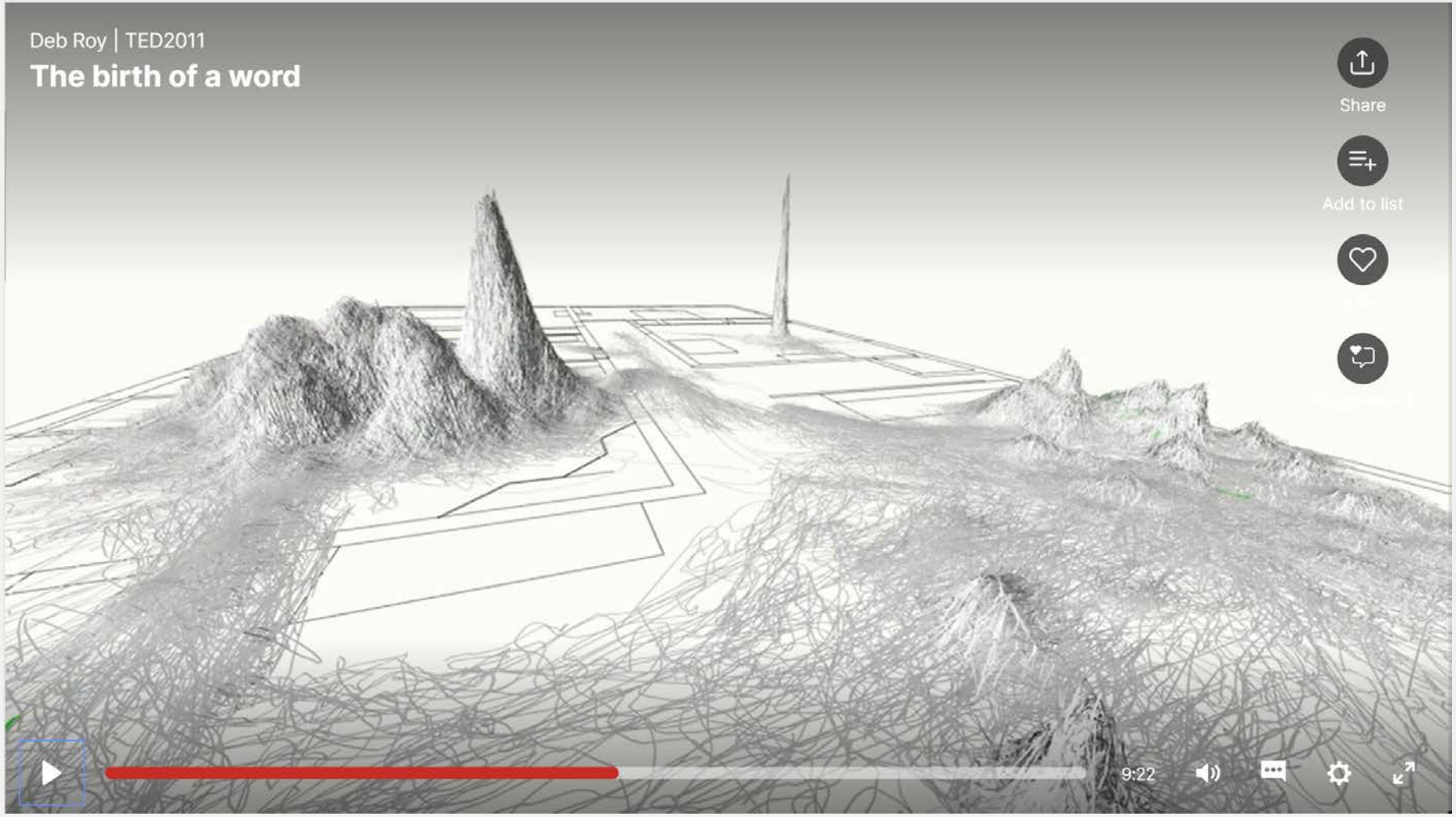
The birth of a word (Deb Roy)

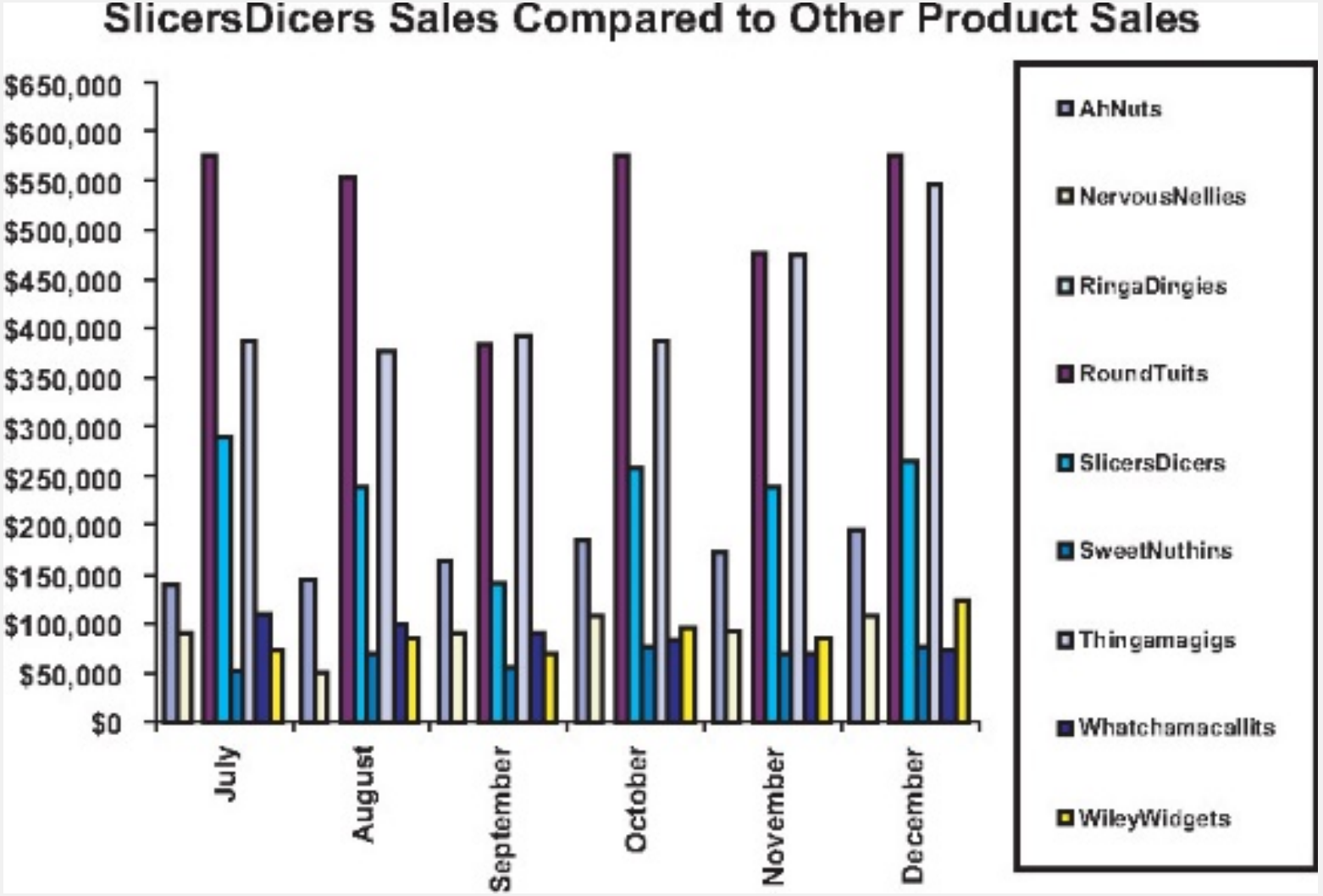
Some 3D data may be mapped to 2D

Space-time worms: show the movement of two persons in a 3D space

And the 2D data may be summed up to get novel 3D representations which allow analysis

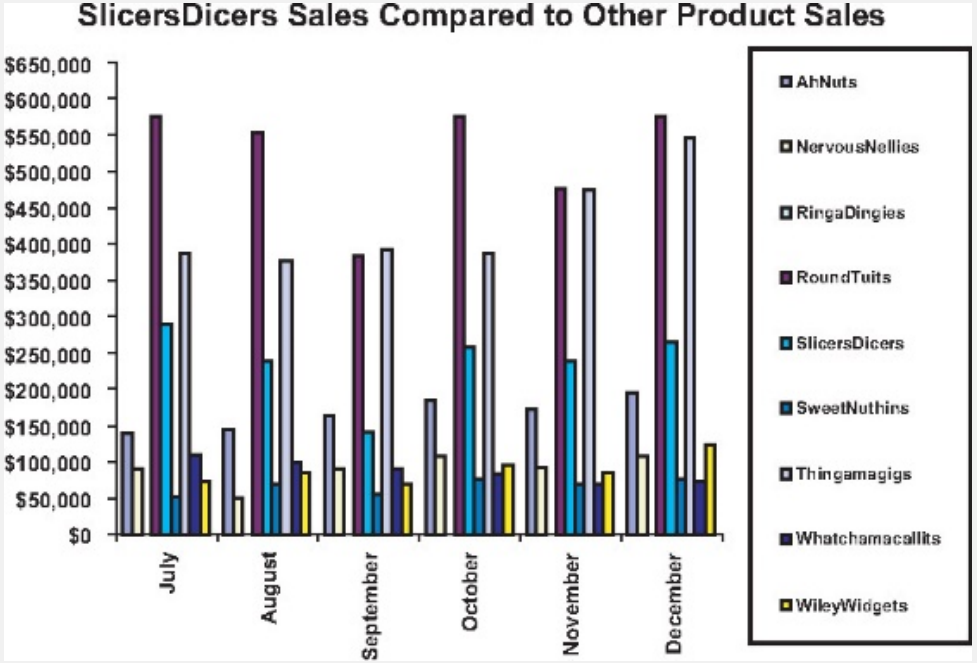
Wordscape: accumulate all the space-time worms related to different persons and sum them. Space-time worms are accumulated when people say a word (in this case the world is “water”)



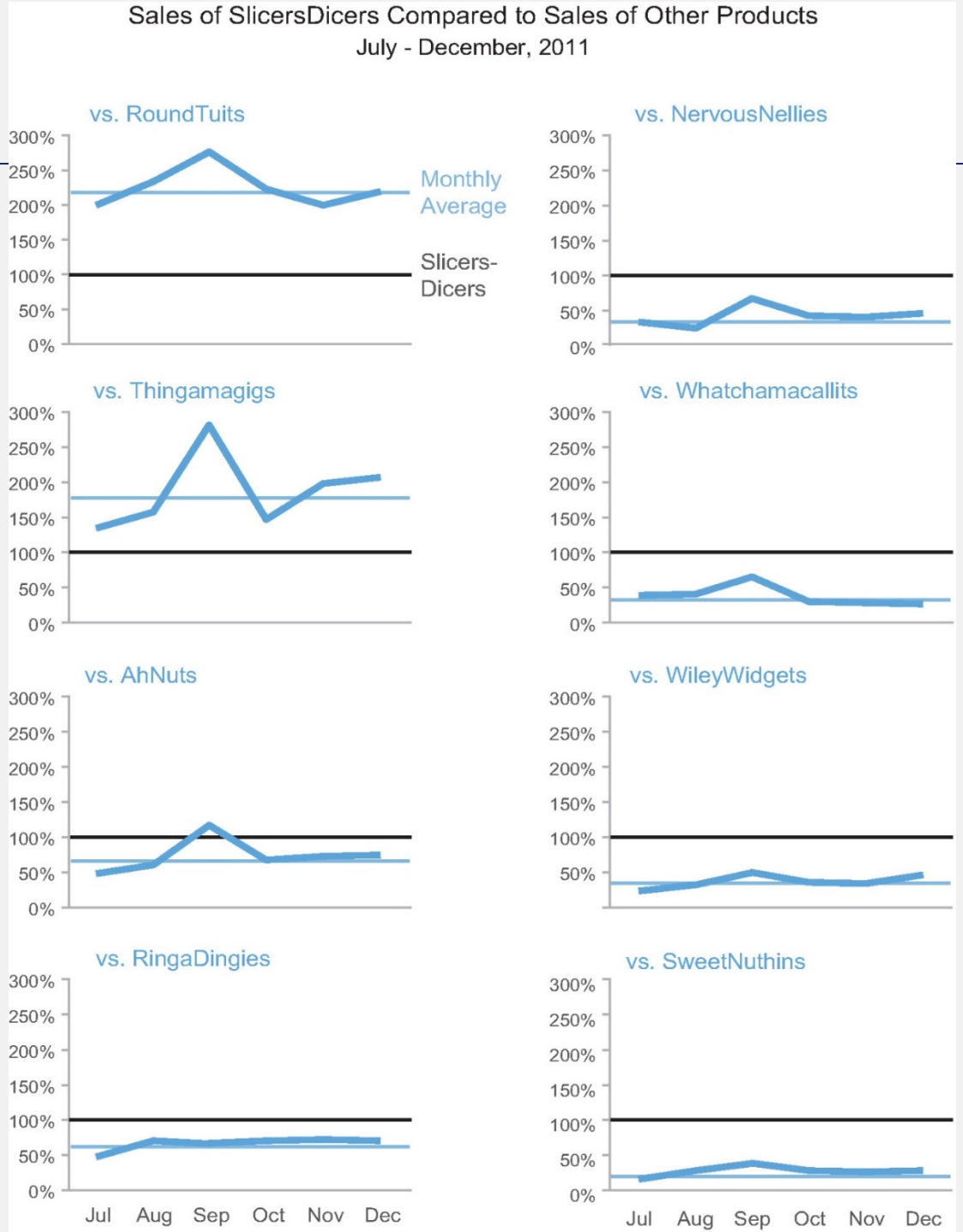


SO NICE TO GO BACK AND FORTH from the legend to the plot!

What the about the trend?



Sales of SlicersDicers Compared to Sales of Other Products
July – December, 2011

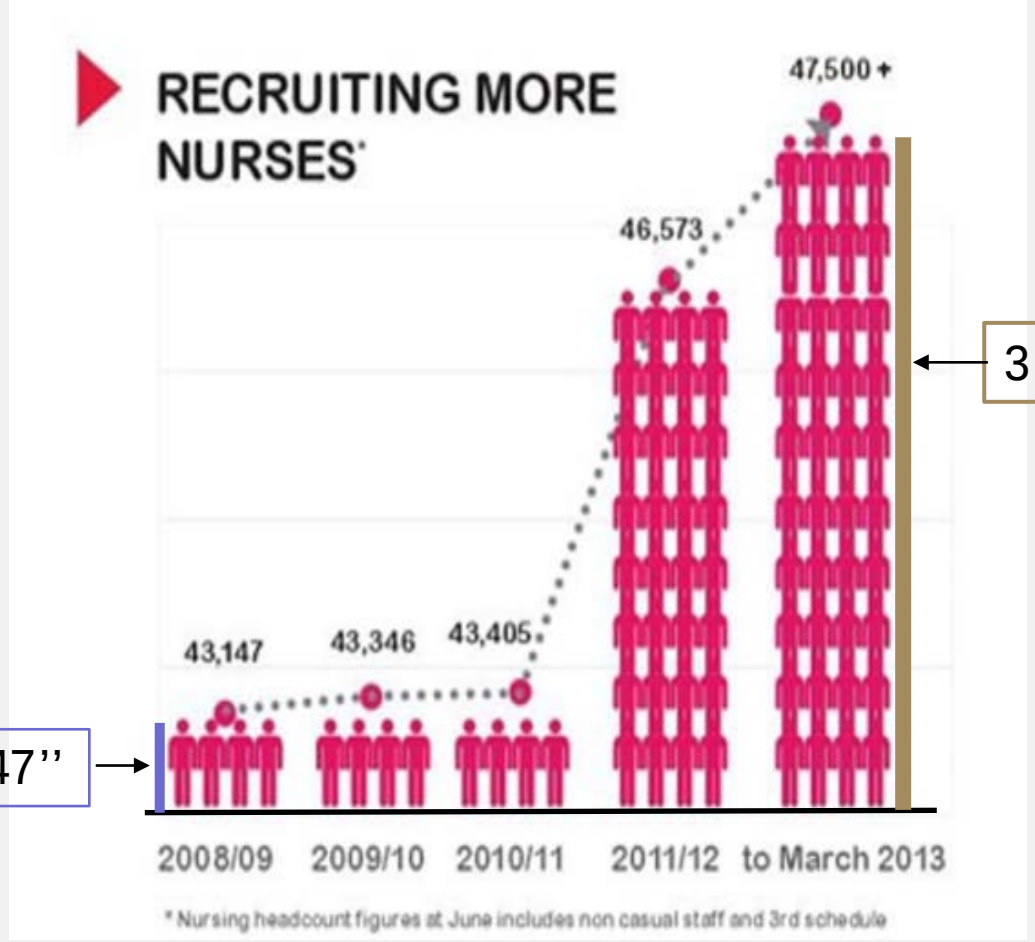


DO NOT LIE

Lowest number / maximum Number =

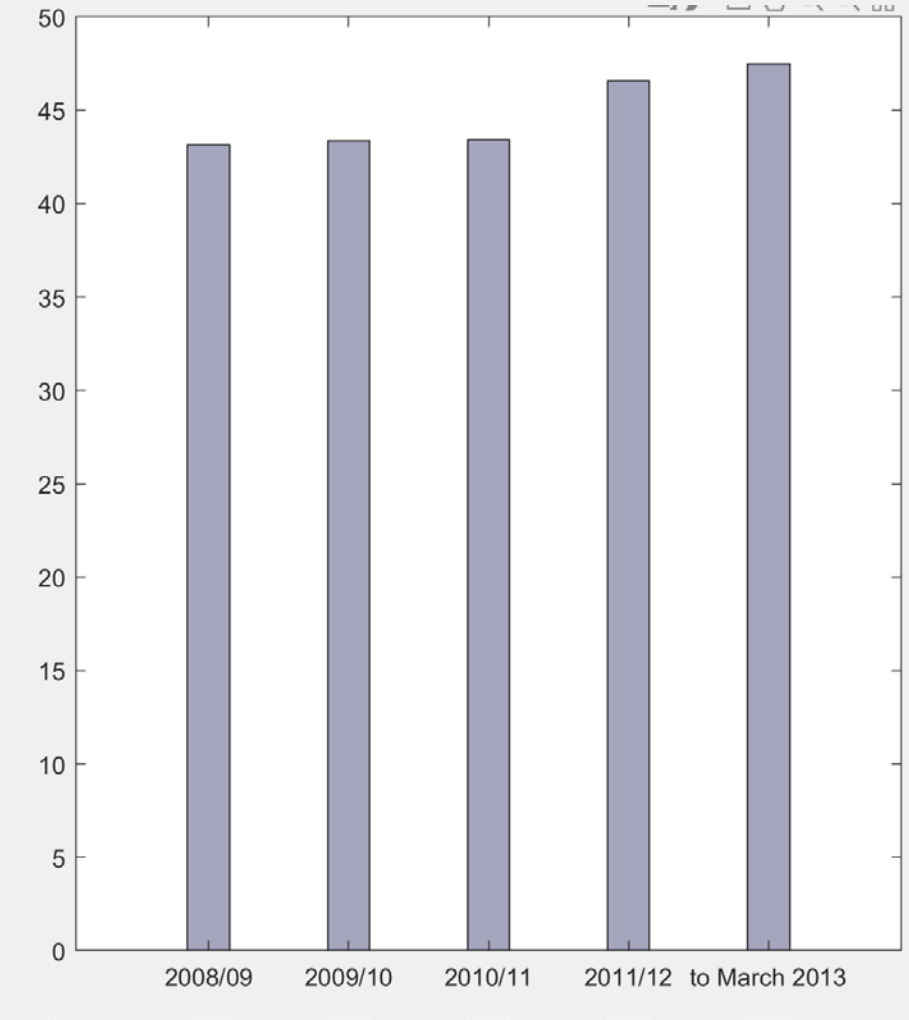
43147 / **47500** = 0.91 (91%)

THE RATIO YOU SEE (YOU ARE SOMEHOW PERCEIVING IS):



Ratio you see =

0.47'' / **3.5''** = 0.13 (13%)



THIS PLOT IS REALISTIC

and

AUGMENTS THE **DATA/INK RATIO**

Too few data in a graph: is the graph really useful?

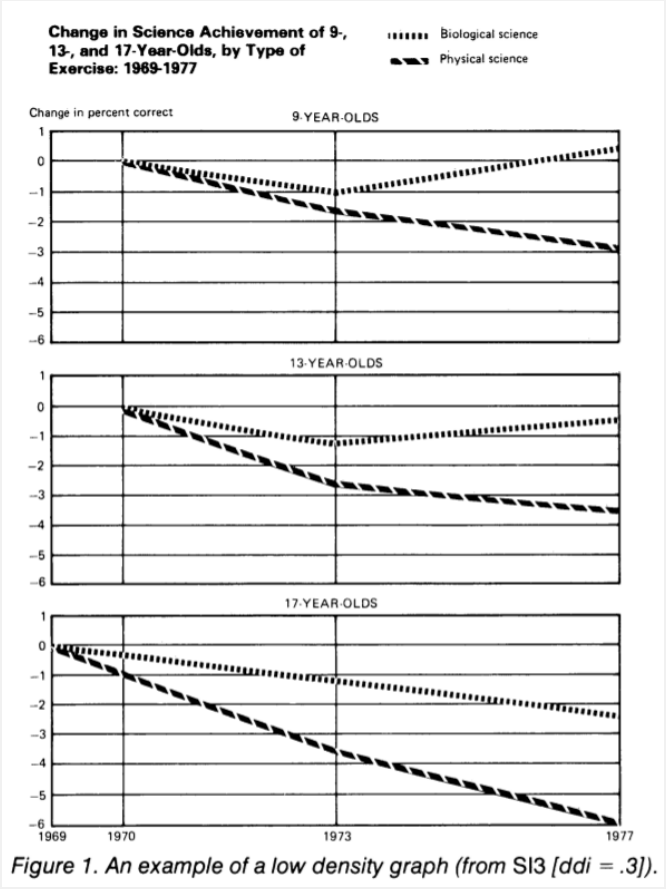


Figure 1. An example of a low density graph (from SI3 *[ddi = .3]).*

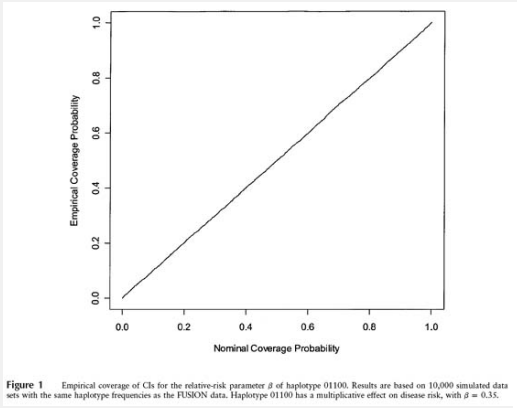


Figure 1 Empirical coverage of CIs for the relative-risk parameter β of haplotype 01100. Results are based on 10,000 simulated data sets with the same haplotype frequencies as the FUSION data. Haplotype 01100 has a multiplicative effect on disease risk, with $\beta = 0.35$.

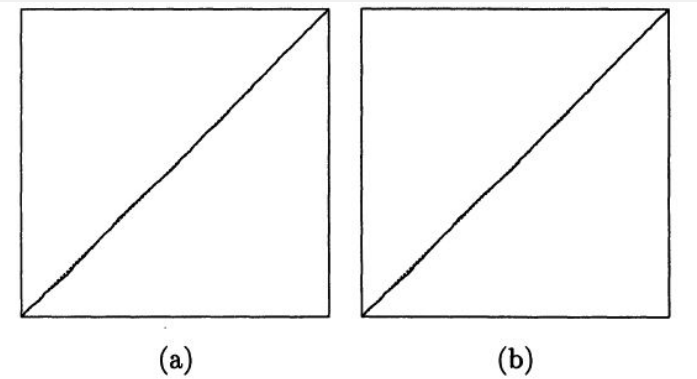


Figure 1. SRQ Plots of T_i/T_n (Vertical Axes) Against i/n (Horizontal Axes) for the Gibbs Sampler (a) and an Alternating Gibbs/Independence Sampler (b) for the Pump Failure Data Based on Runs of Length 5,000. Lines through the origin with unit slope are shown dashed; axis ranges are from 0 to 1 for all axes.

headacke...

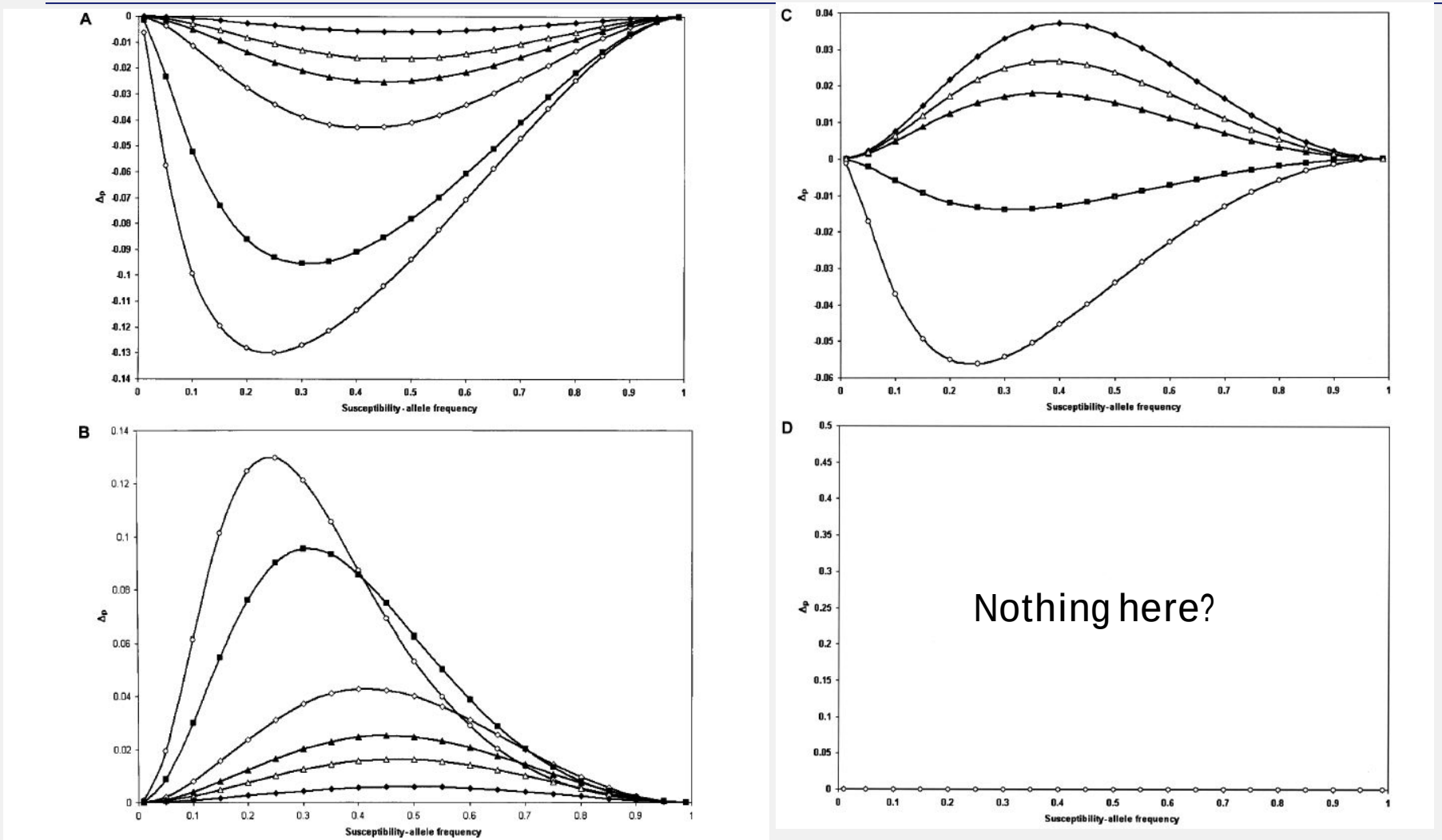


Figure 1 Δ_p plotted versus the susceptibility-allele frequency for patients. *A*, *B*, and *D*, Data points are as follows: $\gamma = 1.1$ (*blackened diamonds*), $\gamma = 1.3$ (*unblackened triangles*), $\gamma = 1.5$ (*blackened triangles*), $\gamma = 2$ (*unblackened diamonds*), $\gamma = 5$ (*blackened squares*), and $\gamma = 10$ (*unblackened circles*). *A*, Dominant model. *B*, Recessive model. *C*, Additive model. Since $\gamma < 2$ would not satisfy our definition of an additive model as $\gamma = 2\beta$ and $\beta > 1$, the data points in *C* are as follows: $\gamma = 2.2$ ($\beta = 1.1$) (*blackened diamonds*), $\gamma = 2.6$ ($\beta = 1.3$) (*unblackened triangles*), $\gamma = 3$ ($\beta = 1.5$) (*blackened triangles*), $\gamma = 5$ (*blackened squares*), $\gamma = 2$ (*unblackened diamonds*). *D*, Multiplicative model.

GRAPHS MAY HIDE DATA.

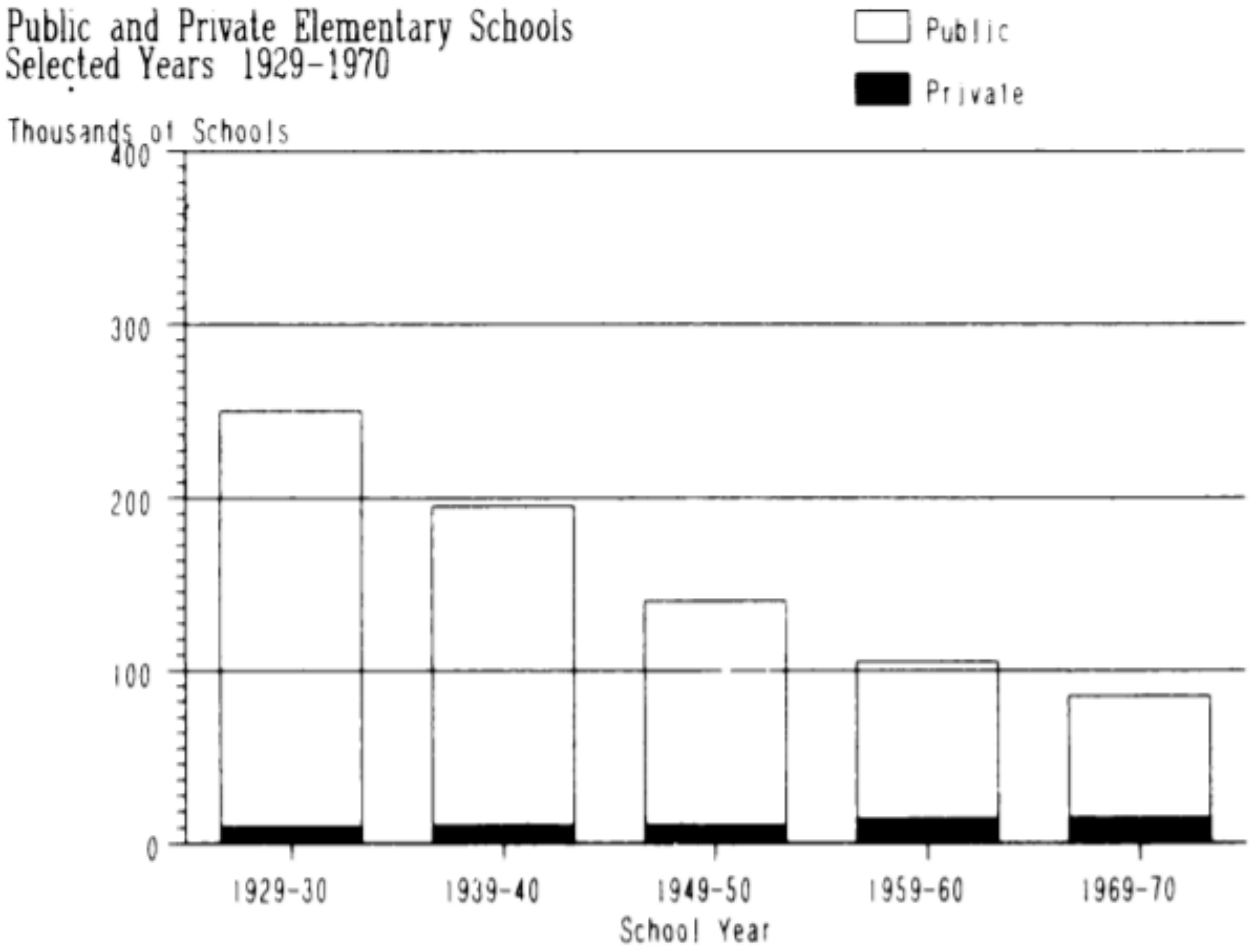


Figure 4. Hiding the data in the scale (from SI3).

What do you see?

Public Schools keep on decreasing.

Private Schools are few though, and their number seems stable

Only notable change is in the decrease of the public education?

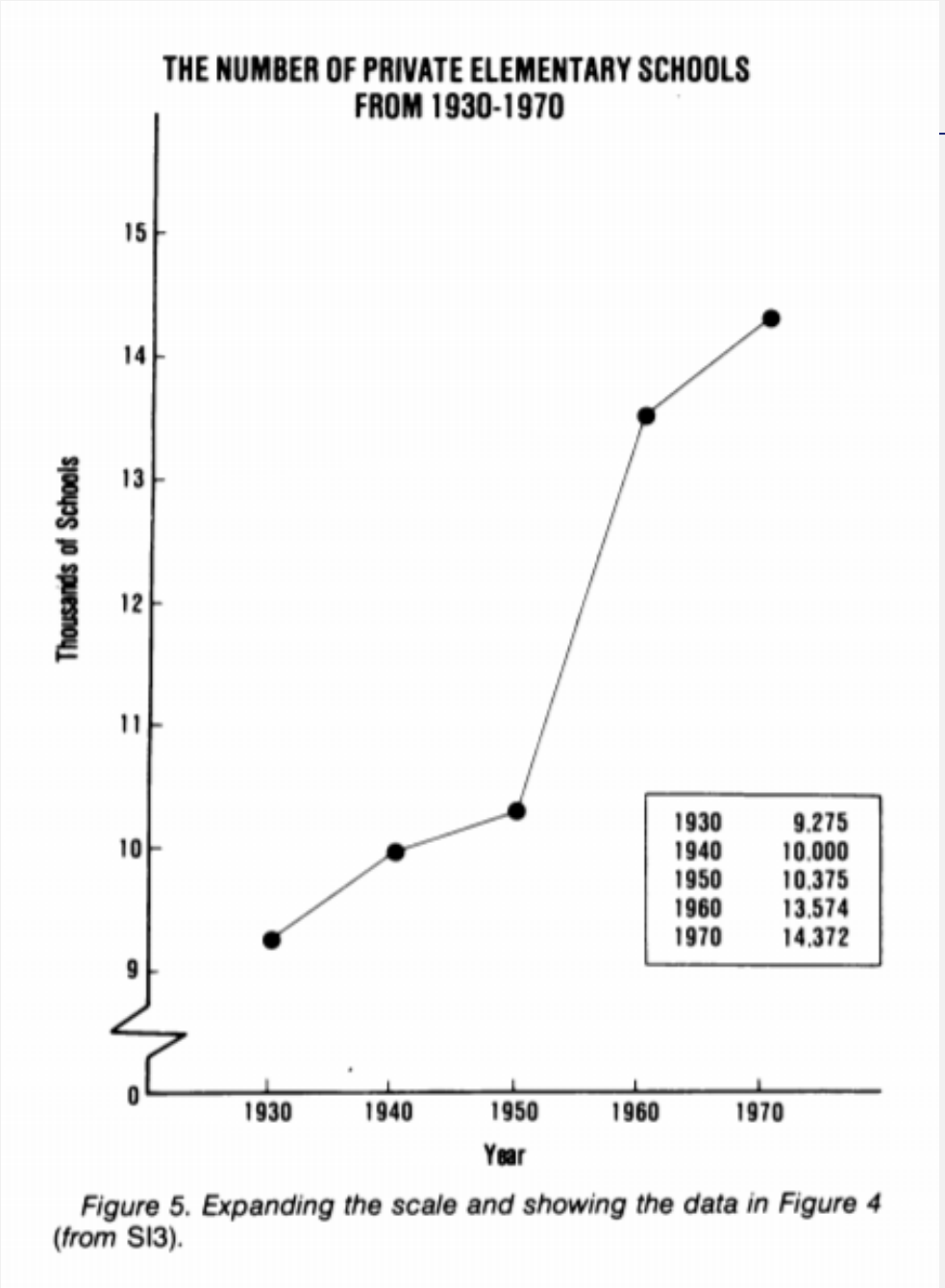


Figure 5. Expanding the scale and showing the data in Figure 4 (from SI3).

Increasing the scale shows a dramatic increase of Private education.

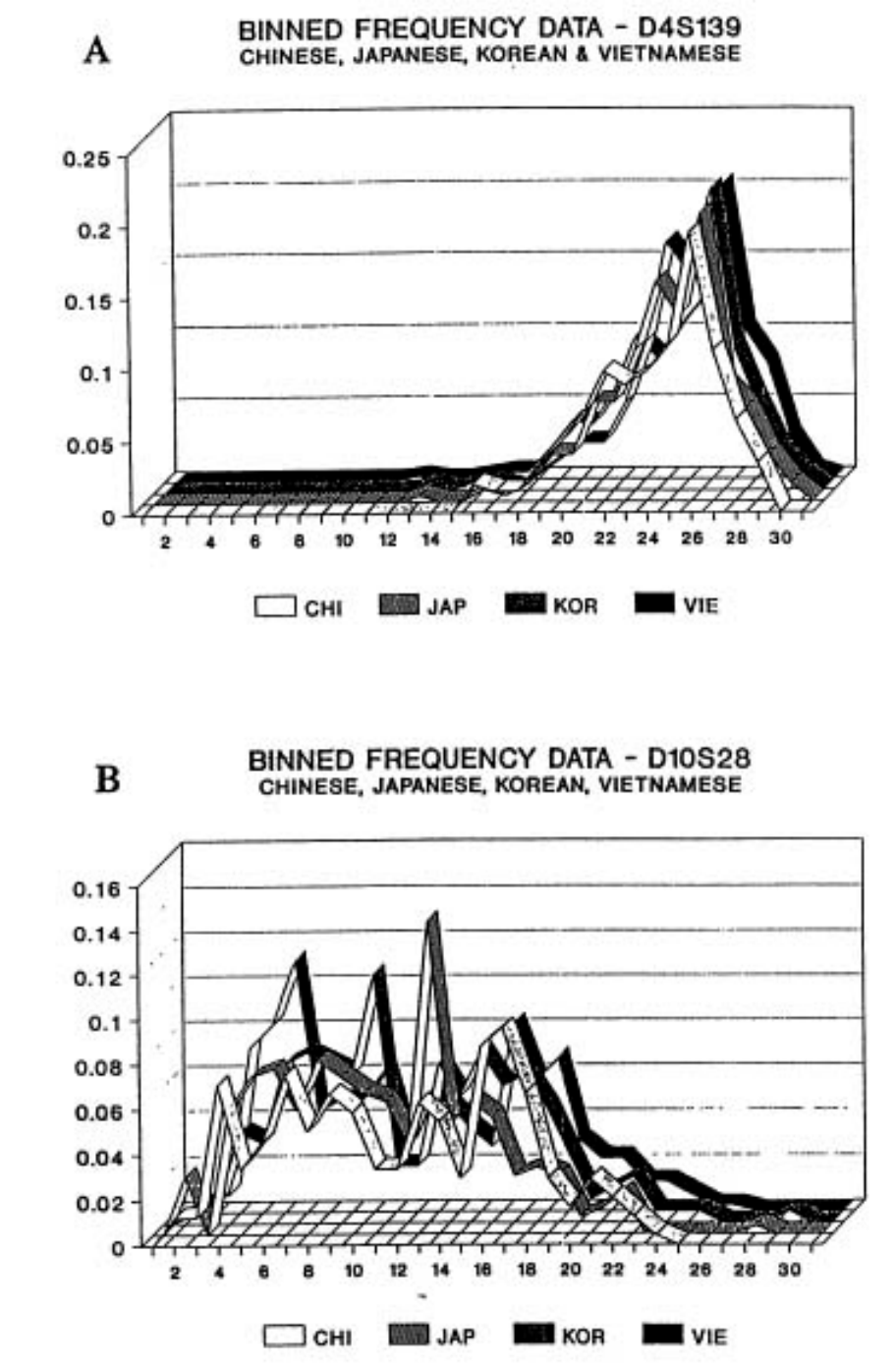
Note that numbers from 0 to 8 (Y axis) are not shown.

IT'S OK!

Lines: show trends

Points: allow perceiving distributions

Shapes: quantities!



Here 3D texture is only visual clutter!

INSTEAD OF USING 3D:

- Line plots with different colors
- Or, if you must print black and white, different line styles (dashed, dash-dot, grey for less important lines, ...)

FOR TRENDS AND TIMELINES USE LINEPLOTS OR POINT PLOTS

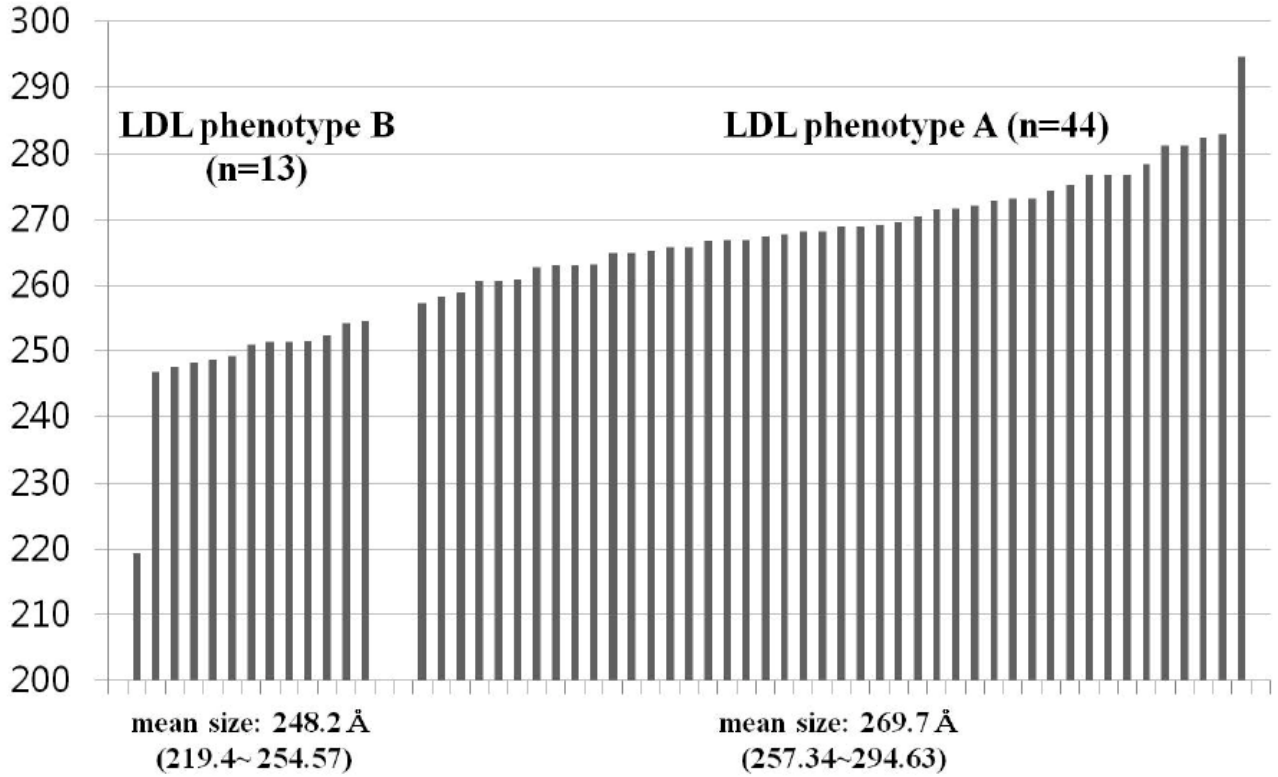


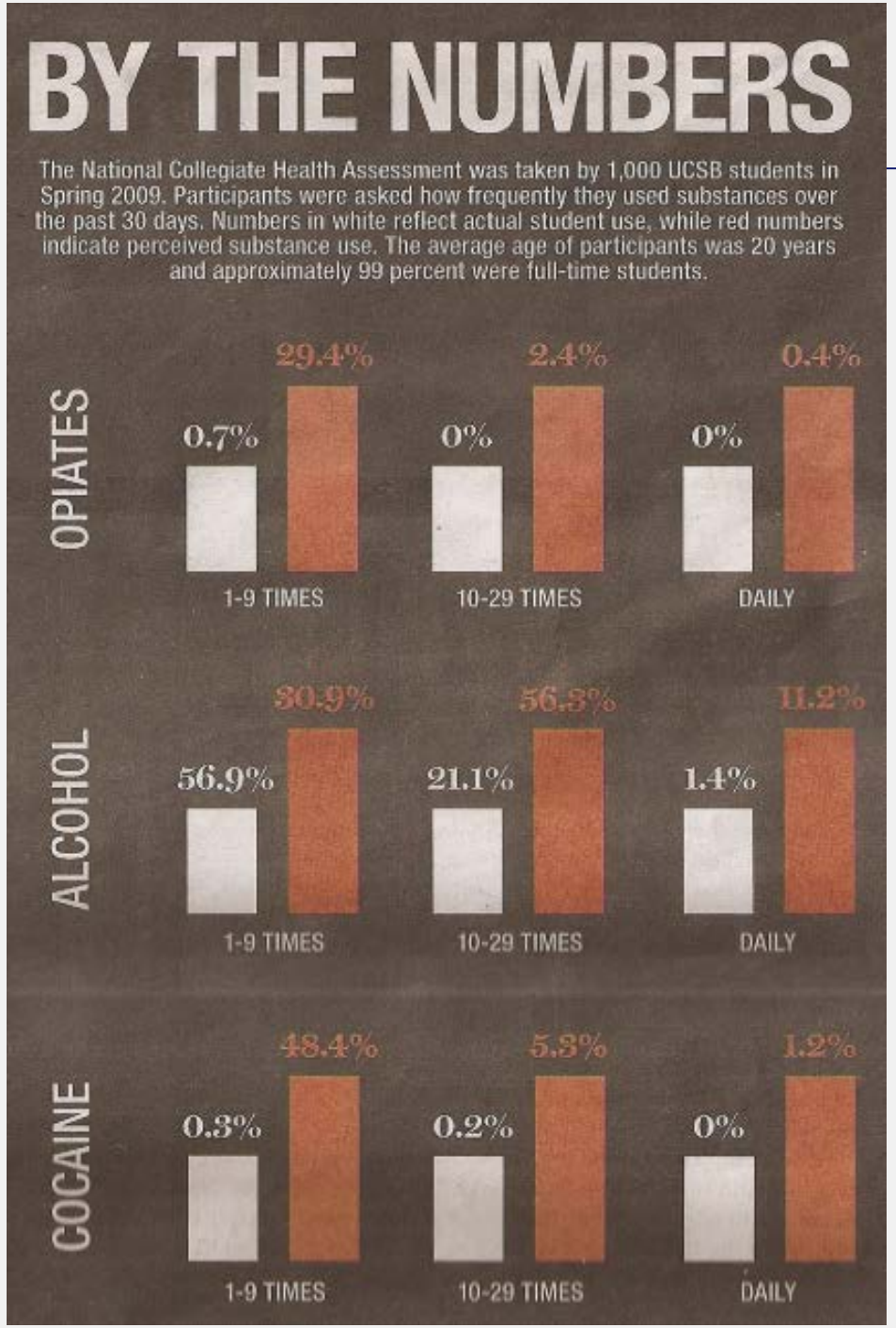
Fig. 1. Distribution of low-density lipoprotein (LDL) particle size in all study subjects (LDL phenotypes A and B). *LDL phenotype A group* (mean size: 269.7 Å, n = 44), subjects with buoyant-mode profiles [peak LDL particle diameter ≥ 264 Å] including intermediate LDL subclass pattern [256 Å ≤ peak LDL particle diameter ≤ 263 Å]; *LDL phenotype B group* (mean size: 248.2 Å, n = 13), subjects with dense-mode profiles [peak LDL particle diameter ≤ 255 Å]

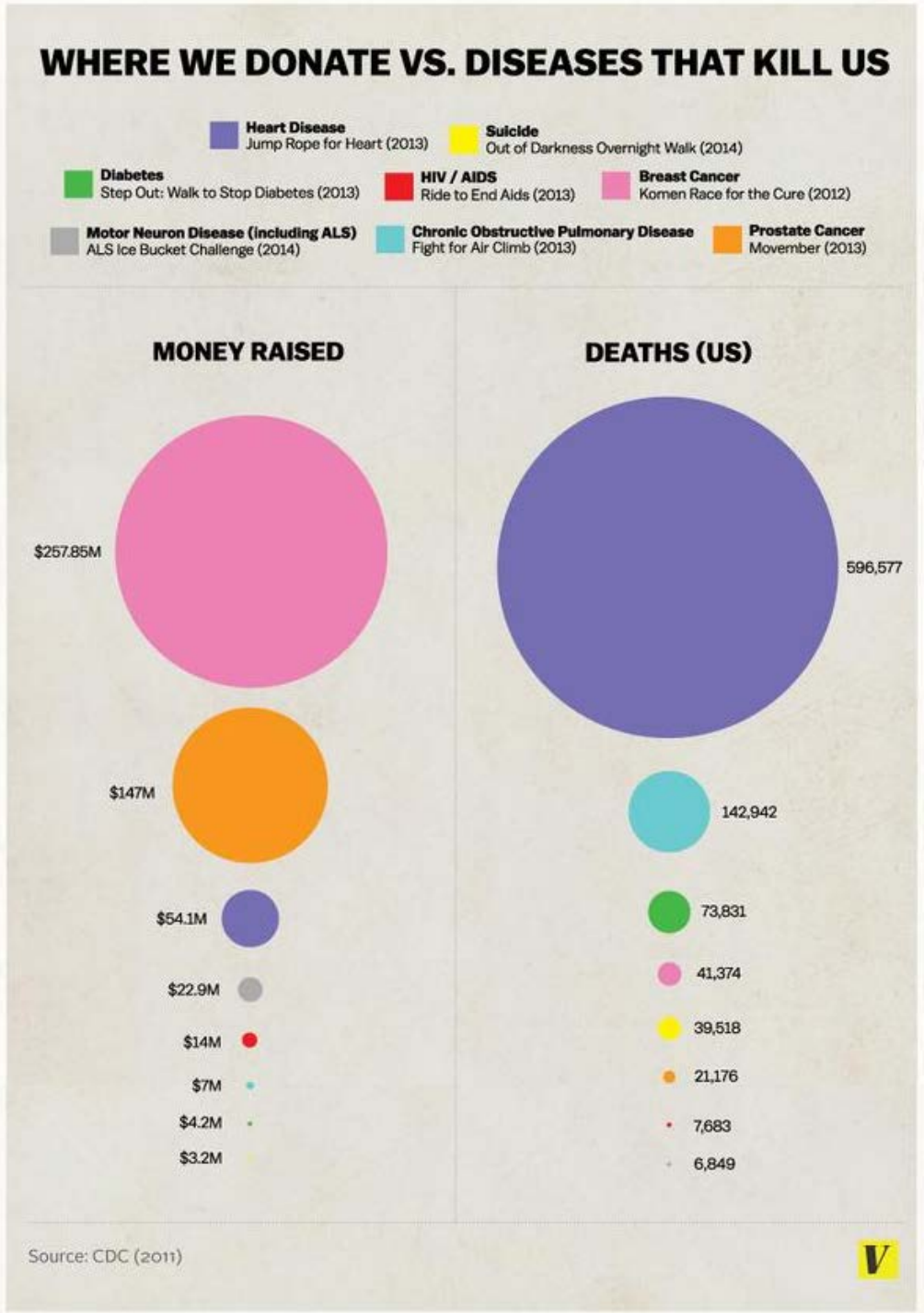
Wrong Y axis and

Visual clutter/chart junk

Wainer H (1984) How to display data badly. *The American Statistician* 38:137-147

Bad Infographics





Gun control in America: A state-by-state breakdown

Laws on file

If no colour appears, there is no such law on file

- 2012 election results
- Background check law
- Permit required to purchase
- Licence required to sell
- Records kept on file
- Firearms banned from workplace

Virginia

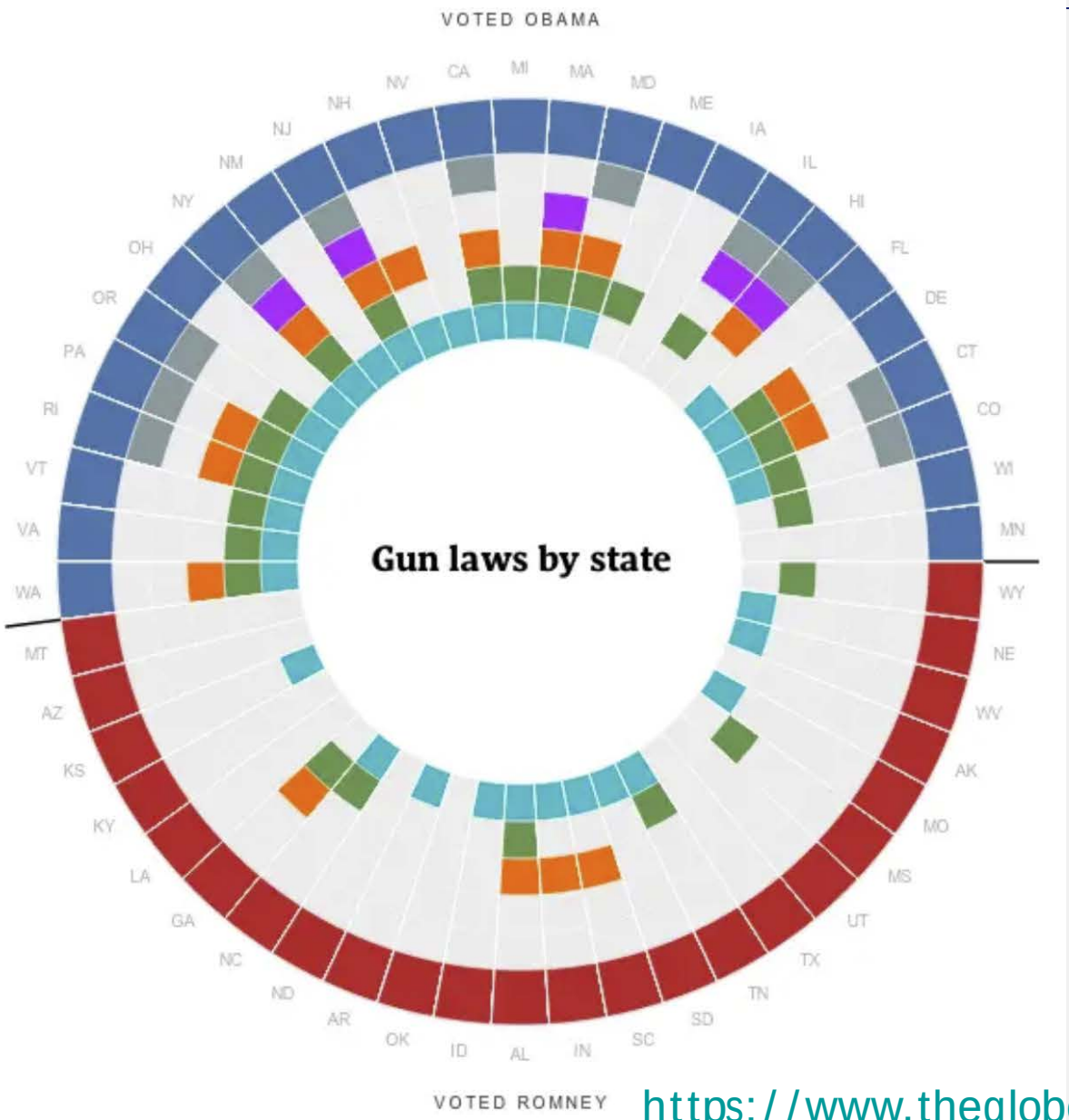
- Voted for Obama in the 2012 election
- **Background check:** not required for handguns
- **Permit**: not required to buy firearms
- **Licence**: not required for dealers
- **Records**: kept on file for handgun owners
- **Workplace**: firearms not allowed in parking lots

Overall gun control score: 12

Virginia has a Brady Campaign score of 12, which is lower than the national average of 16. The score comes from measuring these and other gun laws according to a weighted points system.

Murder rate: 2.58

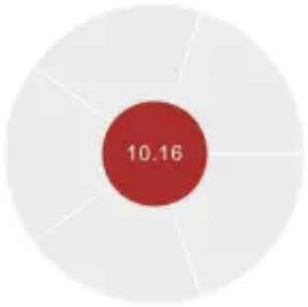
There were 2.58 firearm murders per 100,000 people in Virginia during 2011, which is lower than the national average of 2.77. Overall, it is ranked #27 in murder rates out of 48 states with this data.



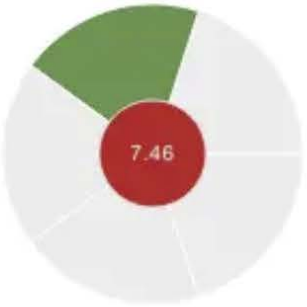
https://www.theglobeandmail.com/

States with the highest firearm murder rate

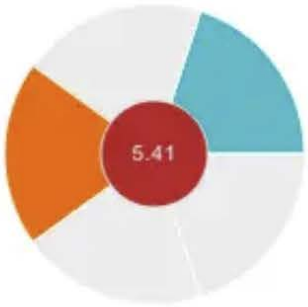
Louisiana scored only two points on the Brady scale for banning guns from college campuses. It also has the highest firearm murder rate per 100,000 people in the country. Oveall, Republican states have an average Brady score of 4.6, compared to 26.73 for states that voted for President Obama in the last election.



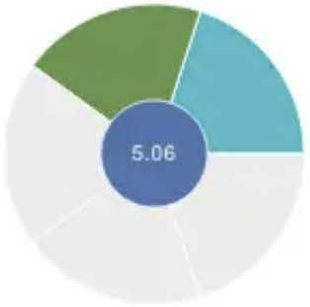
1. Louisiana



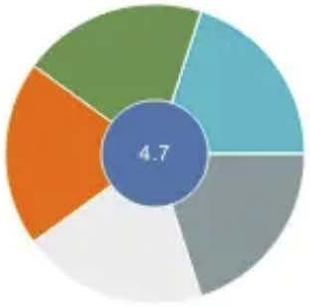
2. Mississippi



3. South Carolina



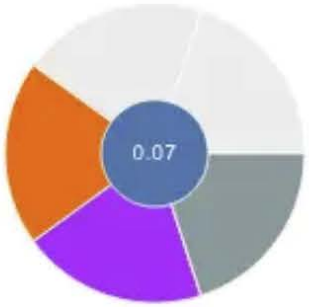
4. Michigan



5. Maryland

States with the lowest firearm murder rate

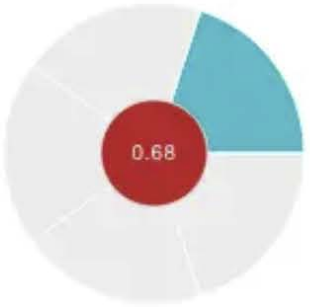
Hawaii has the lowest firearm murder rate in the United States with just 0.07 murders per 100,000 people. South Dakota is the only Republican state to rank on this list. Despite scoring only 7 points on the Brady score and enacting none of the laws highlighted on this chart, Iowa still has one of the lowest firearm murder rates in the country.



1. Hawaii

2. New Hampshire

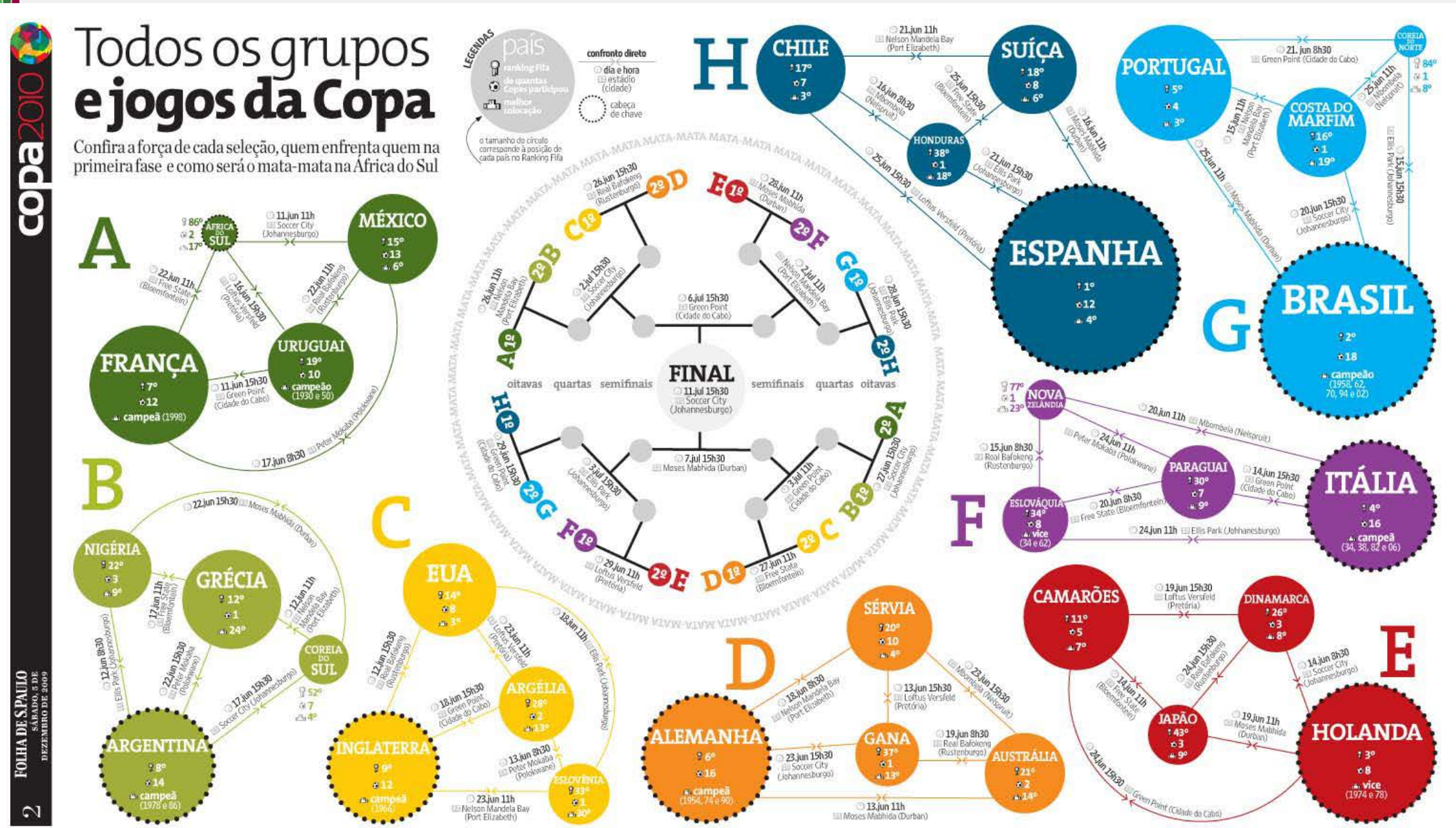
3. Rhode Island



4. South Dakota

5. Iowa

Folha de sao Paulo. This special World Cup Games Table was AWARD OF EXCELLENCE by SND The Best of Newspaper Design 2010.



WHAT'S DATA/INK RATIO?

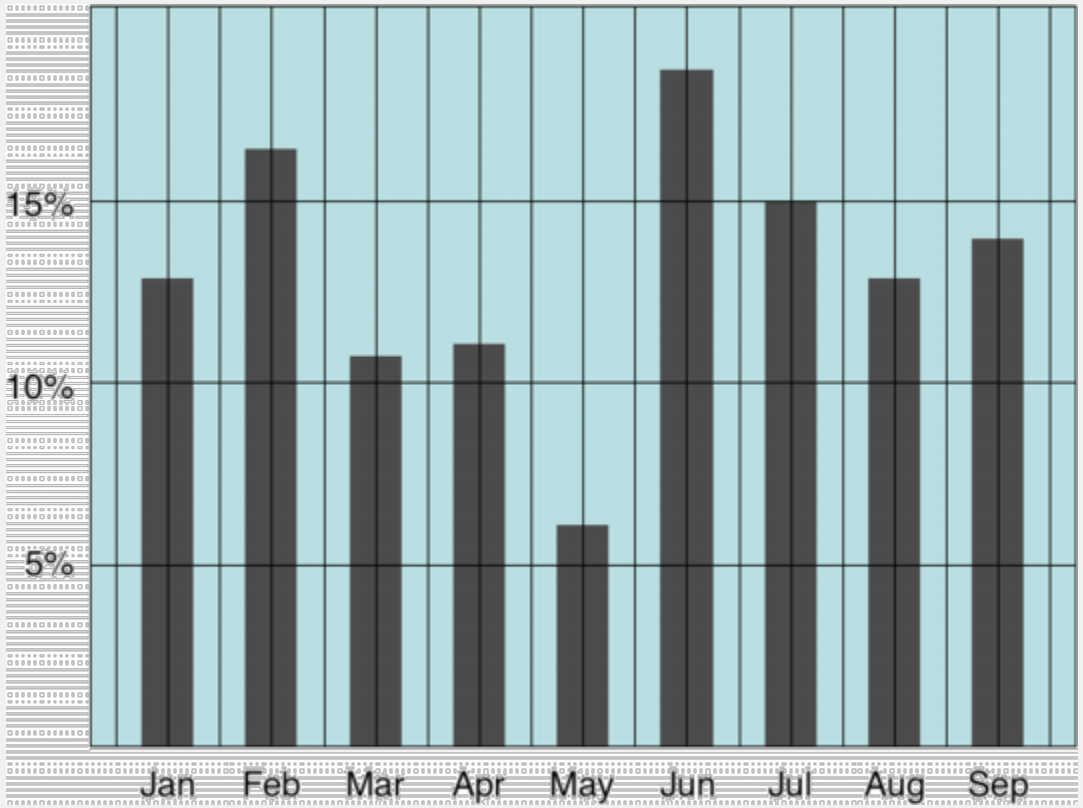
WHAT'S VISUAL CLUTTER?

WHAT'S CHART JUNK?

$$\text{Data-ink ratio} = \frac{\text{Data-ink}}{\text{Total ink used to print the graphic}}$$

= proportion of a graphic's ink devoted to the non-redundant display of data-information

= 1.0 − proportion of a graphic that can be erased



Remove border,

Remove background color

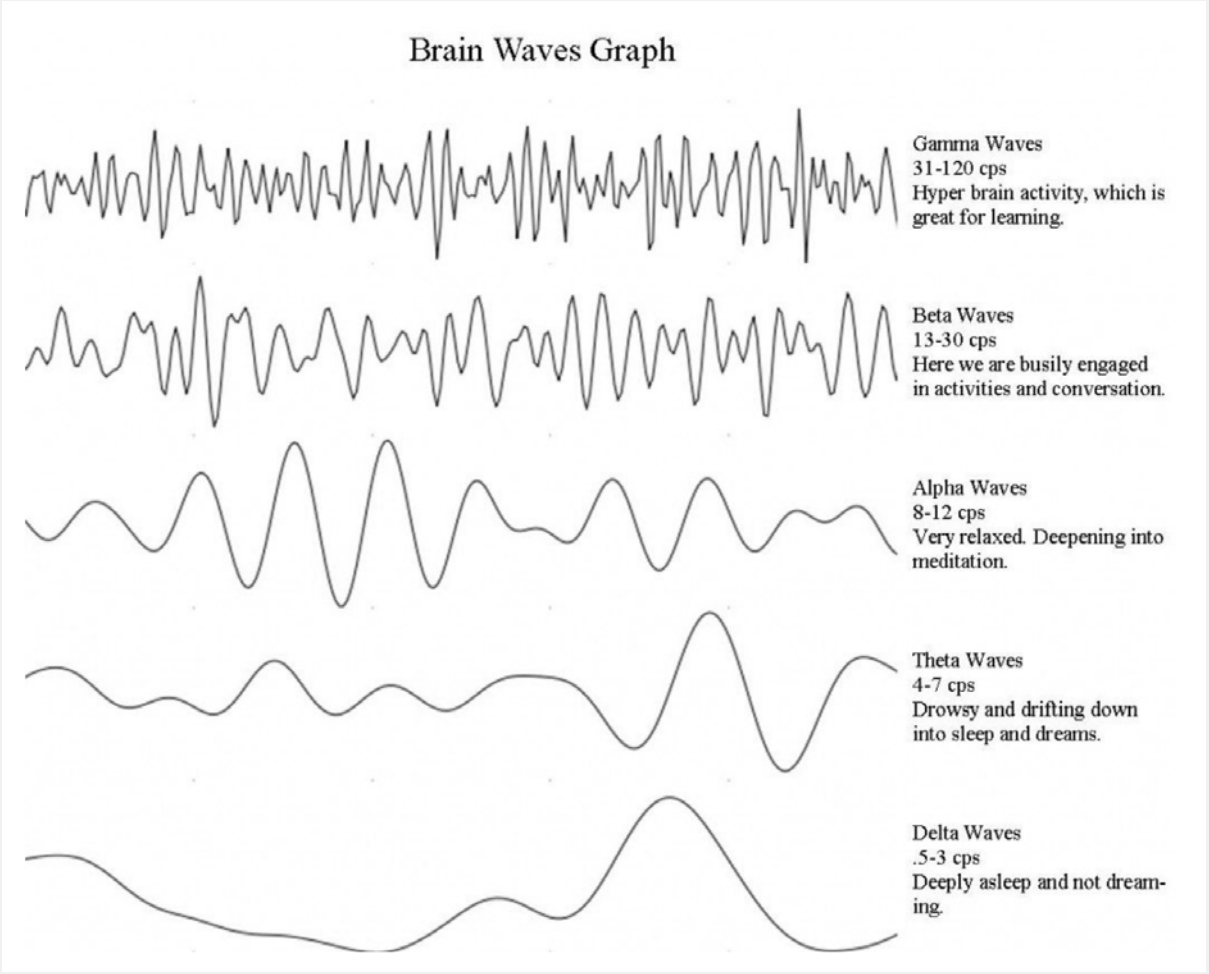
Remove grid lines and eventually draw (grey)

only those helpful for looking up numbers.

DATA-INK PRICIPLES:

1. Above all else show data
2. Maximize the data-ink ratio
3. Erase non-data-ink (visual clutter)
4. Erase redundant data-ink (visual clutter)
5. Revise and edit

Let's See It in practice



High data-ink ratio

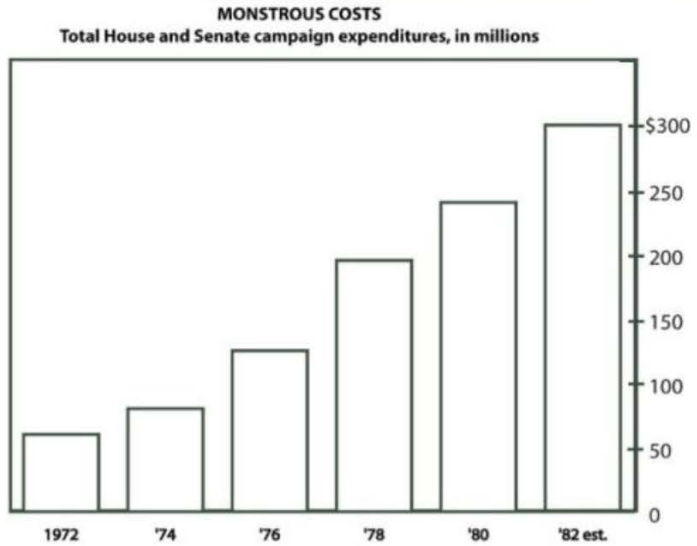


Figure 1. A chart by Holmes [7] (above), and a 'plain' version.

[7] Holmes, N. *Designer's Guide to Creating Charts and Diagrams*, Watson-Guptill Publications, 1984.

CHARTJUNK: the excessive and unnecessary use of graphical effects in graphs.

Though sometimes some artistic view may help interpretation accuracy and long-term recall

Useful Chart Junk

NEUVis: a set of guidelines for creative practitioners developing visualizations for Non-Expert Users.

TUFTE'S GRAPHICAL INTEGRITY: 6 PRICIPLES

1. The representation of numbers, as physically measured on the surface of the graph itself, should be directly proportional to the numerical quantities represented (DON'T LIE WITH SCALES)

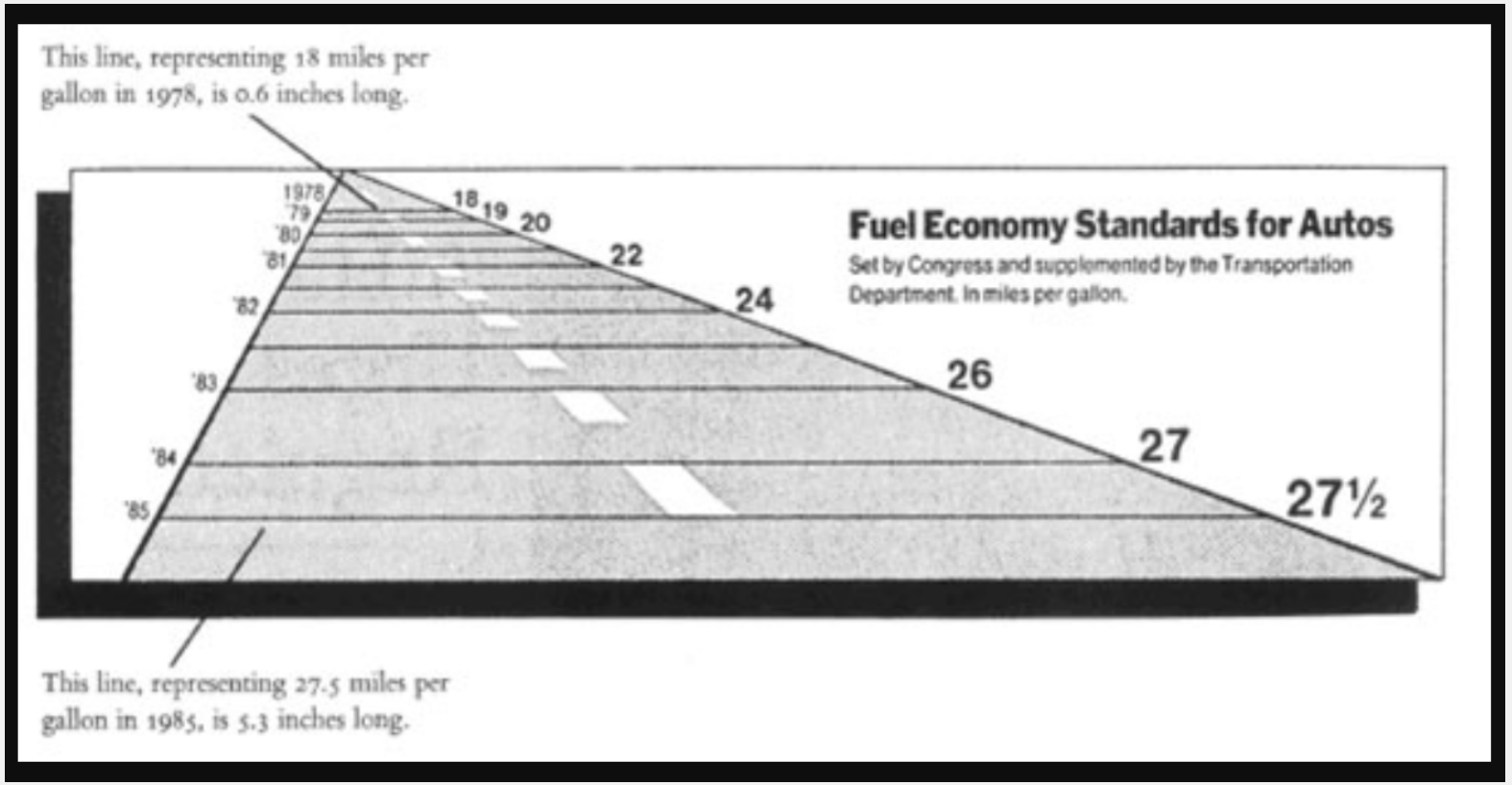
2. Show data variation, not design variation (AVOID TOO ARTISTIC EFFECTS)

3. In time-series displays of money, deflated and standardized units of monetary measurement are nearly always better than nominal units (USE "PROPER" – adjusted/normalized - DATA)

4. Clear, detailed and thorough labeling should be used to defeat graphical distortion and ambiguity. Write out explanations of the data on the graph itself. Label important events in the data. (THE PLOT SHOULD BE AS EXPLICATIVE AS POSSIBLE)

5. Graphics must not quote data out of context. (THE PLOT SHOULD BE AS AUTO-CONTAINED EXPLICATIVE AS POSSIBLE)

6. The number of information carrying (variable) dimensions depicted should not exceed the number of dimensions in the data (DON'T USE MISLEADING 3D-4D….)

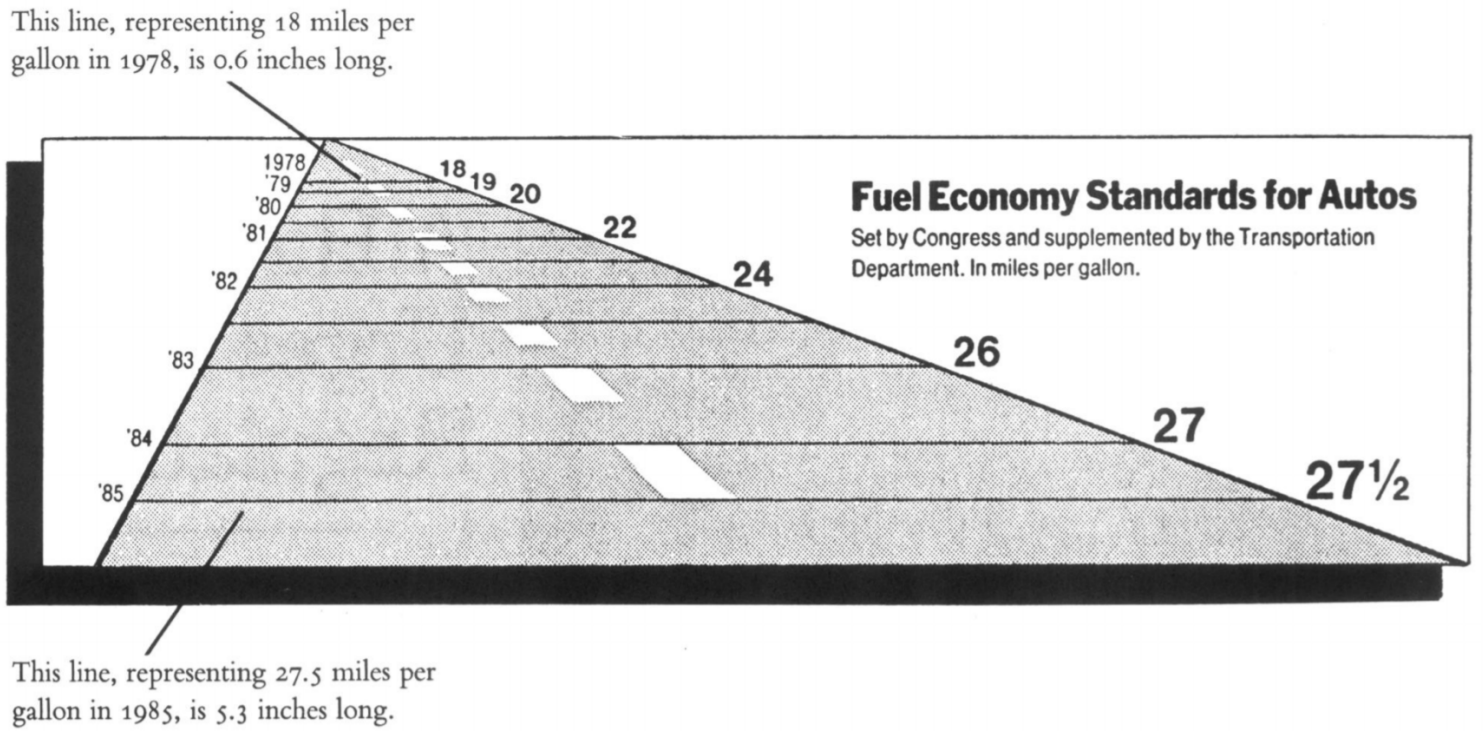


Example of a graph with low graphical integrity.

Lie factor (Edward Tufte): amount of distortion on a graph

$$\text{Lie Factor} = \frac{\text{size of effect shown in graph}}{\text{size of effect shown in data}}$$

If it is greater than one the graph is lying



$$\text{Data Effect} = \frac{27.5 - 18}{18} = 0.53, \qquad \text{Graph Effect} = \frac{5.3 - .6}{.6} = 7.83,$$

$$\text{Lie Factor} = 14.8$$

Ratio you see =

$$\frac{\text{3.5” - 0.47”}}{\text{0.47”}} = 6.45 \quad \text{graph}$$

$$\frac{\text{47,500 - 43,147}}{\text{43,147}} = 0.1 \quad \text{real}$$

Lie Factor = 6.45/0.1 = 64.5

And someone else has concentrated on the image scale

A plot must be taller or wider??

Cleveland et al. suggest that the mean orientation of all segments should be 45°

Heer at al. find a scale that makes the mean orientation of the "trend" data 45°

The trend curve is found by applying spectral decomposition to remove high-frequencies in the data.

The trend curve is obtained by smoothing the lower bend (lower frequencies).

This is a bit too complex… Experts suggests using the same scale if the axis are semantically similar.

Otherwise, just make your choice in an objective ways

IT'S THE SAME FOR TABLES!!!

As Tufte states, simple methods help

Video: Al Gore's CO2 Emissions Chart

An interesting TED'S TALK

https://www.ted.com/talks/david_mccandless_the_beauty_of_data_visualization

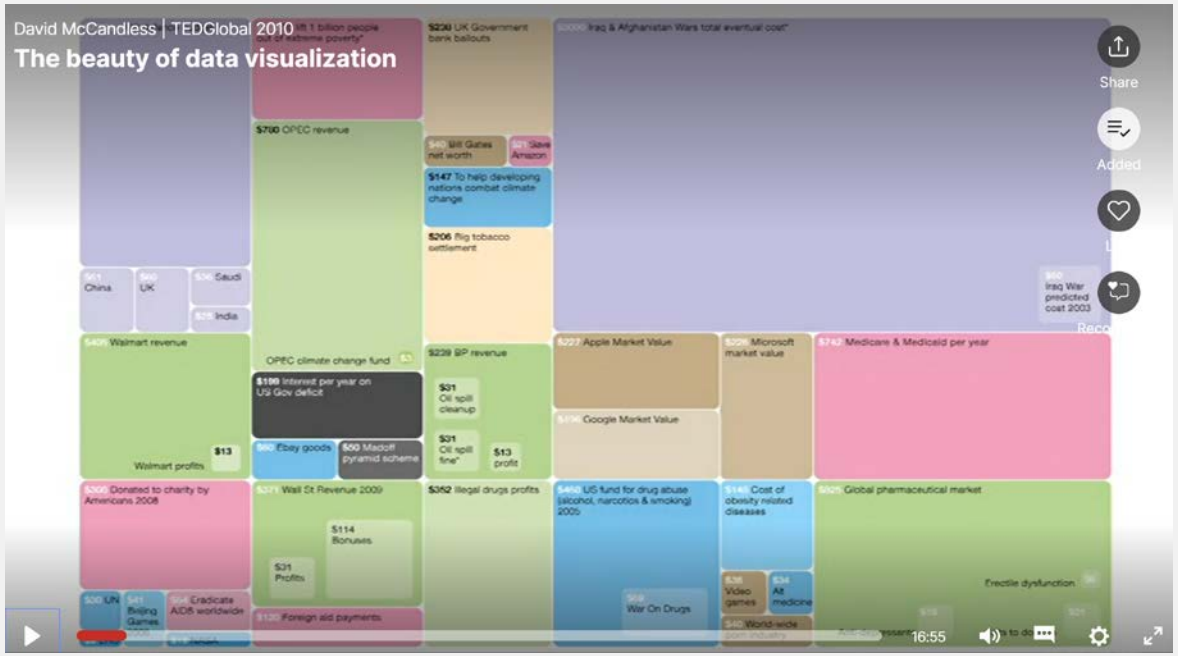
David McCundless uses what he uses the name **information Maps** to define graphs that "map" the information he has scraped from various newspapers into a visible/understandable representation

Treemaps

Treemap representation is used to show money spent/donated/received

(as it was mentioned in various newspapers).

- Colors helps define the spending, donating, receiving, …
- Text in each rectangle mentions WHO spent/received/donated
- area shows how much is the money w.r.t. to the others

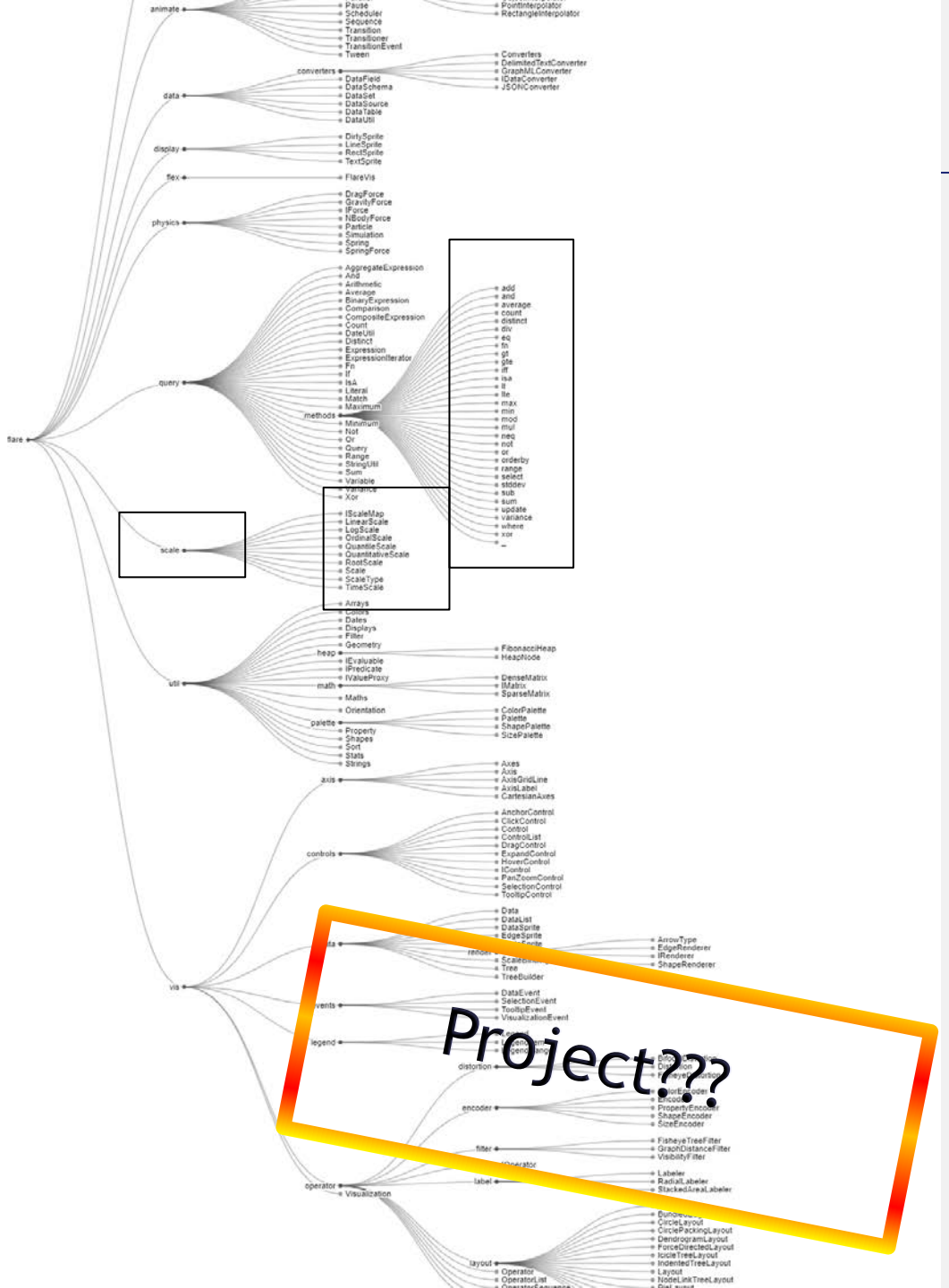


Treemaps: originally developed by Ben Shneidermann for viewing the hard disk content

They allow showing hierarchical data distributions by showing the proportions of samples per classes, which are then grouped by samples per sub-classes and so on…

There are several treemaps version:

- Unordered treemaps
- Nested Treemaps
- Slice-and-dice treemaps
- Hierarchical treemaps



Treemaps are a compact representation of Trees layout (This image is from the tidy trees implementation)

"Tidier Drawings of Trees"

Reingold and Tilford

IEEE TRANSACTIONS ON SOFTWARE ENGINEERING, VOL. SE-7, NO. 2, MARCH 1981

D3.js implementation

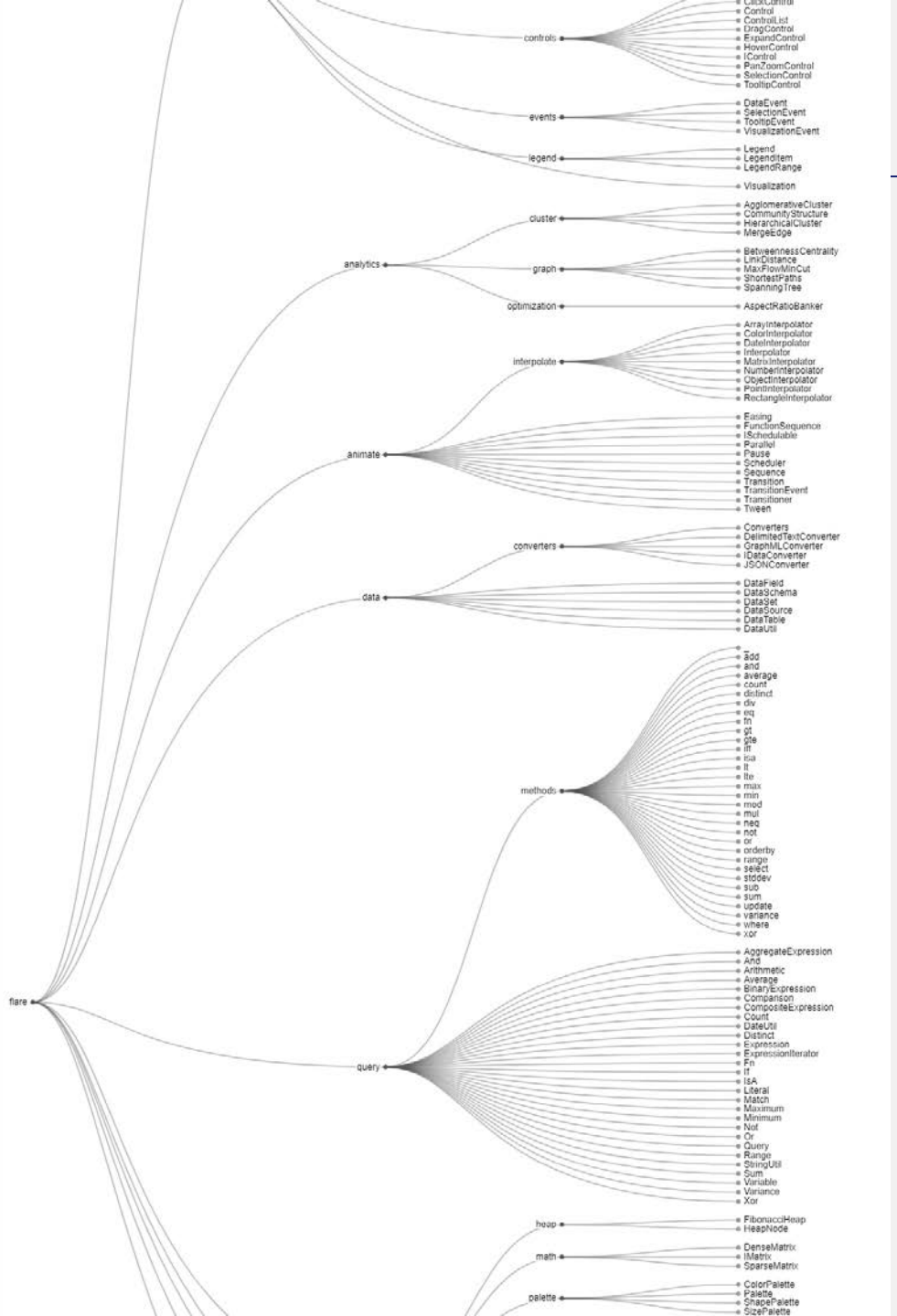
https://observablehq.com/@d3/tidy-tree

Radial variant of tidy trees:

- it's more compact
- there is not to and bottom: we don't have an unconscious sorting by importance

BUT

- text is rotated and don't horizontal.
- more difficult to see it



Tidy trees are better visualizations than cluster dendrograms which put leafs all at the same level

Project???

D3.js

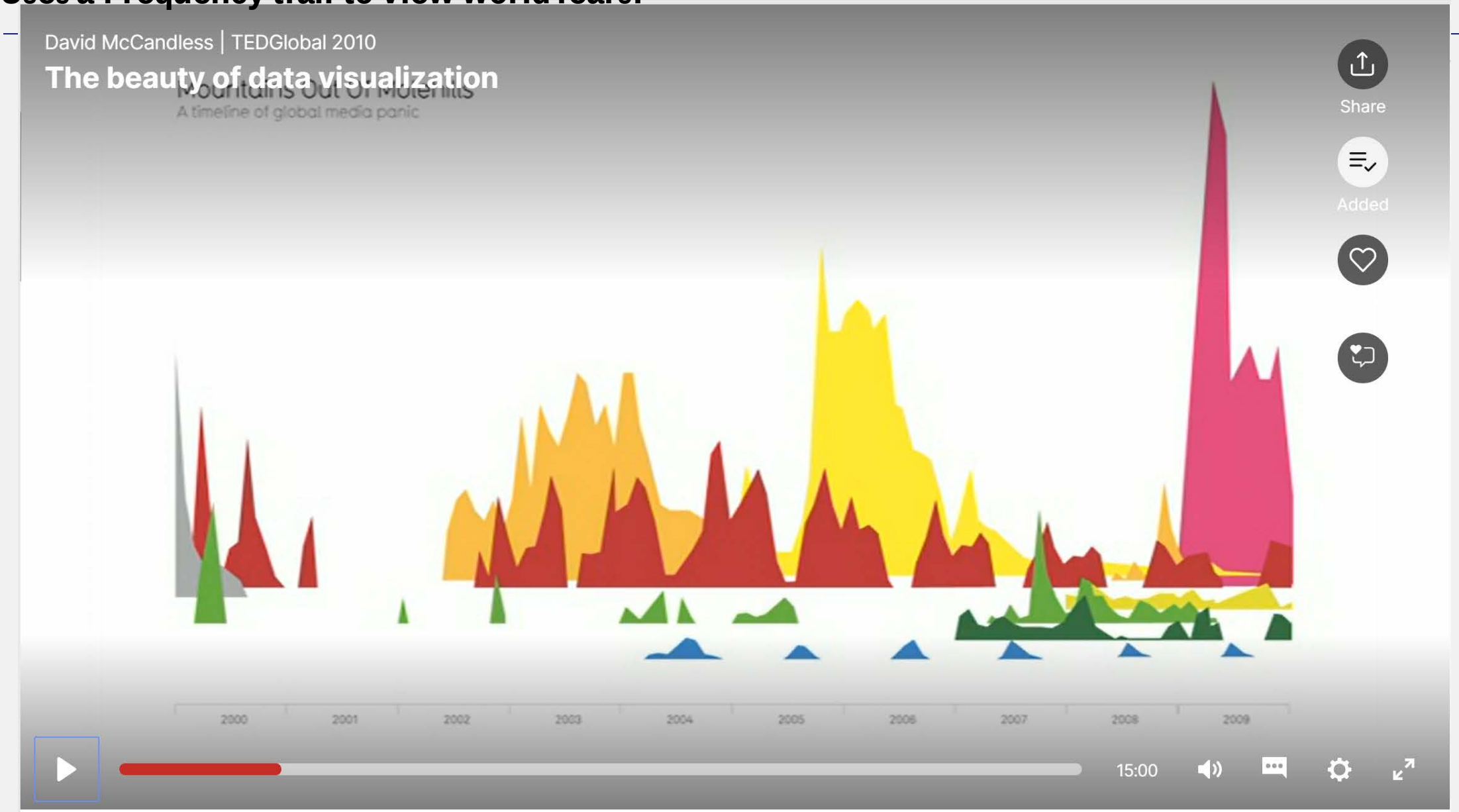
Here is a d3.js implementation of Treemaps

https://observablehq.com/@d3/treemap

Short course at:

https://observablehq.com/@d3/learn-d3

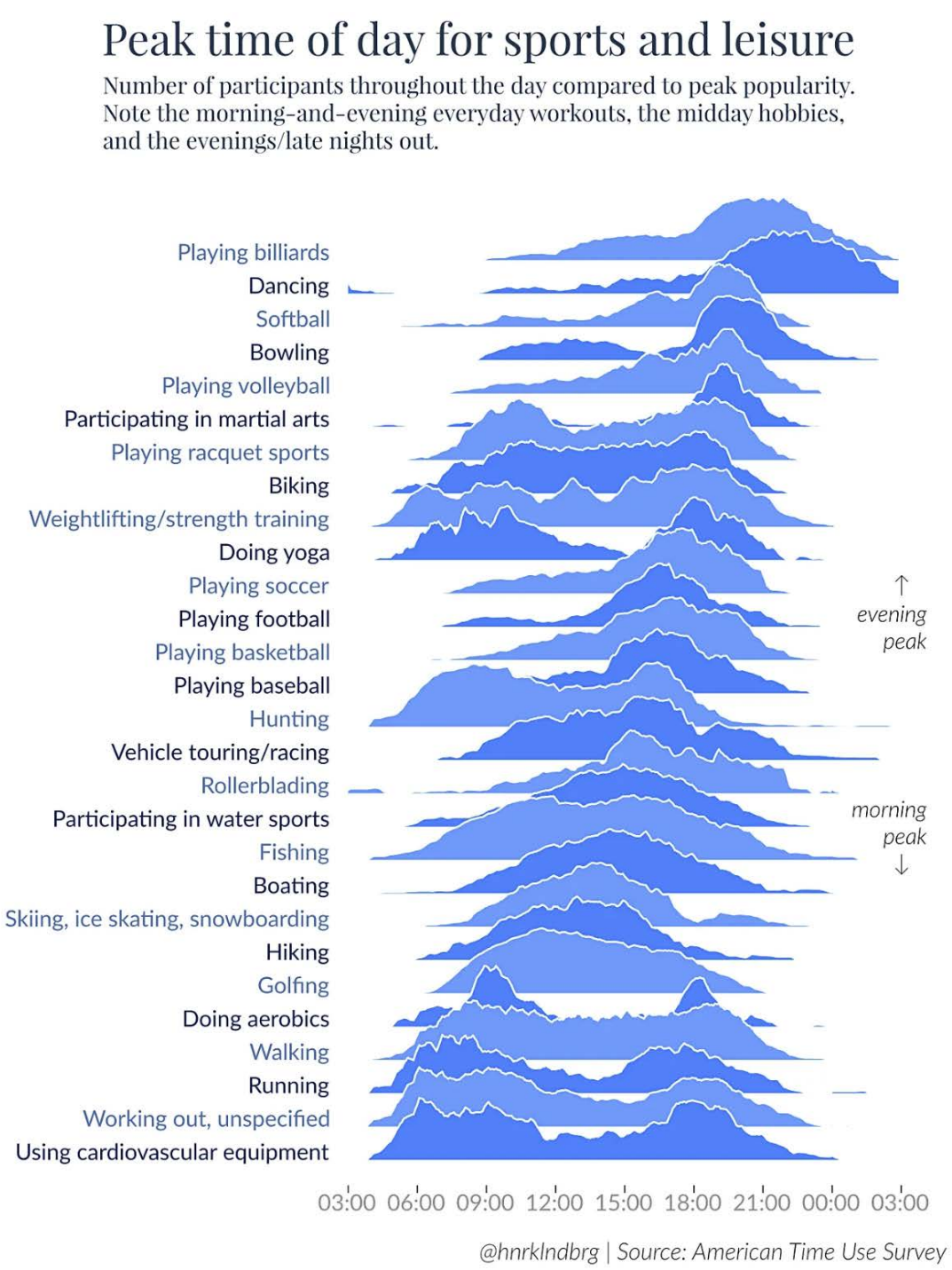
Uses a Frequency trail to view world fears:



Frequency trails (also known as joy or ridgeline plots) are a method for comparing distributions by vertically offsetting each curve (a 3D-ish way of aligning charts – sometimes 3D helps!).

They are an alternative to:

- multi-line charts (where overcrowding increases with the number of series)
- small multiples (which are harder to compare when there are too many lines - preattentive memory limits)

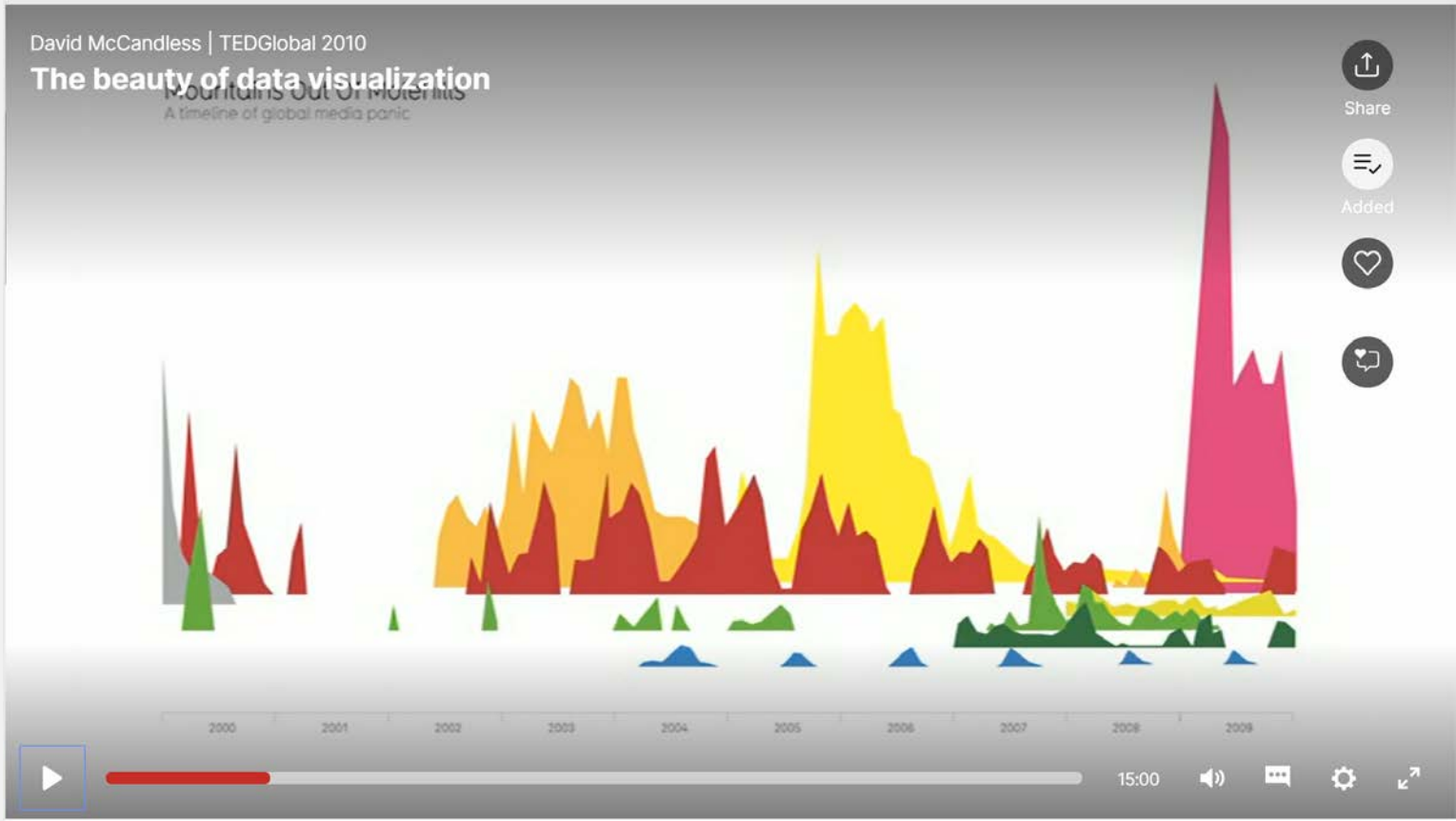


Have been around for some time but they hit peak popularity in 2017 when Henrik Lindberg posted a chart that showed “sports participation by time of the day”

Here colors help distinguishing neighboring lines

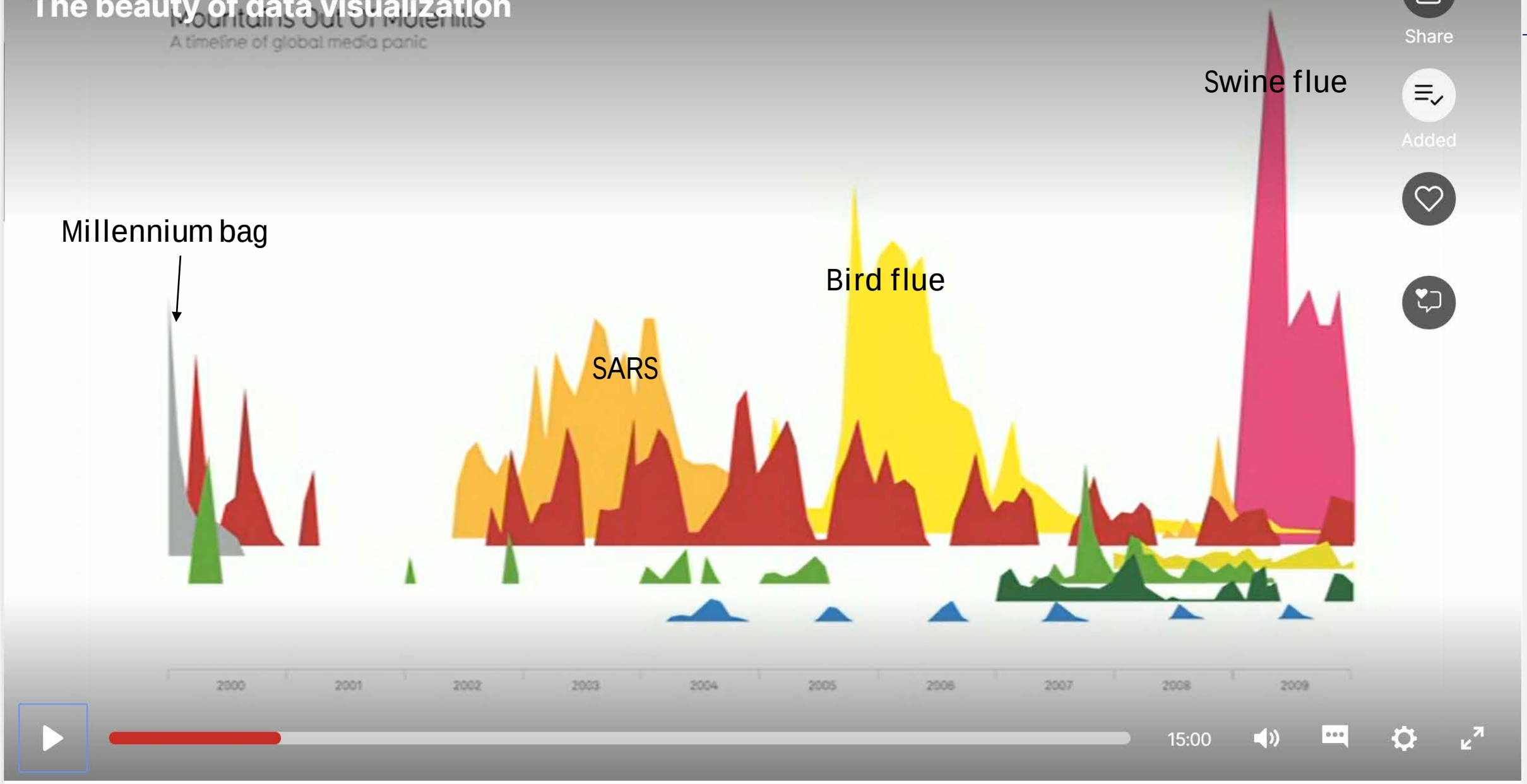
Colors help differentiating “important” and (believed) “less important” fears:

- fears due to similar reasons are represented with similar colors
- more important fears are highlighted with hues in red channel
- fears which are less important (not motivated) are marked with colors considered as “positive”, e.g. green (grey)



David McCandless | TEDGlobal 2010

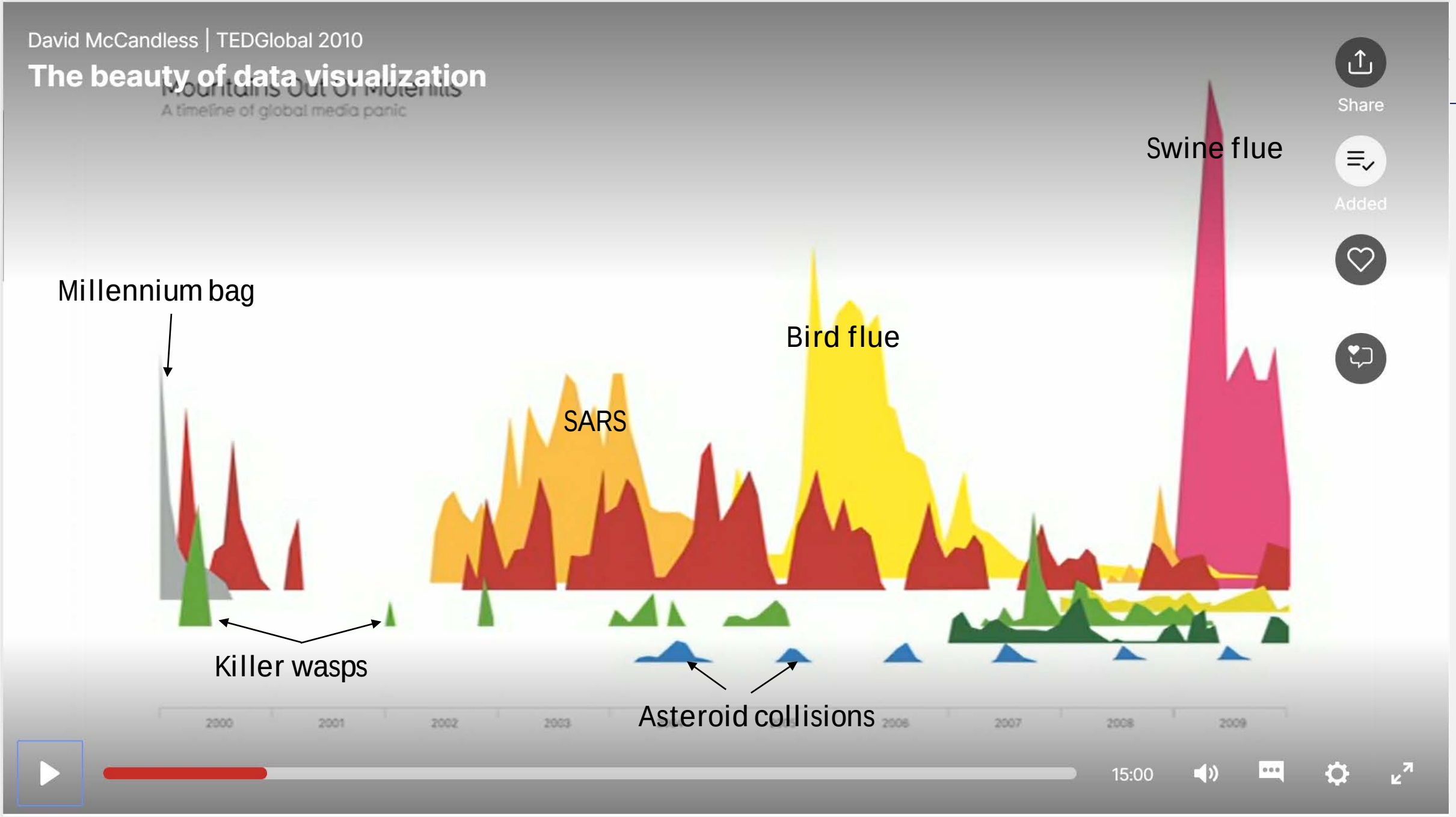
The beauty of data visualization



David McCandless | TEDGlobal 2010

The beauty of data visualization

A timeline of global media panic



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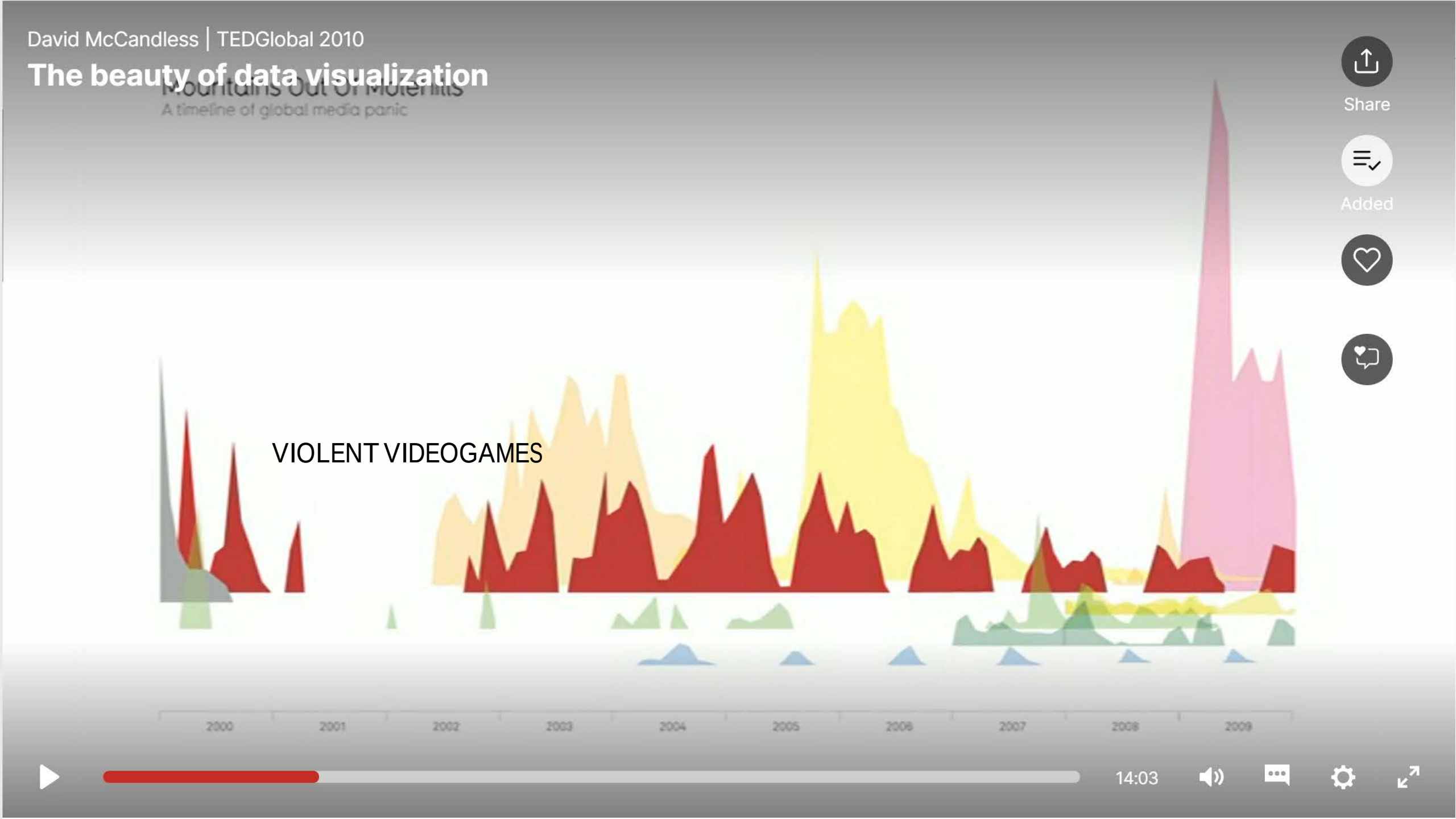
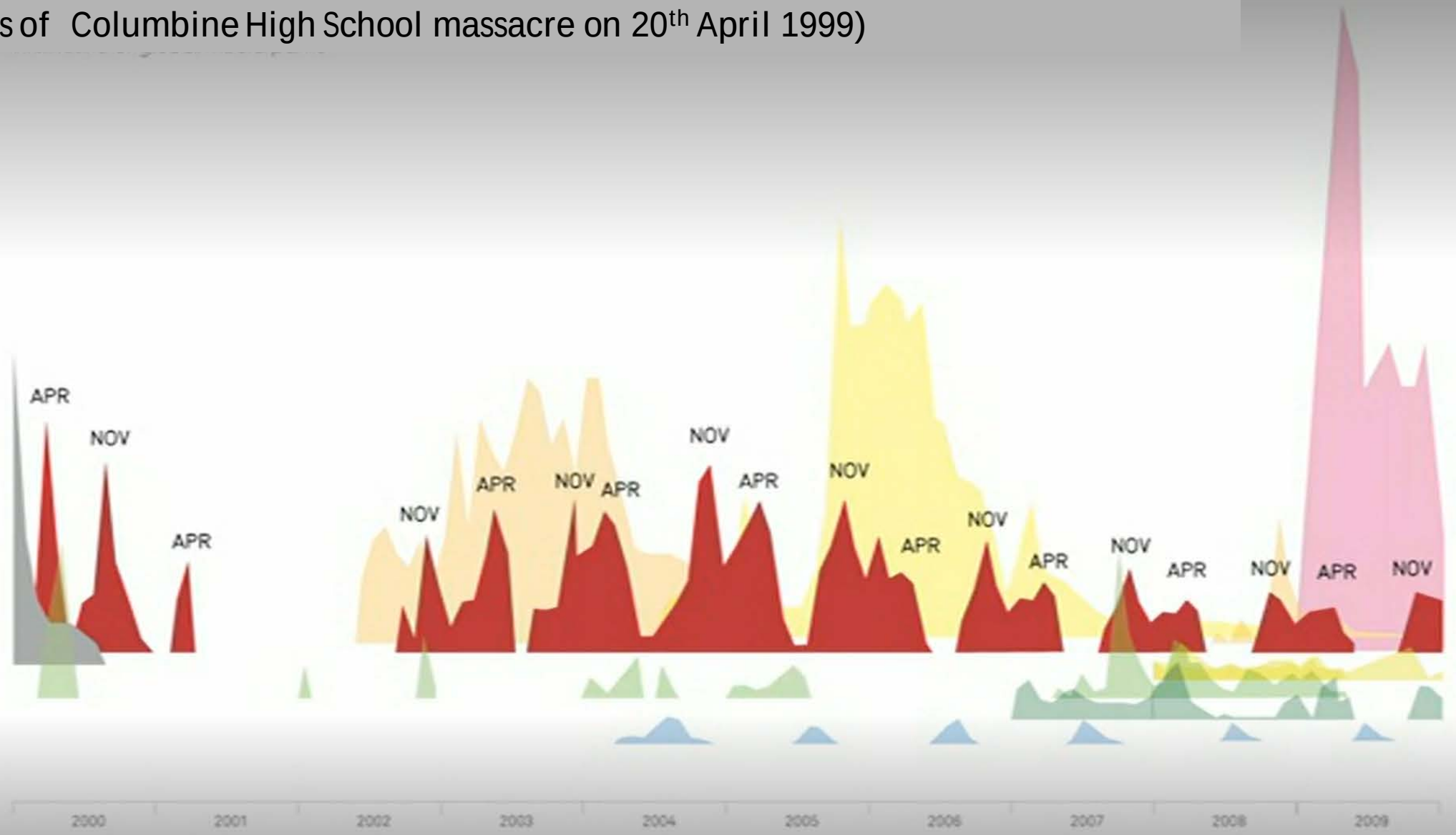
David McCandless | TEDGlobal 2010

The beauty of data visualization



You see a regular pattern: twin peak in November (before Christmas time) and April (memories of Columbine High School massacre on 20th April 1999)



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13:54

Why not using histograms (generally represented by bar charts) instead of lines?

Lines instead of histograms help emphasizing peaks (intensity in media news)

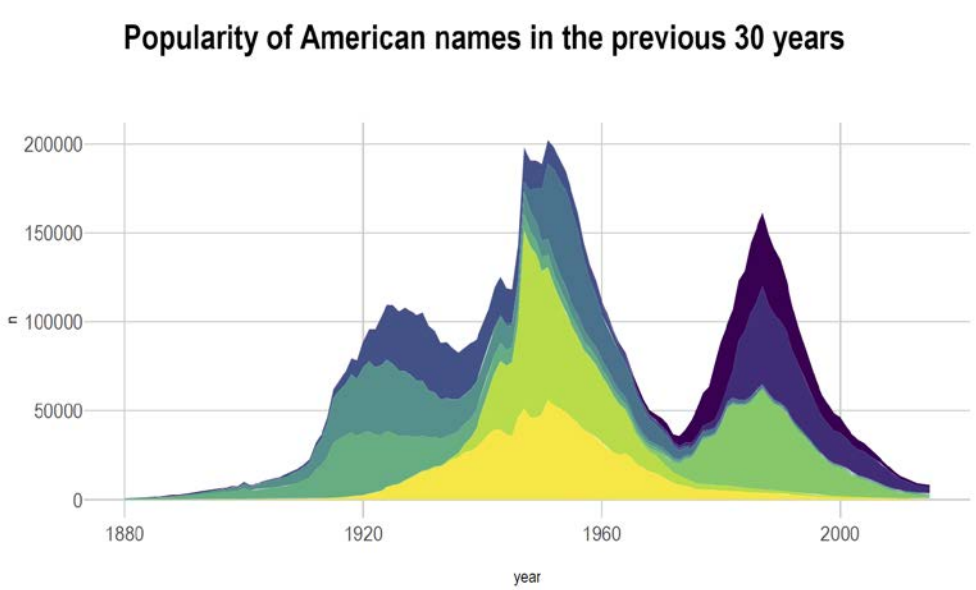
Why FILLED (Area) plots? Filled lines (form mountains) create shapes with areas.

- **Shape/Area** an **added visual clue** -> enforce and emphasize perception of relative quantities, therefore inherently helping the comparison of their importance.

Direct comparison of trends could also be done with streamgraphs

“A Stream graph is a type of stacked area chart. It displays the evolution of a numeric value (Y axis) following another numeric value (X axis). This evolution is represented for several groups, all with a distinct color.
Contrary to a stacked area, there is no corner: edges are rounded what gives this nice impression of flow. Moreover, areas are usually displaced around a central axis, resulting in a flowing and organic shape. ”

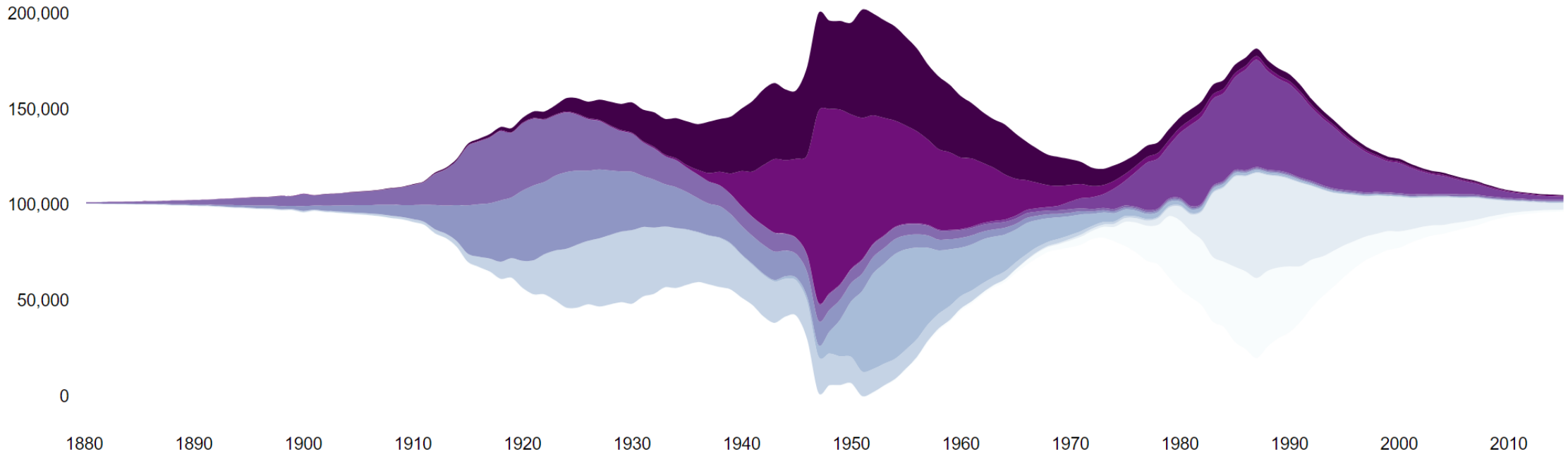
https://www.data-to-viz.com/graph/streamgraph.html



From stacked area charts

To Stream graphs

CODE



Stream-graphs designed like this are good to view the overall distributions

But suppose you want to

- perform pairwise comparison between di distributions the distributions

or

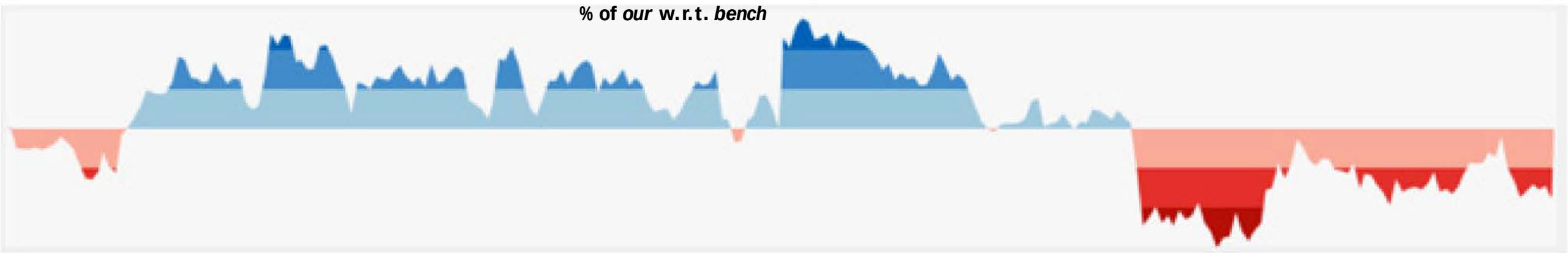
- compare all the distribution to a Benchmark distribution.

It is very hard to subtract the height of one distribution to the other and it is hard to see this comparison with many distributions arranged as we have done before.

We can still use stream graphs **for the pairwise comparison,** but **we need to change our point of view**…

And then, **for comparing all the (many) pairwise comparisons** we may **use small multiples**.

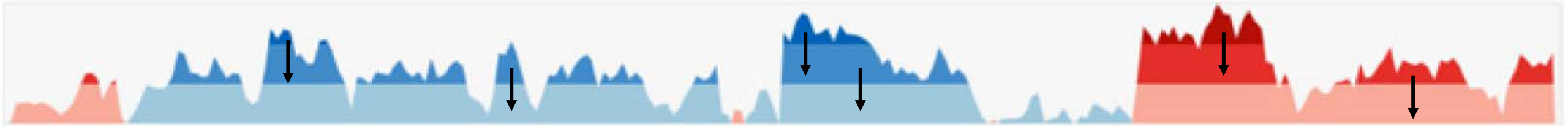
A different point of view for pairwise comparison



We want to compare the result of our algorithm, *our*, to those obtained by a benchmark algorithm, *bench*, on N experiments (performed e.g. daily), to see when *our* scores better than *bench.*

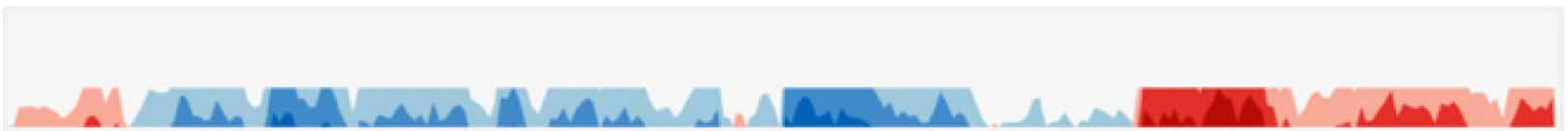
- on the x axis the number of the experiment
- on the y axis, instead of showing the result of *our* and *bench*, we show the percentage of our results w.r.t. the corresponding result of *bench*
- reddish colors alerts: *our* is going worse than *bench* (the higher the color saturation the more we need to worry)
- Blueish colors calm: *our* is going better than *bench* (the higher the color saturation the more we need to be happy)

Now that we know that reddish means worries, reverse the reddish

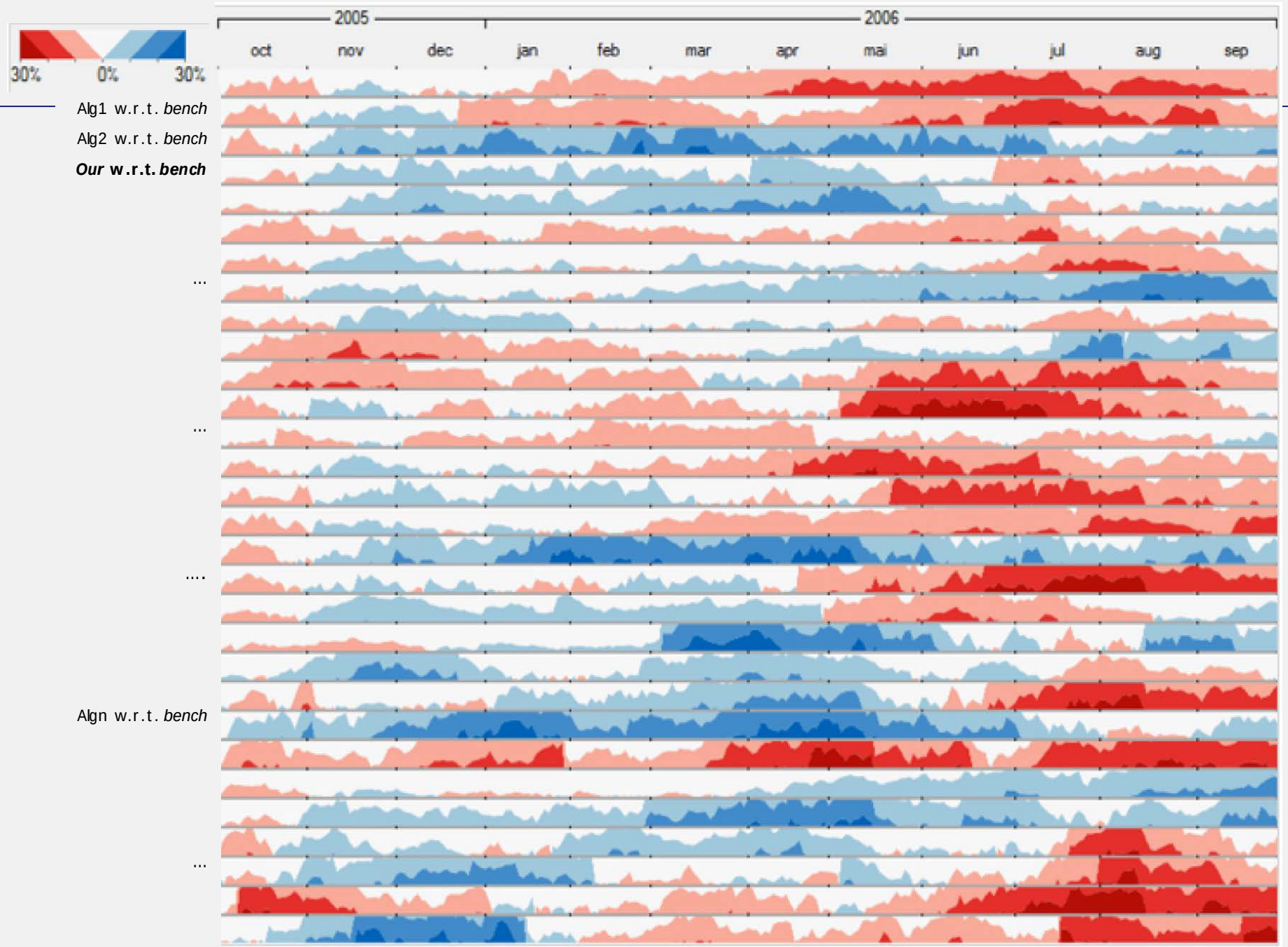


Now that we know that color saturation means higher happiness/higher worries

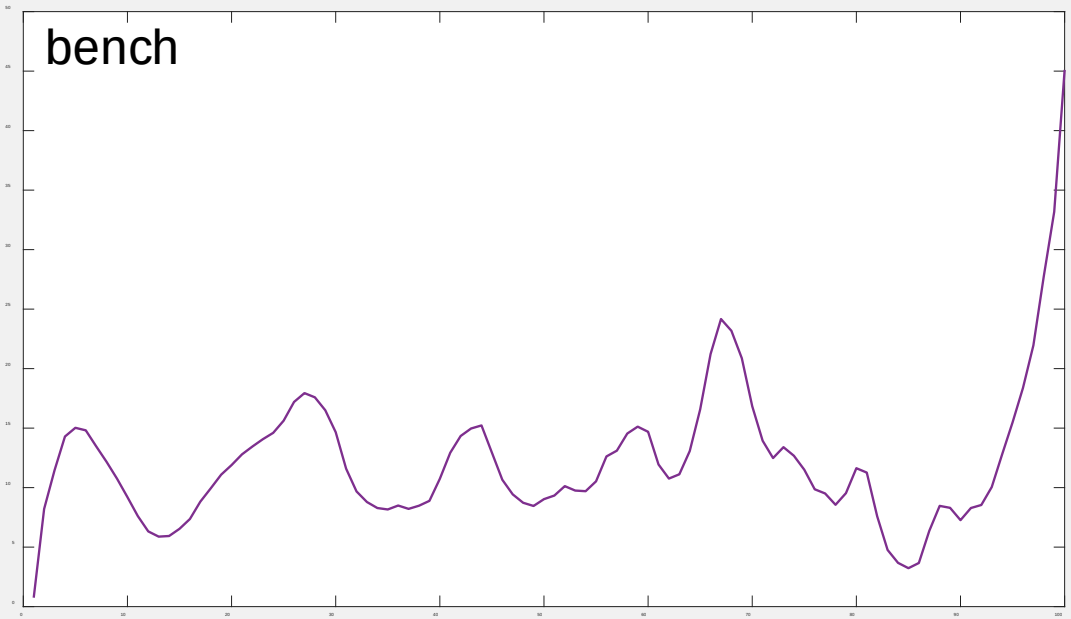
contract the heights superimposing the colors

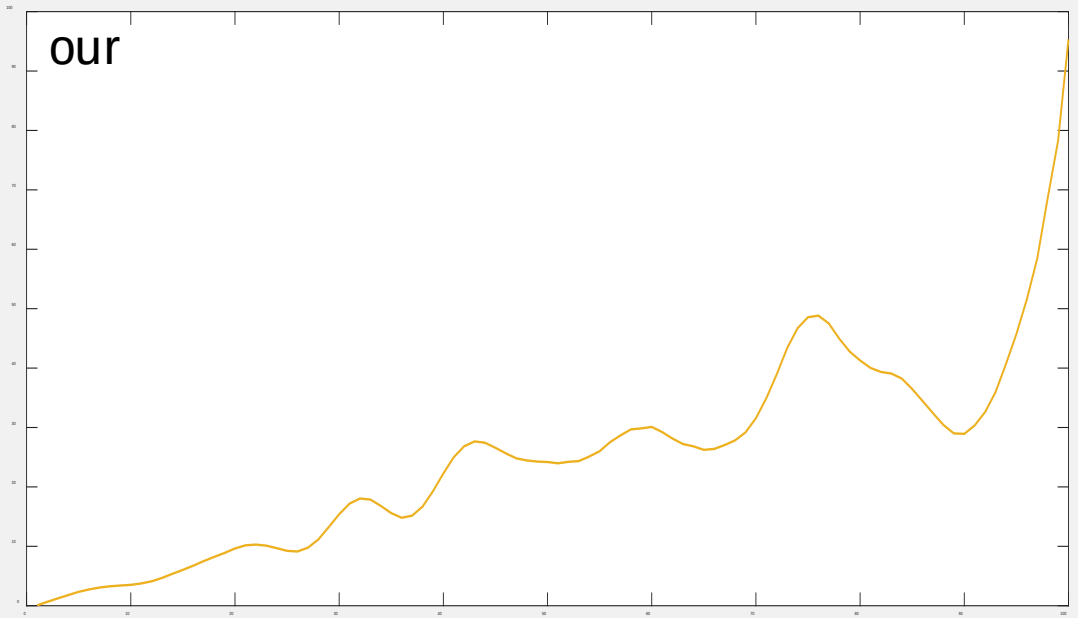


And now join all the pairwise comparisons in a small multiple



We've already seen this

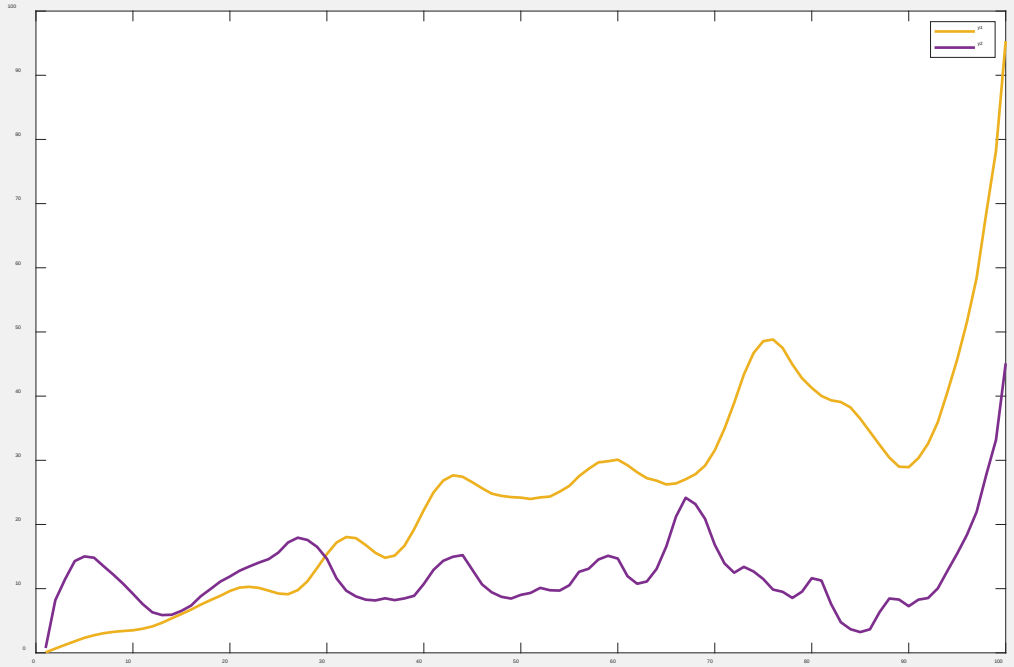


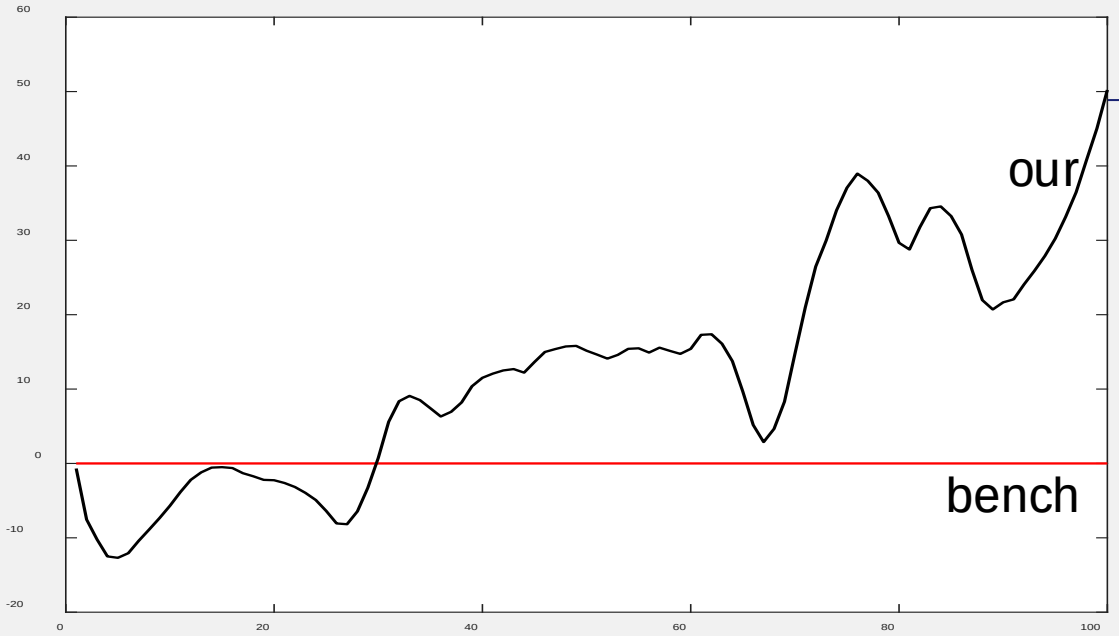


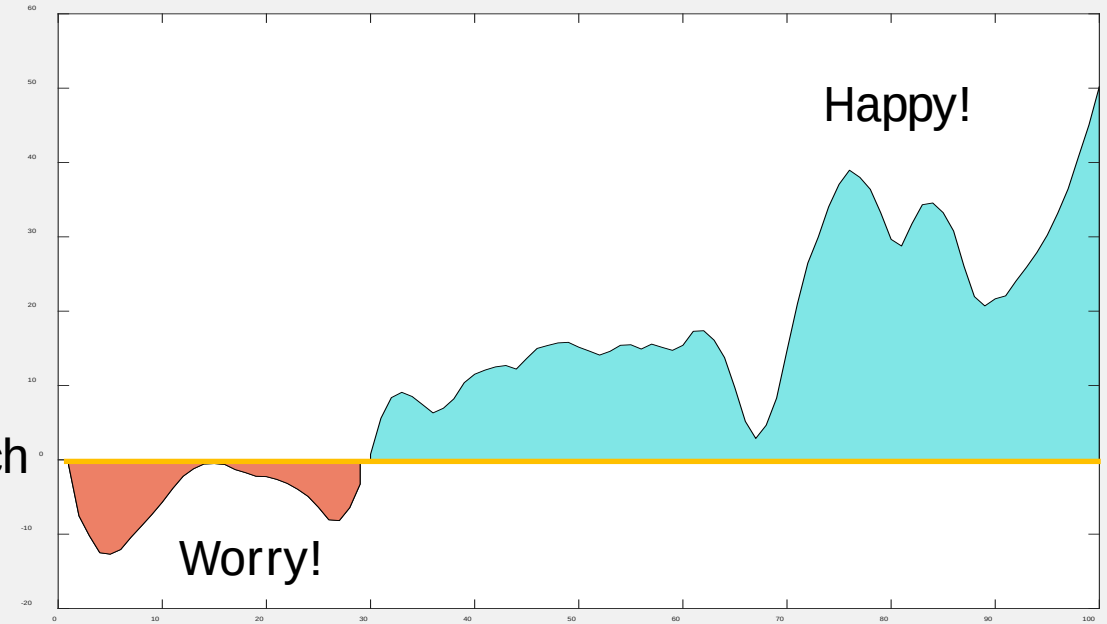
Is there something that isn't ok?

What about the scales?

The real situation is this one!







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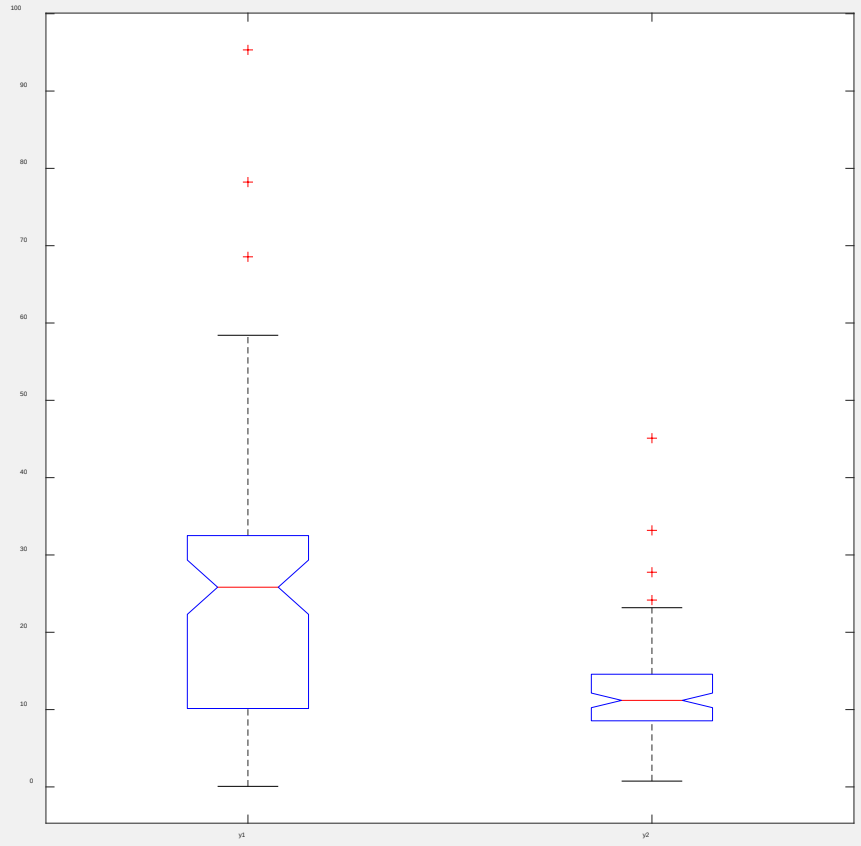
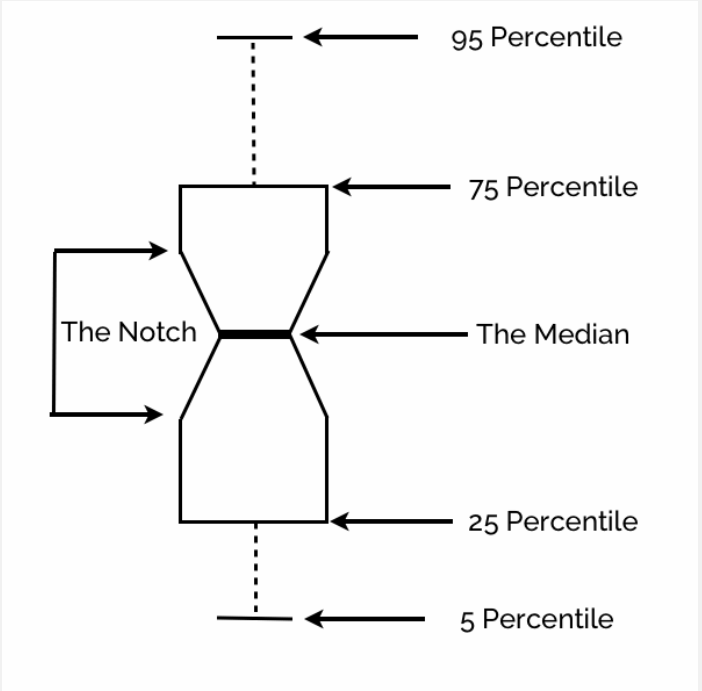
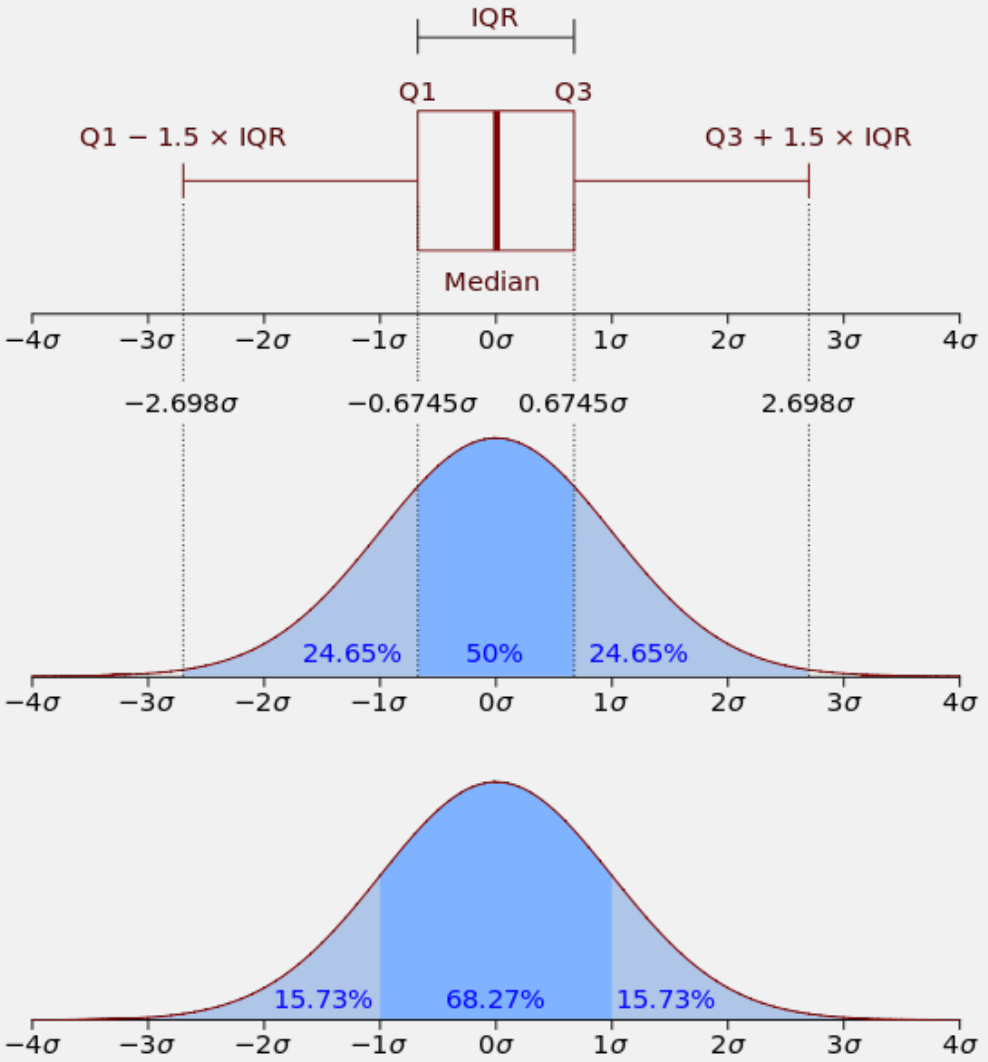
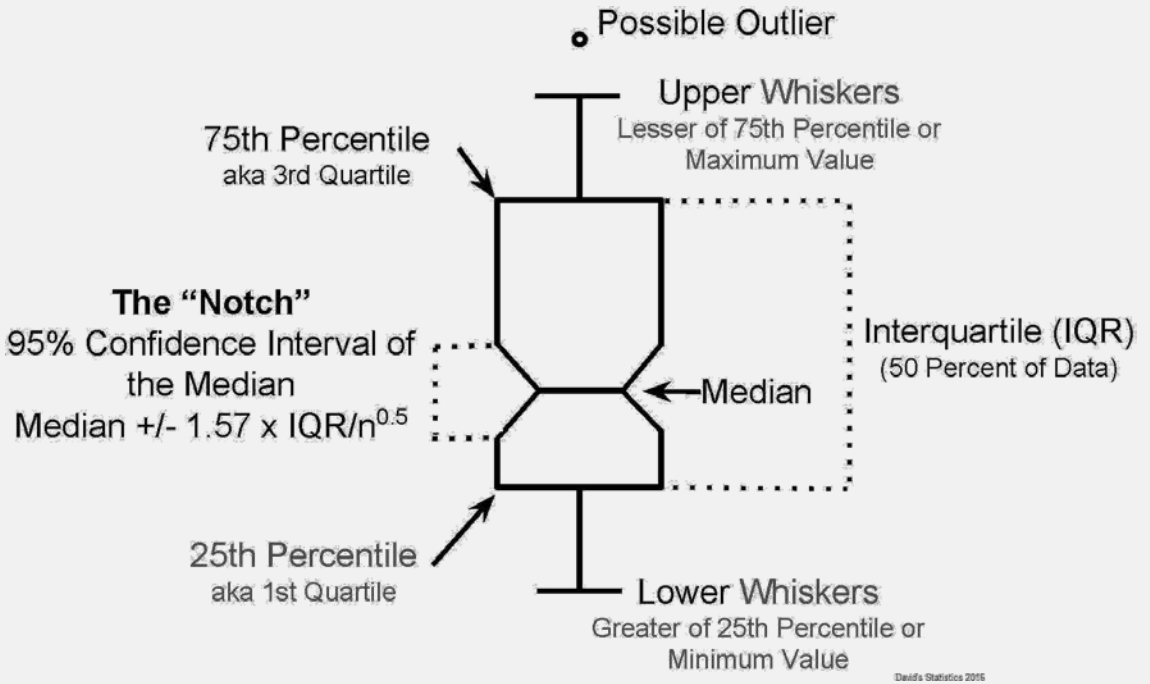
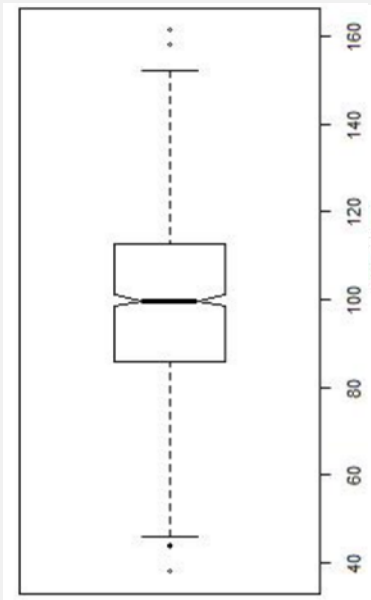
If you are not interested in the day by day comparison but only in watching the global distribution

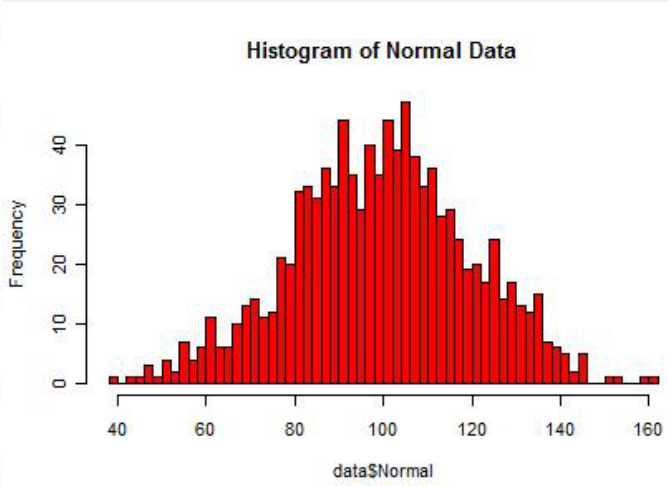


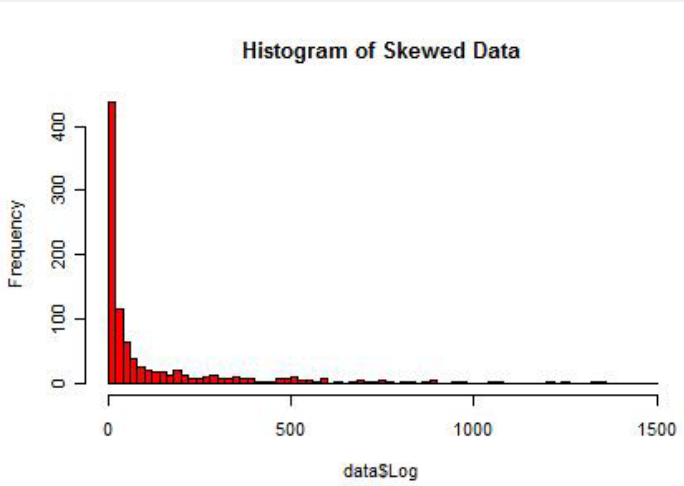


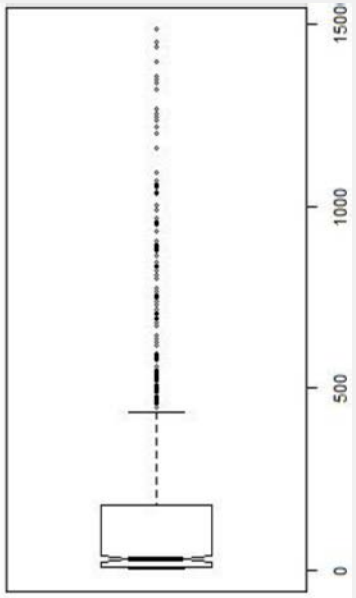


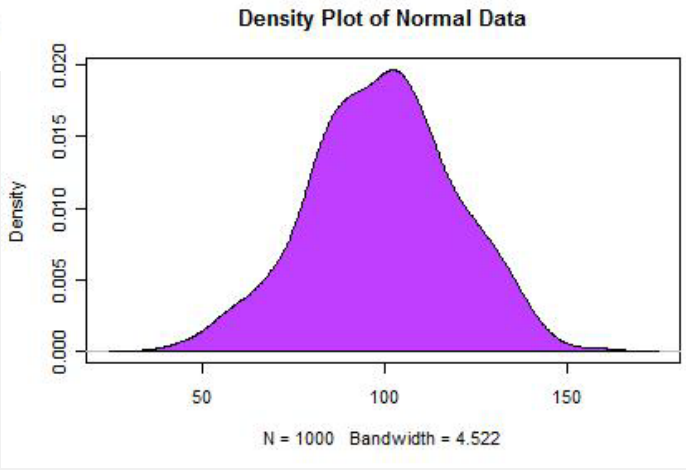


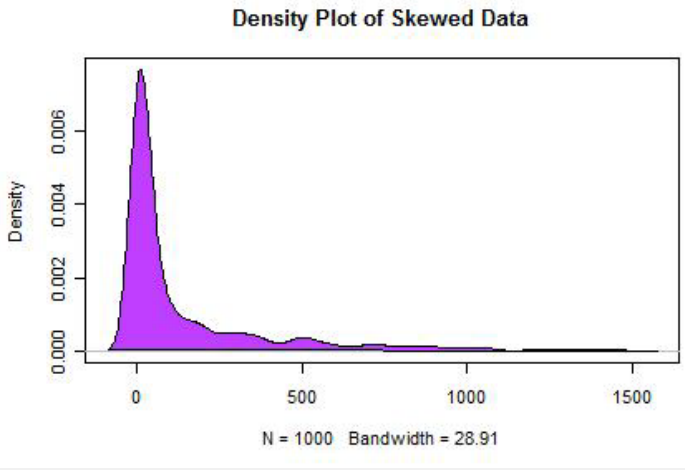




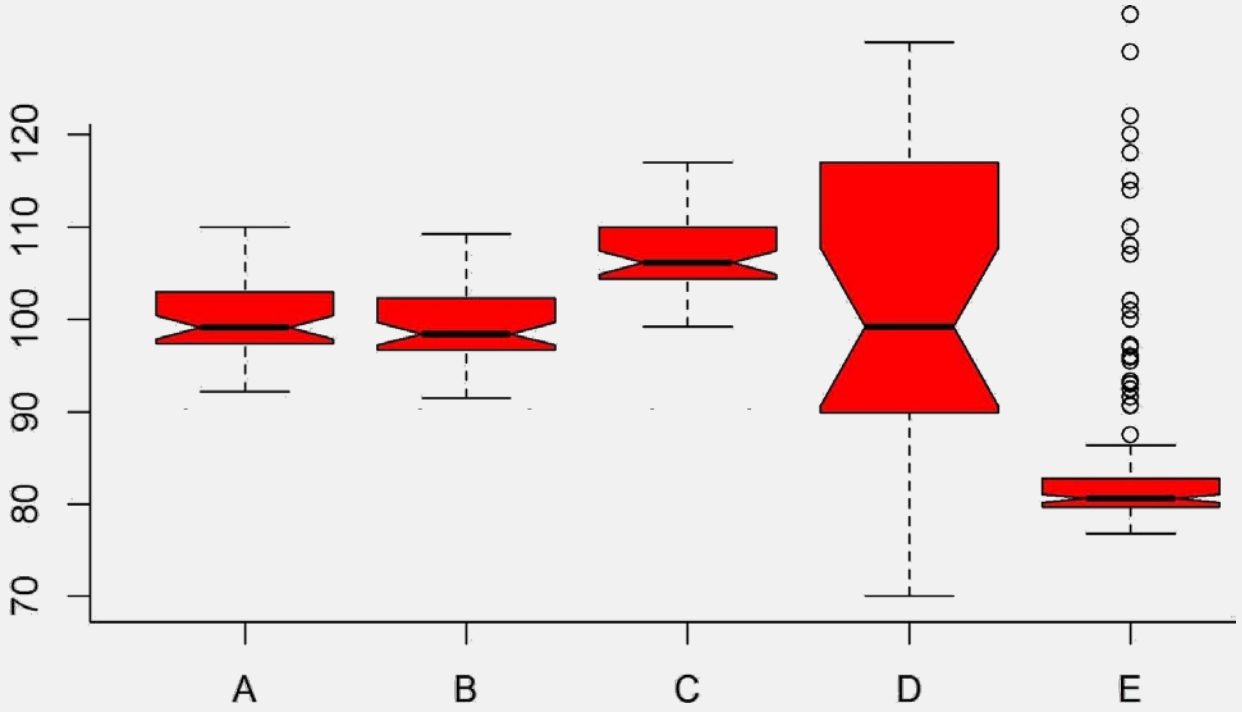








Visually compare distributions A,B, C, D, E through boxplots



Height of boxplots = Variances

A,B, C have similar variance, D, has larger variance, E has lowest variance.

A, B, C, are skewed with big longer tail to the right.

D is larger (higher variance) and has also a tails to the right

E is really skinny, with a very long tail to the right.

Notches = 95% confidence interval of medians = statistical comparison between distributions

E differs from all the distributions

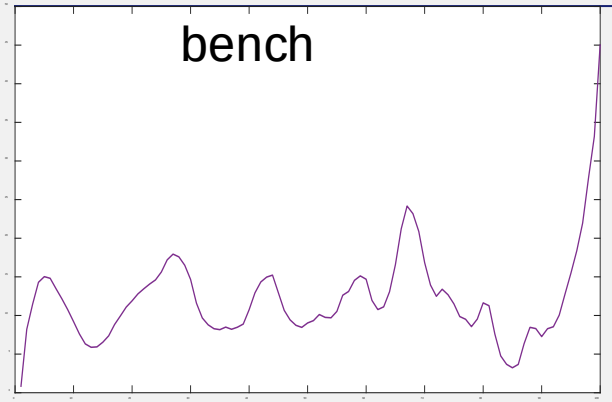
A, B have overlapping notches: they have similar distribution

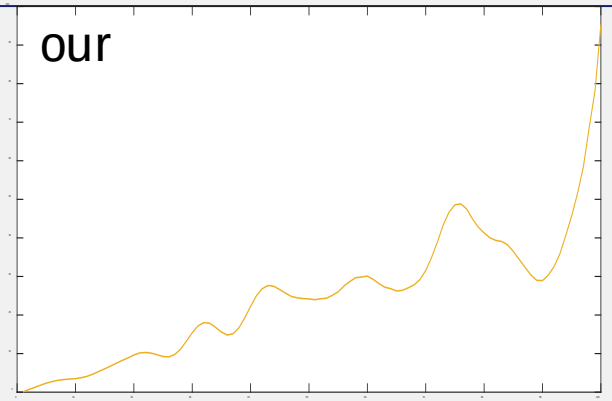
C does not overlap with B and A: A, B come from distributions that differ from that underlying C

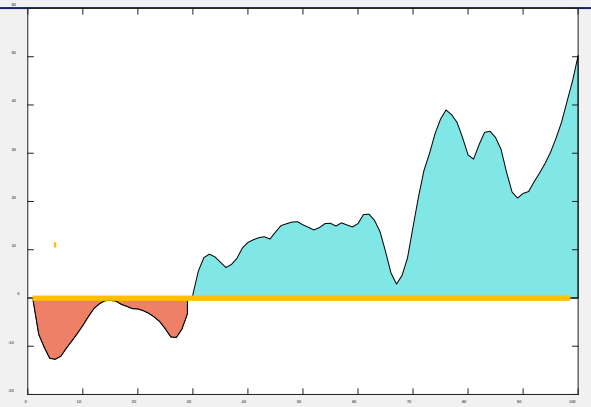
A, B notches overlap with D notch: they may be drawn from D.

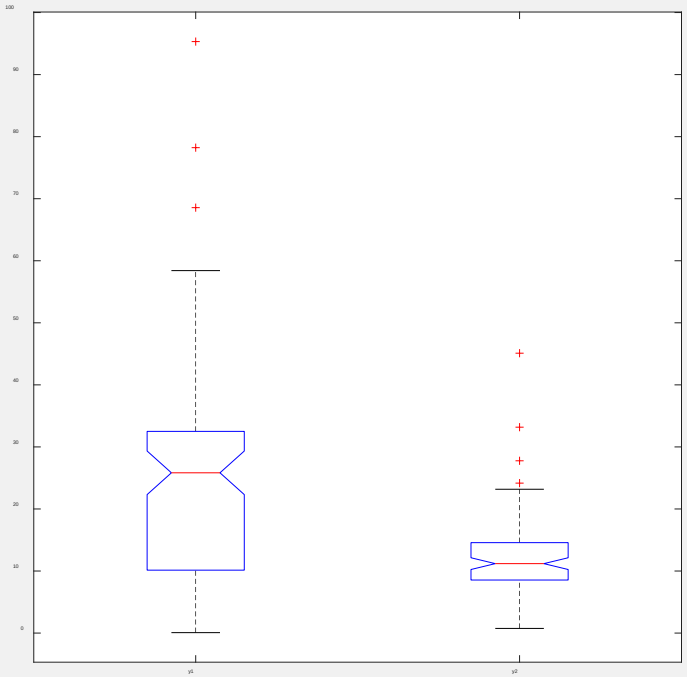
C notch overlap with D notch: C and D may have similar underlying distribution.

Let's go back to our distributions









The notches do not overlap: statistically different distributions?

Use the non-parametric Kruskall-Wallis test the null hypothesis (h_0) that data come from the same distribution:

```
p = kruskalwallis([y1 y2])
p = 6.8029e-09
```

Is there any statistical evidence that y1 is greater than y2??

Wilcoxon rank-signed test returns a *p-value* for the test on

h_0 (null hypothesis): y1 – y2 comes from a distribution with **median = 0.** The alternative hypothesis $h_\varnothing$ is

- **using wilcoxon 2 sided** ==> $h_\varnothing$: y1 – y2 comes from a distribution with **median ≠ 0**

```
p = signrank(y1,y2)
p = 3.2998e-11
```

- **using wilcoxon left sided** ==> $h_\varnothing$: y1 – y2 comes from a distribution with **median < 0**

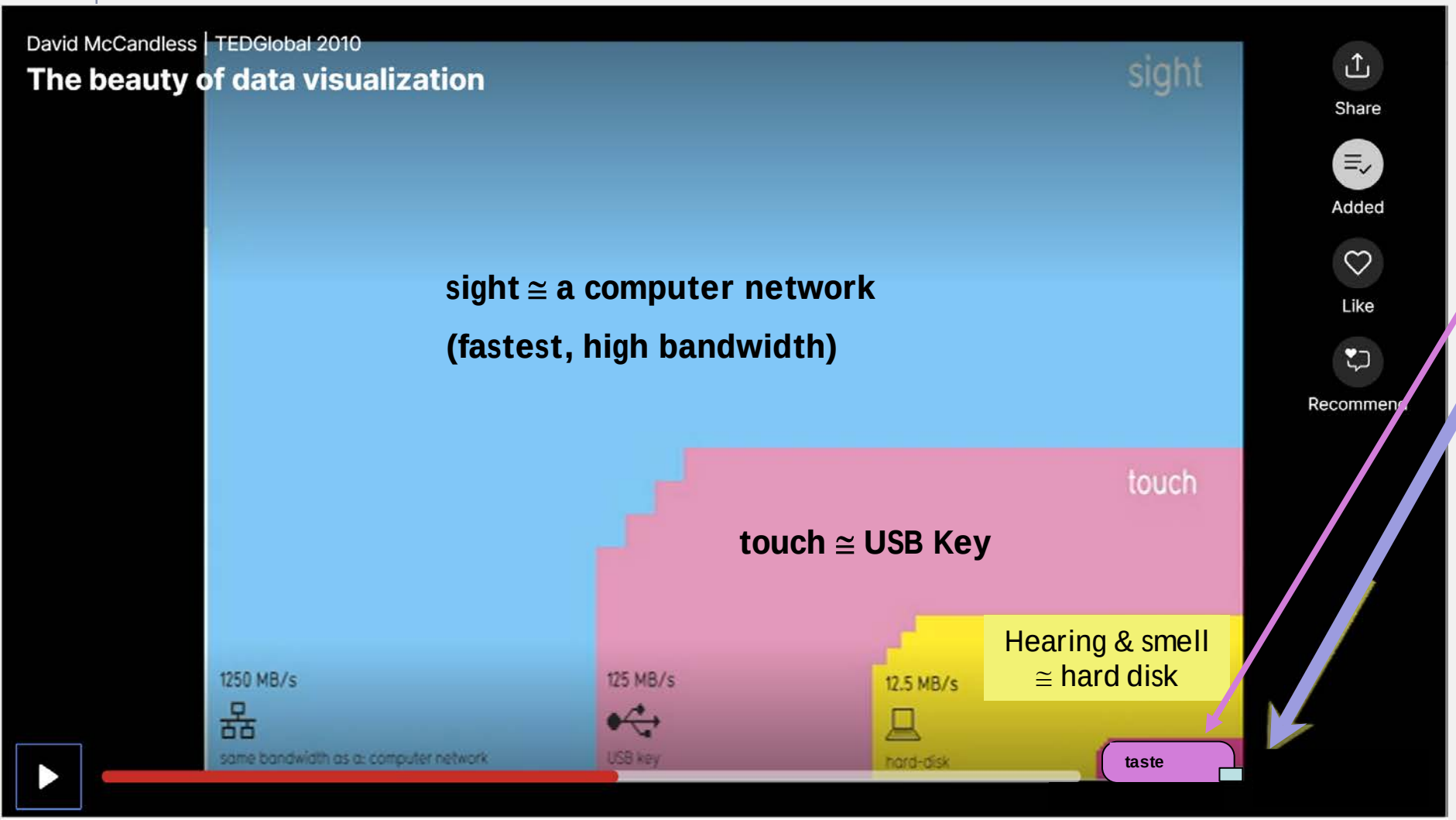
```
p = signrank(y1,y2, 'tail', 'left' )
p = 1
```

- **using wilcoxon right sided** ==> $h_\varnothing$: y1 – y2 comes from a distribution with **median > 0**.

```
[p,h] = signrank(y1,y2, 'tail', 'right')
p = 1.6693e-11
```

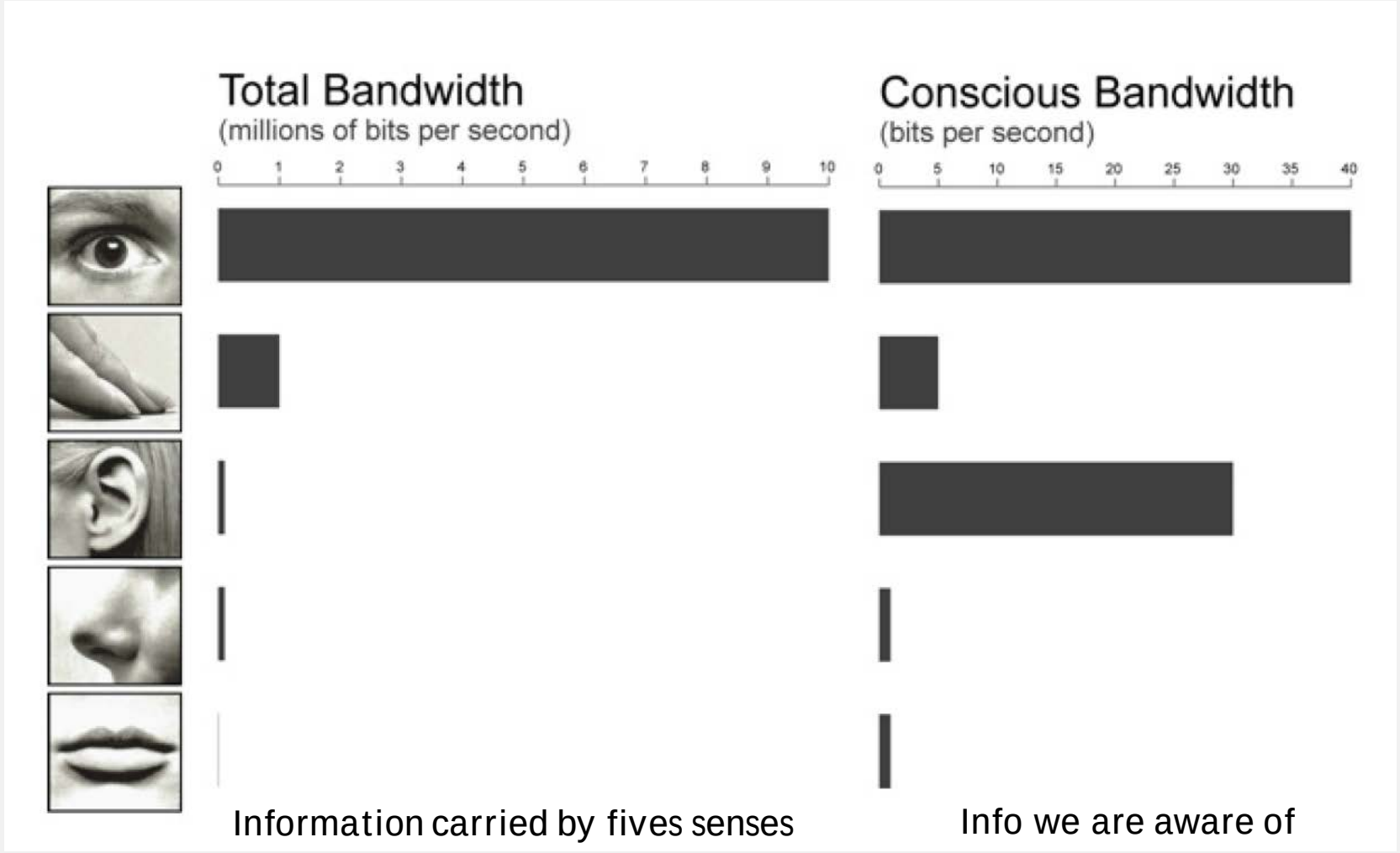
bandwidth of the senses converted into computer terms: amount of info we get from ...

Tor Norretranders



Taste ≅ pocket calculator

0.7% amount of info we are aware of



Snake Oil: scientific evidence for nutritional supplements

https://www.informationisbeautiful.net/visualizations/snake-oil-scientific-evidence-for-nutritional-supplements-vizsweet/

FUNCTION OUTLINES THE SHAPE

Here is an example

Which graph may I use to compare population distribution by age?

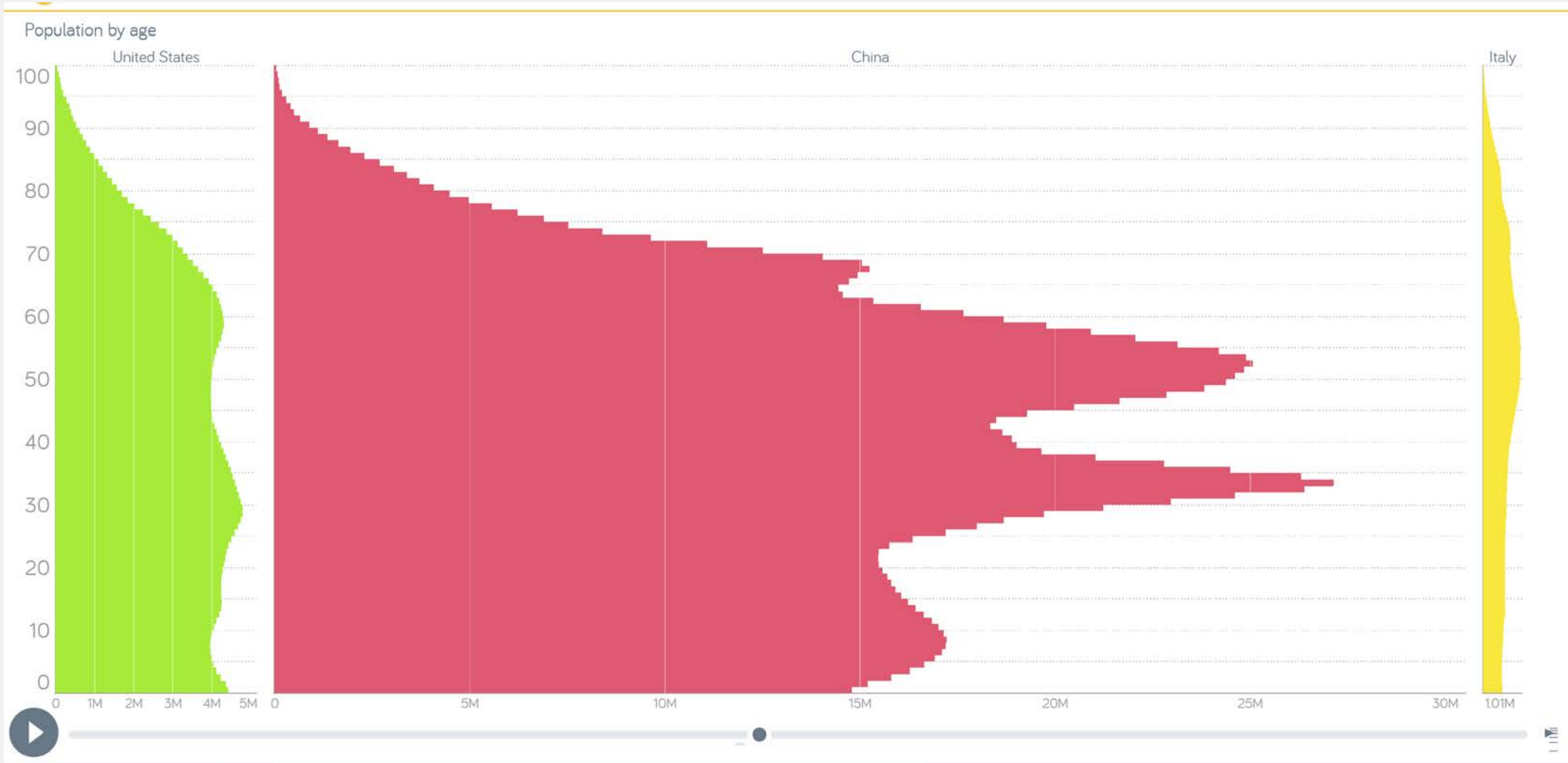
If I had data such as:

Country (C), age (A), sex (S), number of people in C with age A and sex S…

….

…

DataBars example. Distribution of population per age. Gapminder Tools



Visualizing the Titanic Disaster


coolbubble.com
Do you see the dolphin?

Context and color may hide things


coolbubble.com
Do you see the dolphin?

Next lecture:

- How to view categorical data (parallel sets/histograms)
- Data analysis: a sketch