

What is information visualization?

“To show information in a spatial or graphical representation, in order to facilitate comparison, pattern recognition, change detection, and other cognitive aptitudes of our visual system”

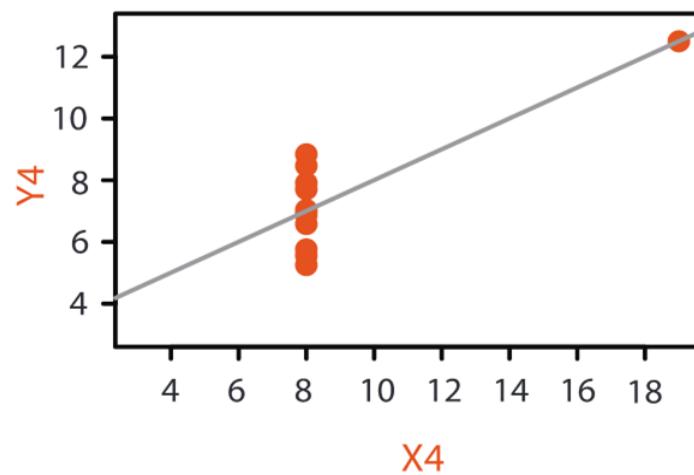
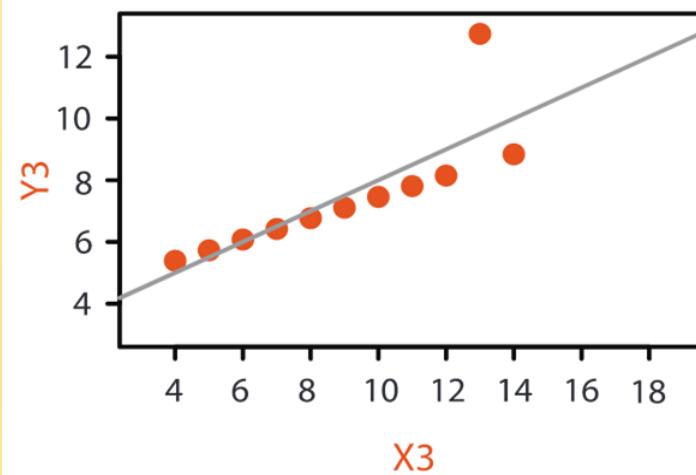
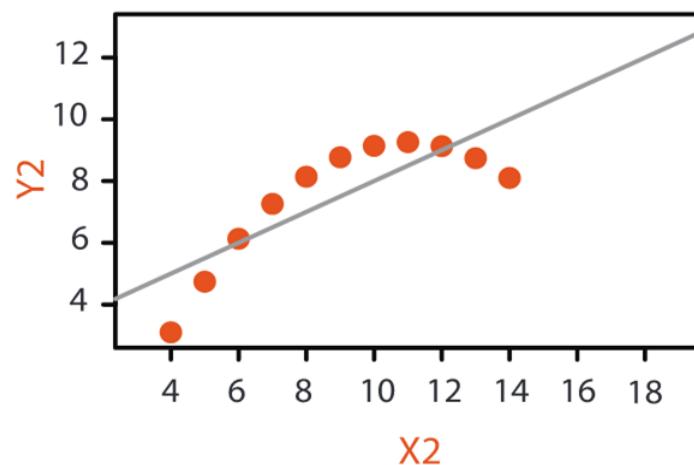
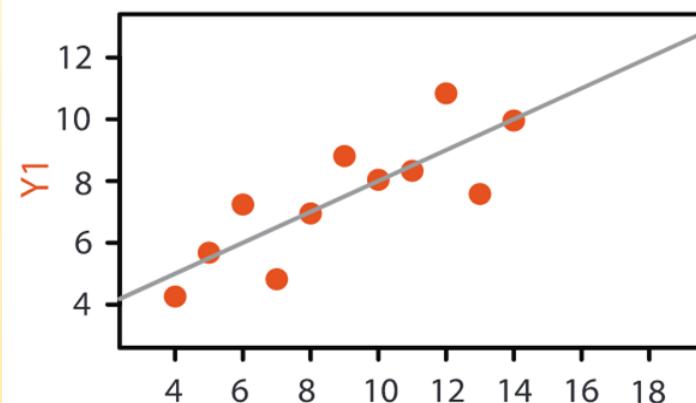
Marti Hearst

Why

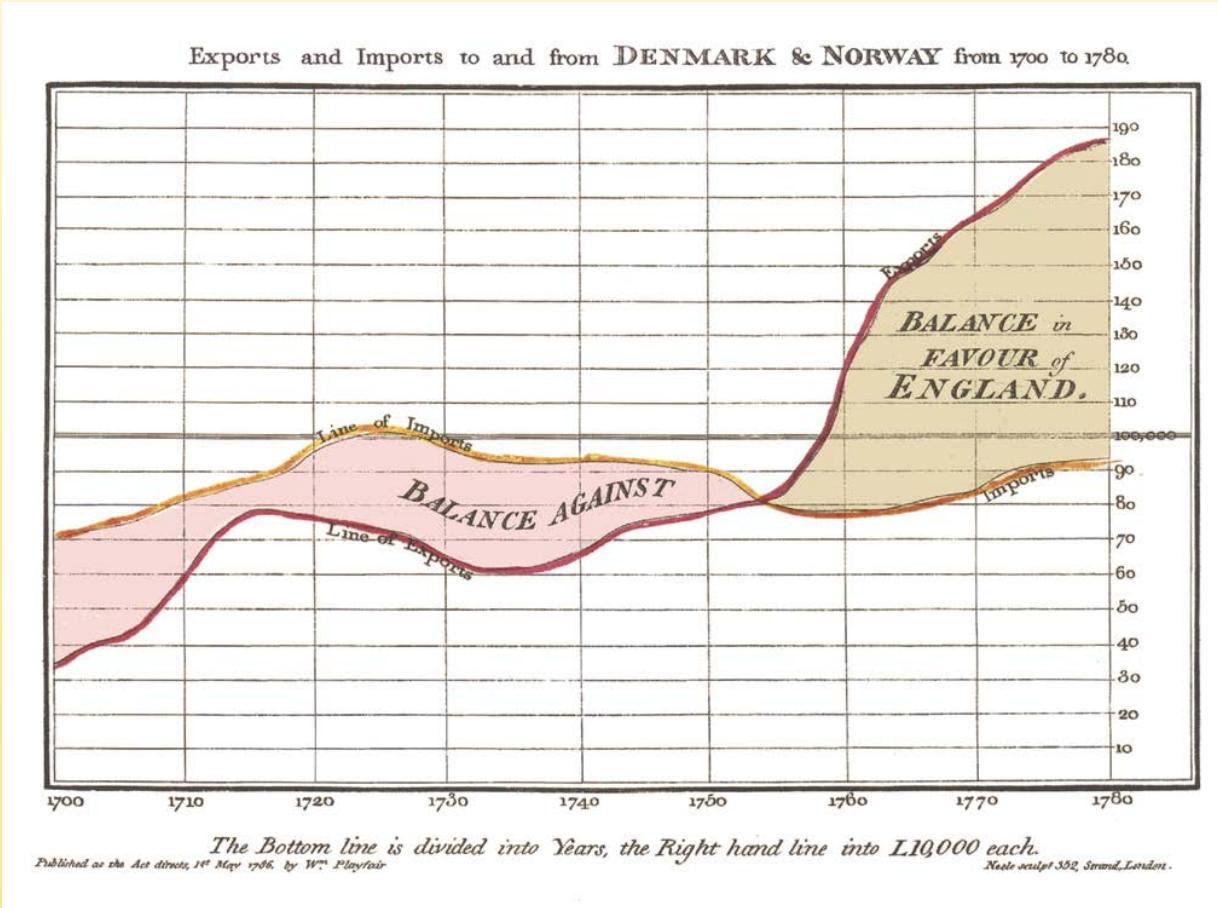
Anscombe's Quartet: Raw Data

	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
	10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
	8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
	13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
	9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
	11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
	14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
	6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
	4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
	12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
	7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
	5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89
Mean	9.0	7.5	9.0	7.5	9.0	7.5	9.0	7.5
Variance	10.0	3.75	10.0	3.75	10.0	3.75	10.0	3.75
Correlation	0.816		0.816		0.816		0.816	

Why

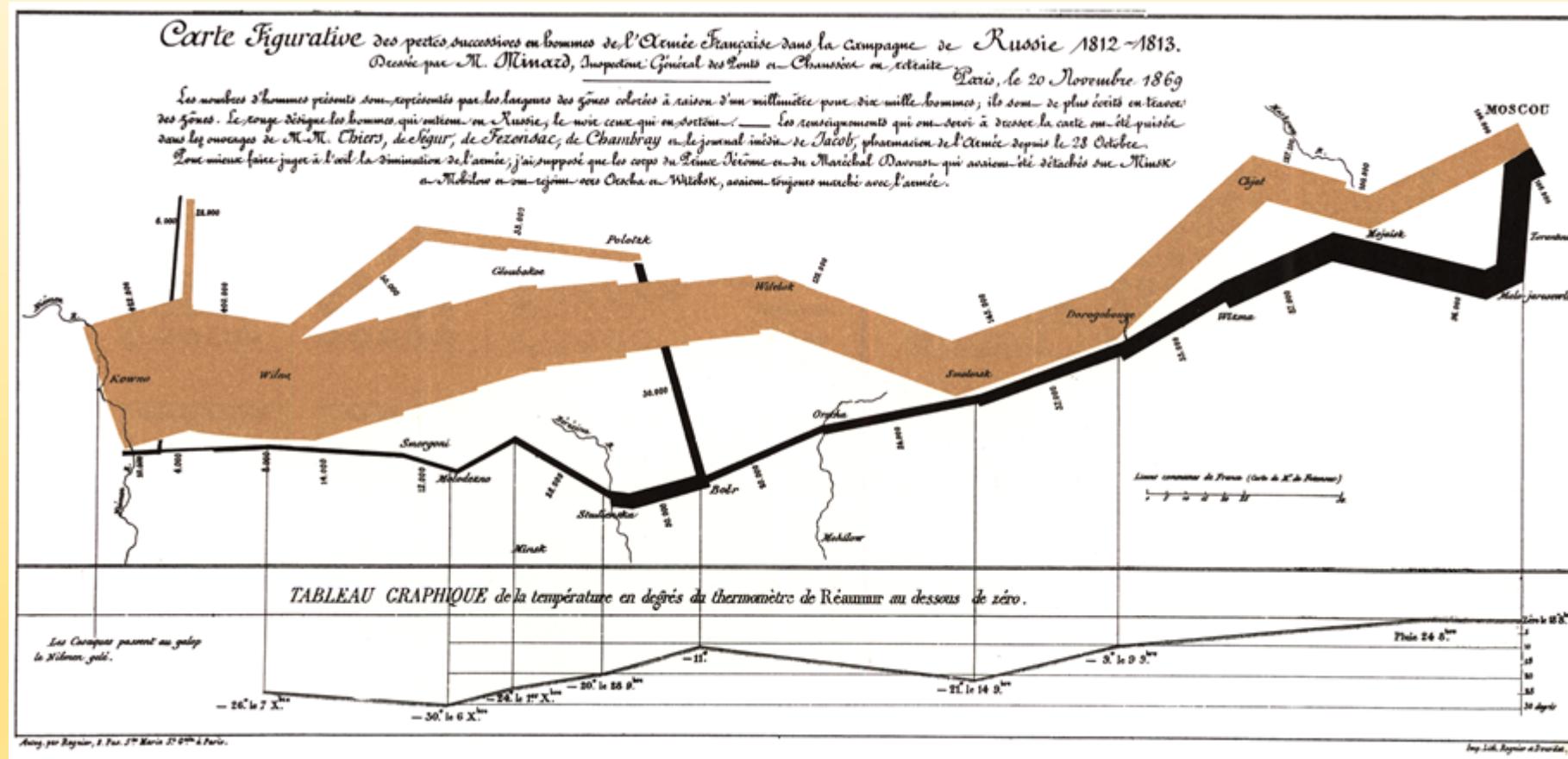


Example 1: William Playfair



Line, bar and pie charts were all invented by William Playfair.

Example 2: Joseph Minard

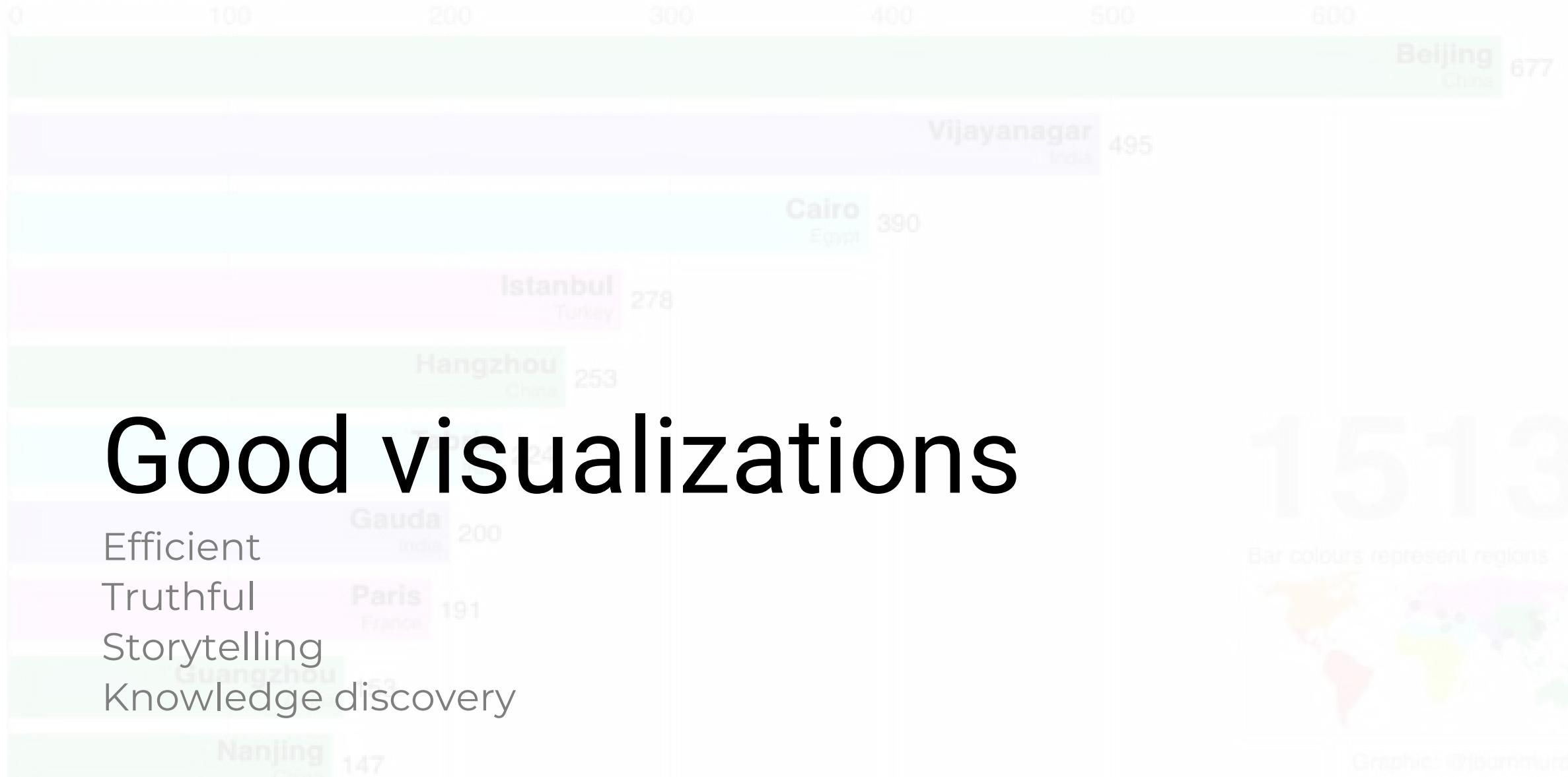


We use information visualization to...

- Communicate
 - Clearly
 - Efficiently
- Facilitate discovery
 - To identify relations
 - To discover patterns
- Help digest the data

The most populous cities in the world from 1500 to 2018

Population (thousands)



Good visualizations

Efficient

Truthful

Storytelling

Knowledge discovery



Bar colours represent regions

Efficient

To **fit** your users **needs**

To require **low effort**

Text: plain language

	Consejo 1: Piense antes de escribirPágina 3
	Consejo 2: Piense en el lectorPágina 4
	Consejo 3: Dé forma a su documentoPágina 5
	Consejo 4: Sea breve y concisoPágina 6
	Consejo 5: Dé sentido a sus frases ordenándolas correctamentePágina 7
	Consejo 6: Reduzca el número de sustantivos: las formas verbales dan fluidez al textoPágina 8
	Consejo 7: Utilice más activas que pasivas y no indique el sujeto si no es precisoPágina 9
	Consejo 8: Sea concreto, no abstractoPágina 10
	Consejo 9: Cuidado con los falsos amigos, las jergas y las siglas y abreviaturasPágina 11
	Consejo 10: Revise y compruebe lo que haya escritoPágina 14

Numbers – Precision (1)

Use only the **number of digits which are necessary and make sense** for the purpose of a clear communication

Rounding of numbers should take place at the latest phase of data processing and analysis.

- Tables with percentages: general rule is to **round to one decimal**
- For tables with absolute numbers, identify **the smallest number**, decide **how many digits to keep** for this number and then round all other entries to those digits

Numbers - Precision(2)

- For target indicators always use the full precision of the indicator to assess whether the target has been met. The rounding should not change the situation
- Big numbers are difficult to grasp. It may be reasonable to round them and use the words millions, billions, etc.

Example of rounding

GEO/TIME	1970
Belgium	9660154
Germany (until 1990 former territory of the FRG)	61194591
France	:
Italy	53685300
Luxembourg	338500
Netherlands	12957621

Before

Member State	Population in 1970
BE	9 660 000
DE	61 190 000
FR	:
IT	53 690 000
LU	340 000
NL	12 960 000

After

Tables



Less
is **more**
(effective)

See the bar chart, pie chart, and choropleth maps versions as well

Truthful

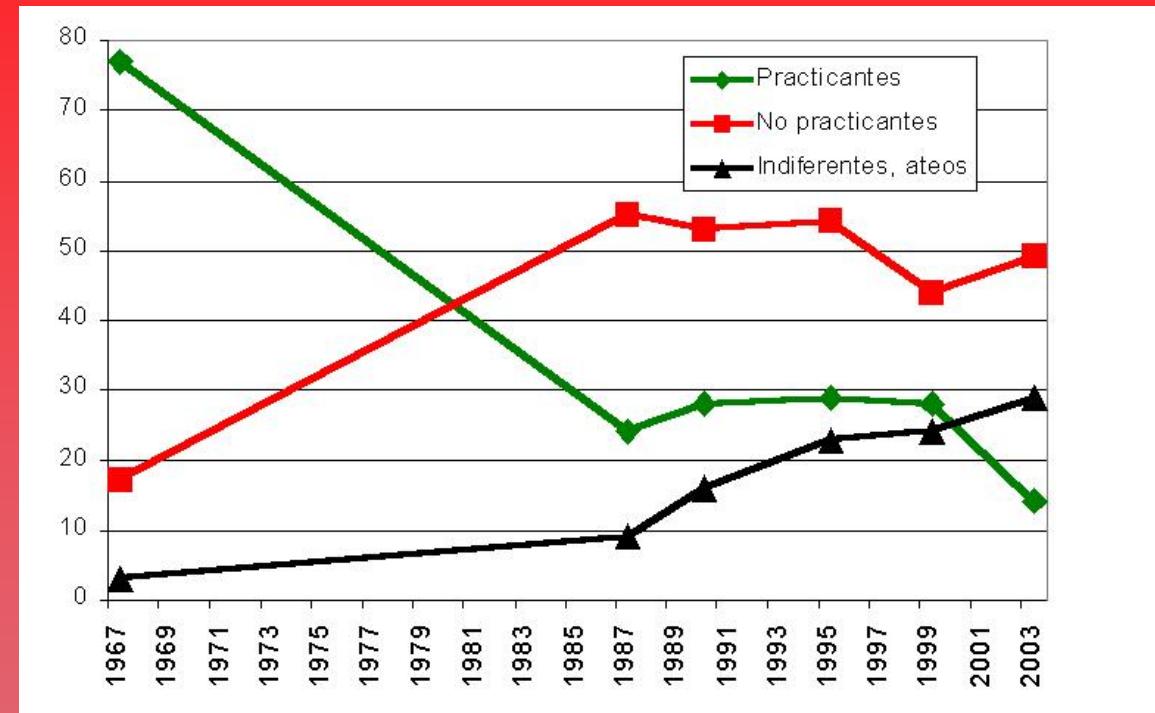
To communicate **clearly** you must avoid some misleading practices

Misleading practices

Scales are not regular

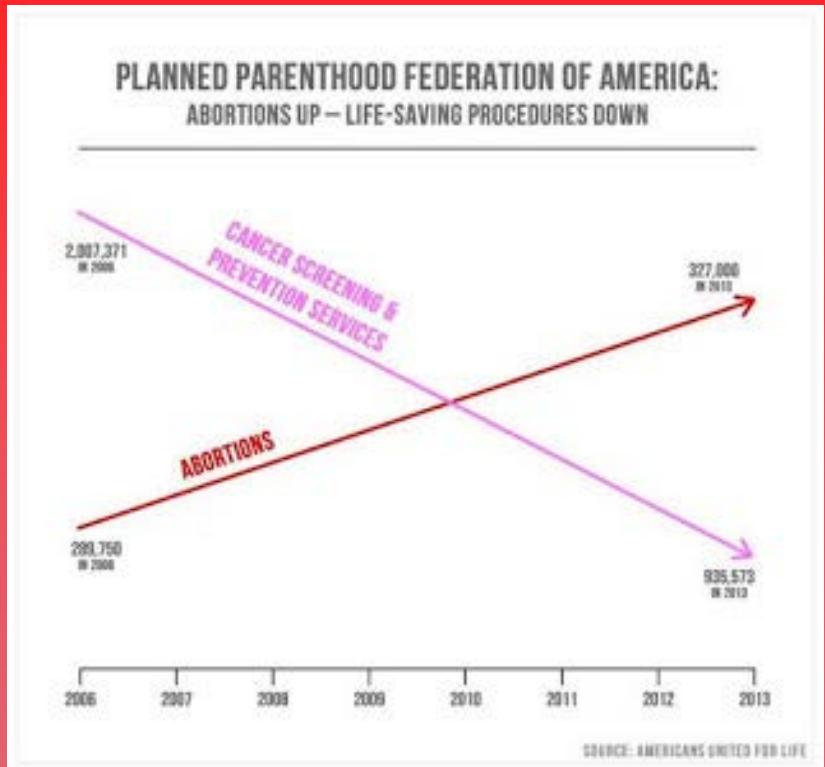


Before

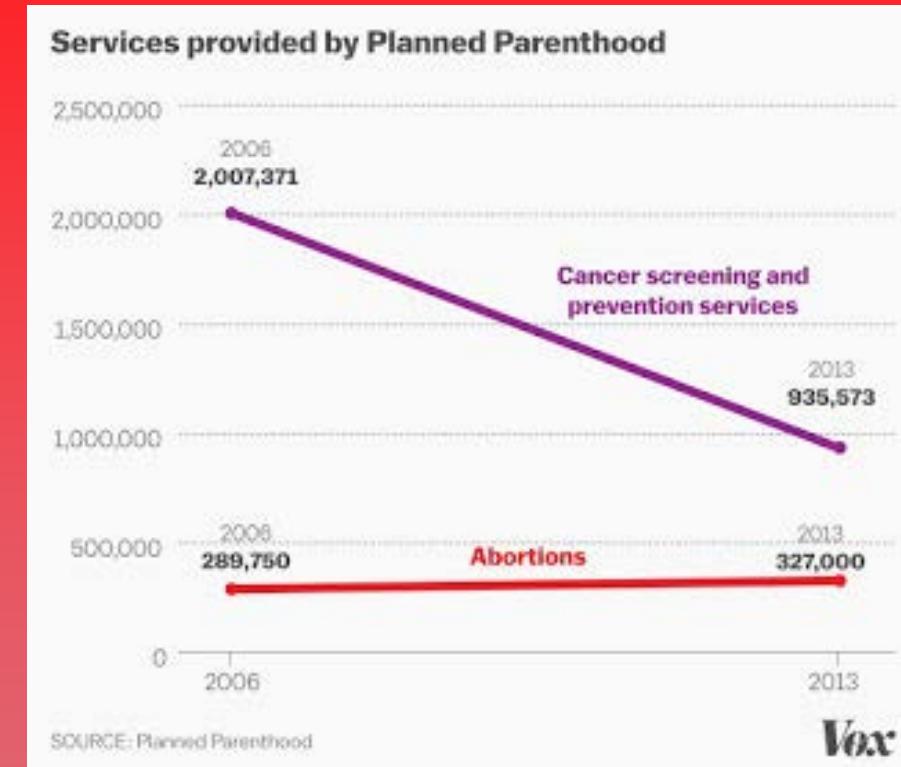


After

Dual axes

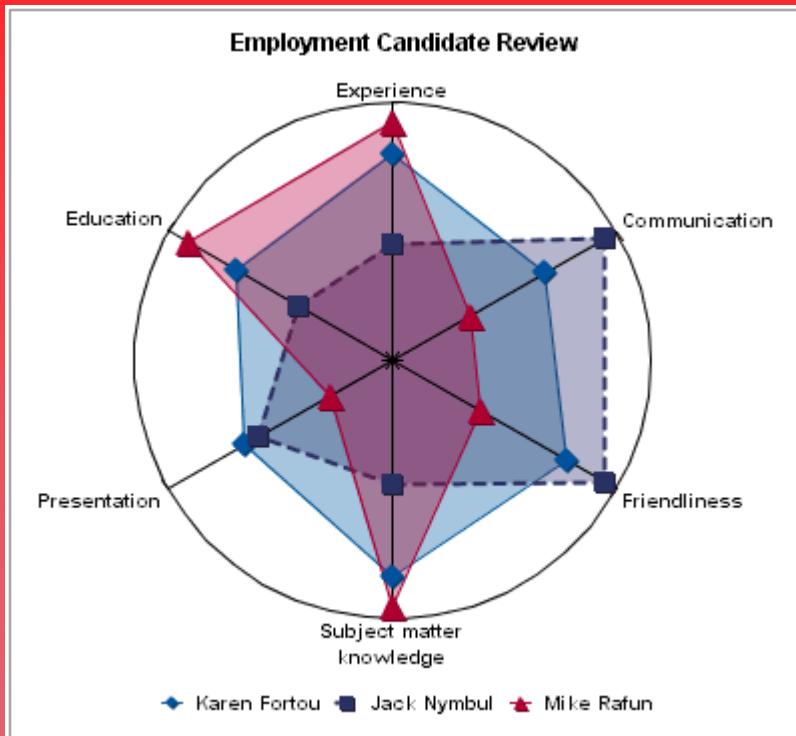


Before

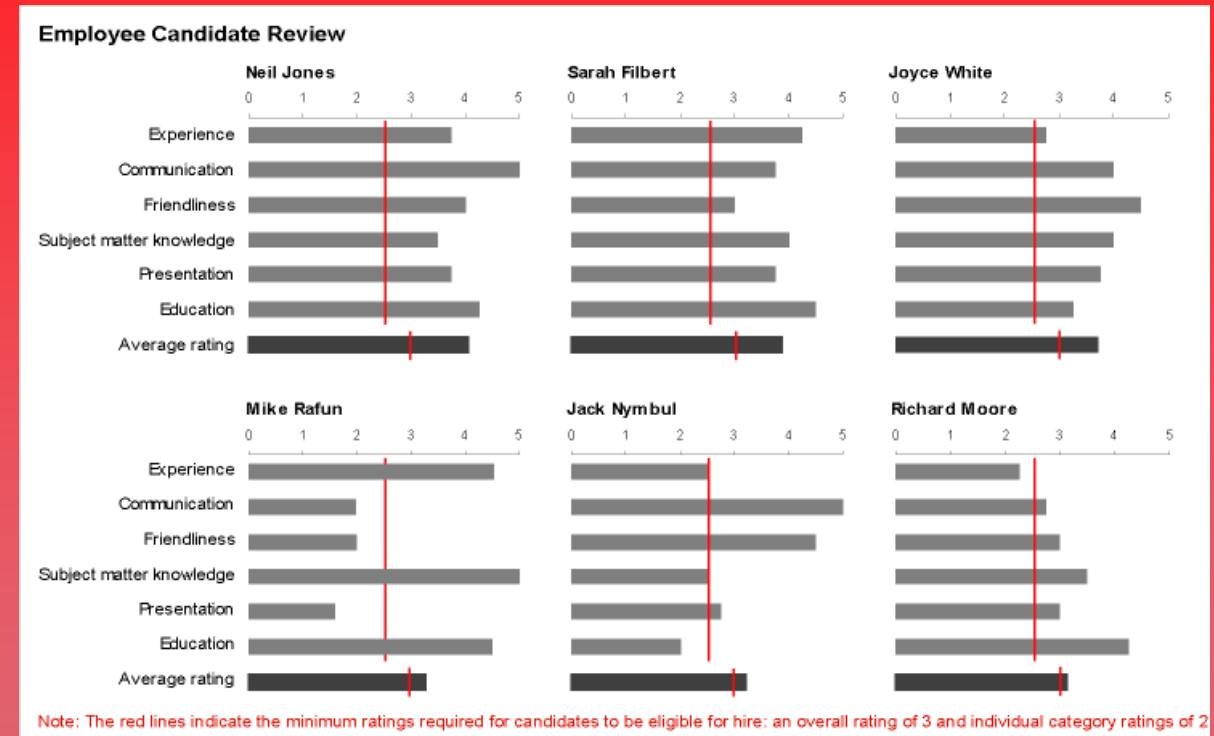


After

Use the appropriate chart

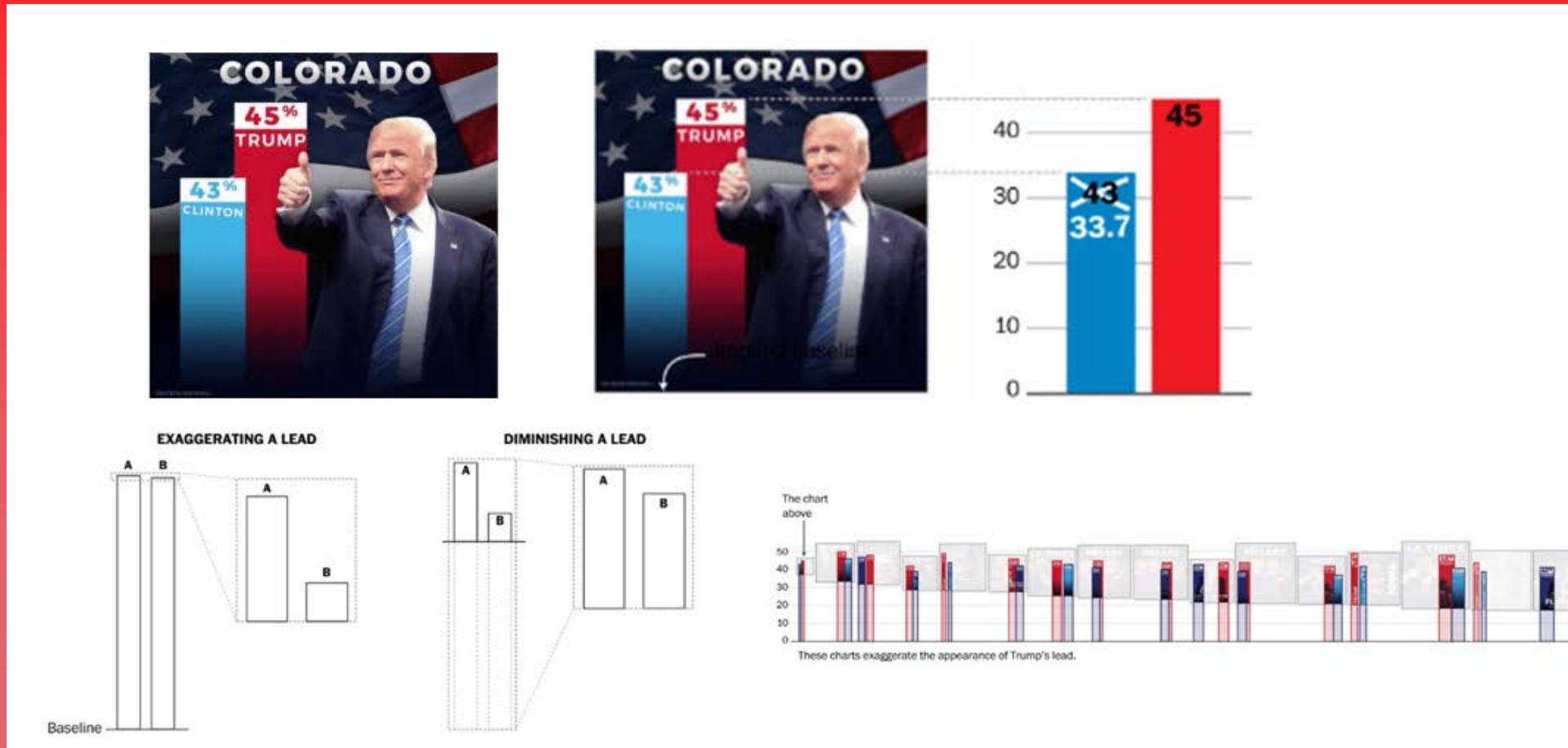


Before

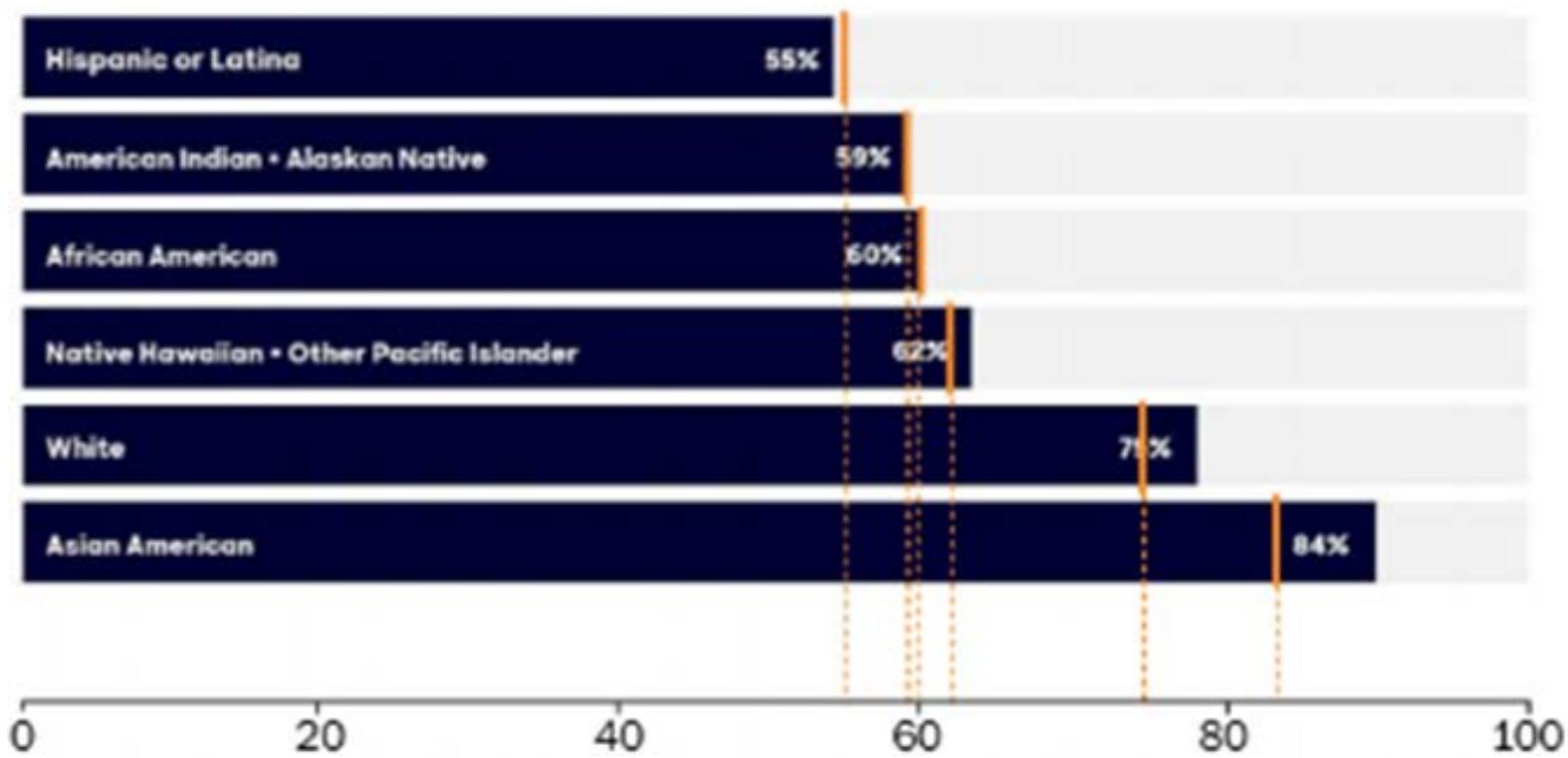


After

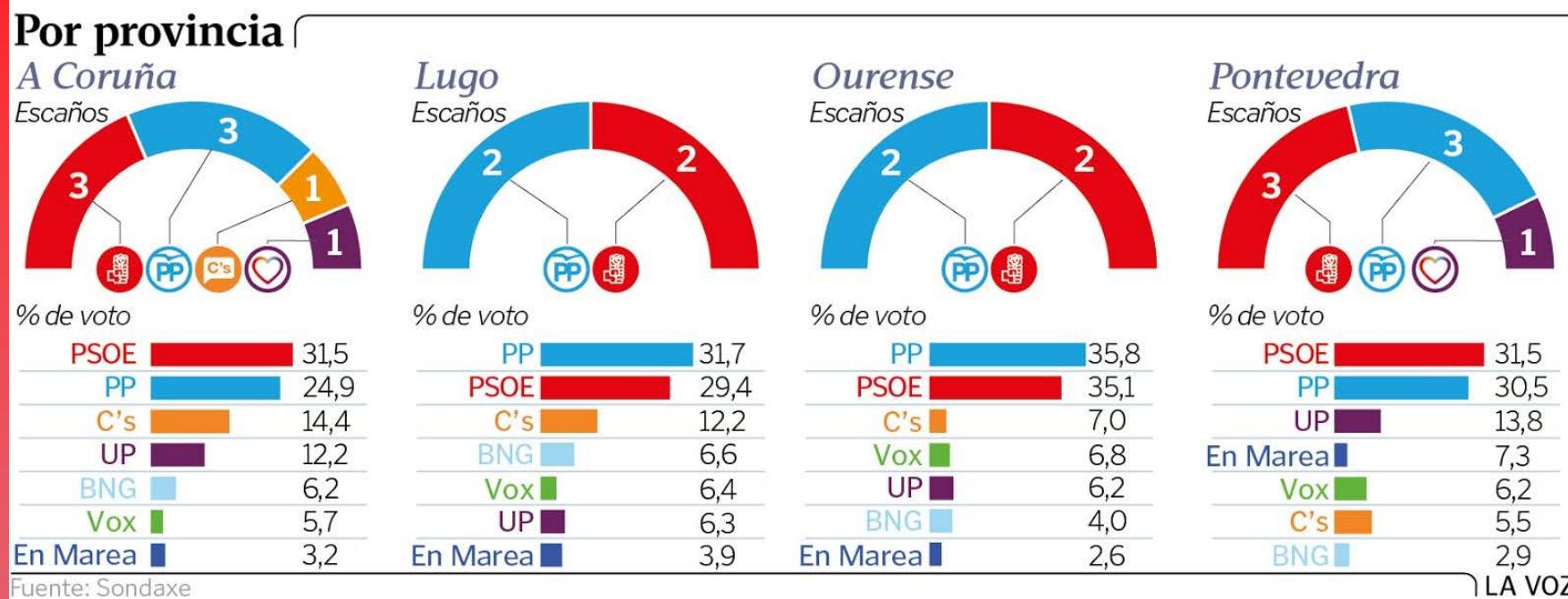
Bar charts length. Always start at 0



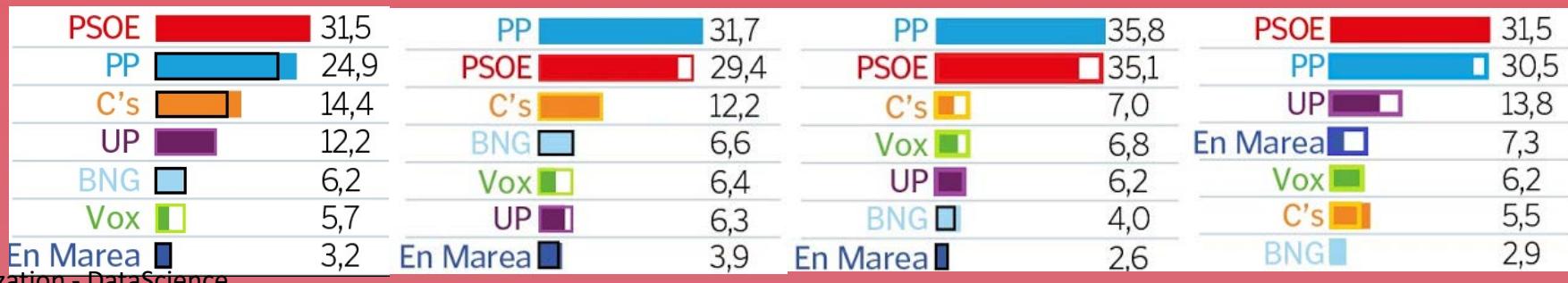
Use scales wisely (1)



Use scales wisely (2)

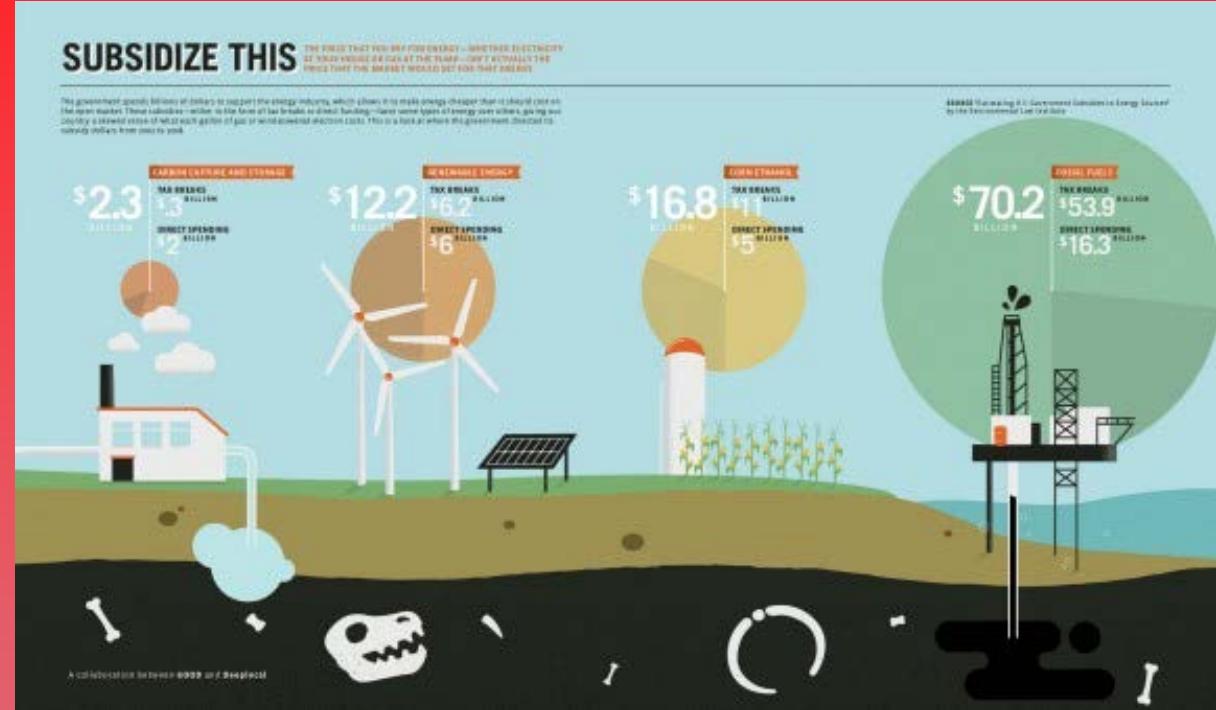
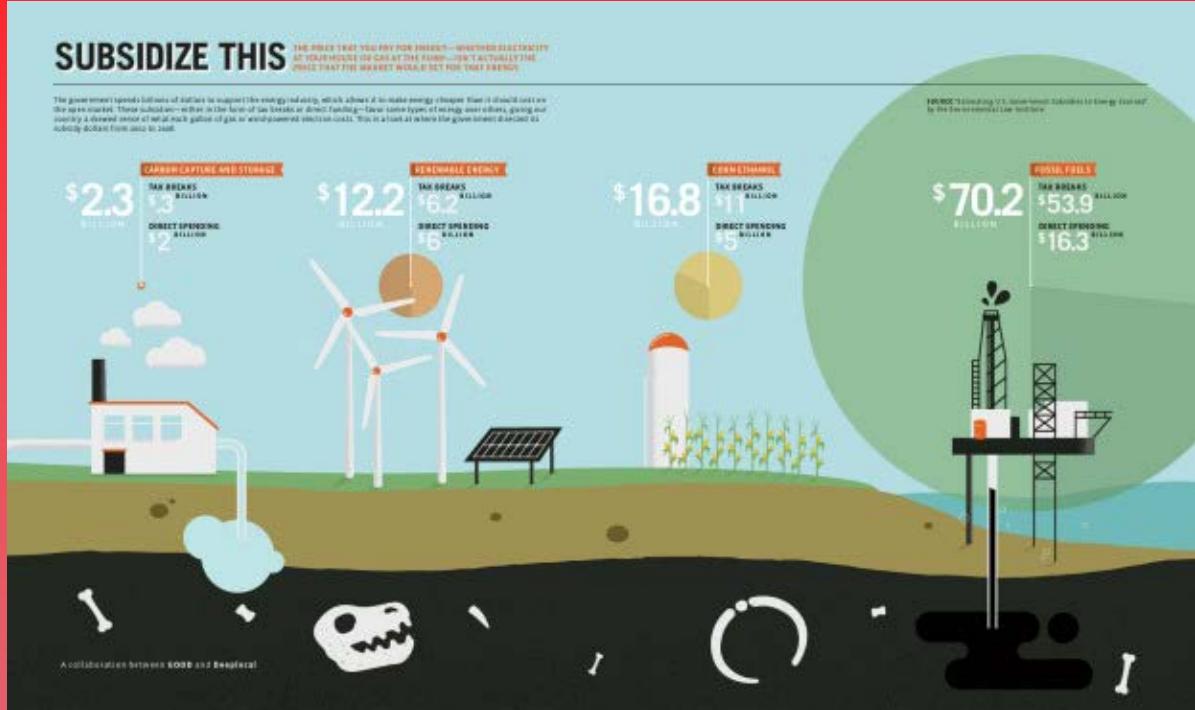


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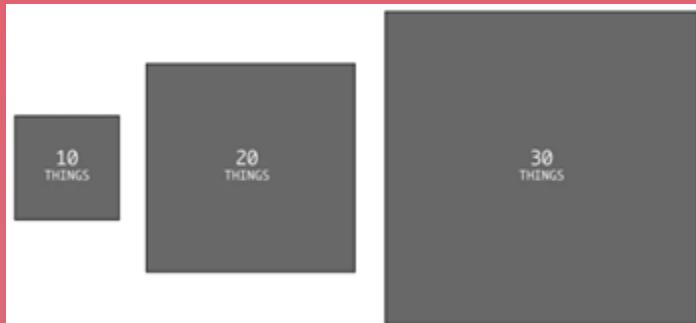


After

Area vs diameter, be careful!

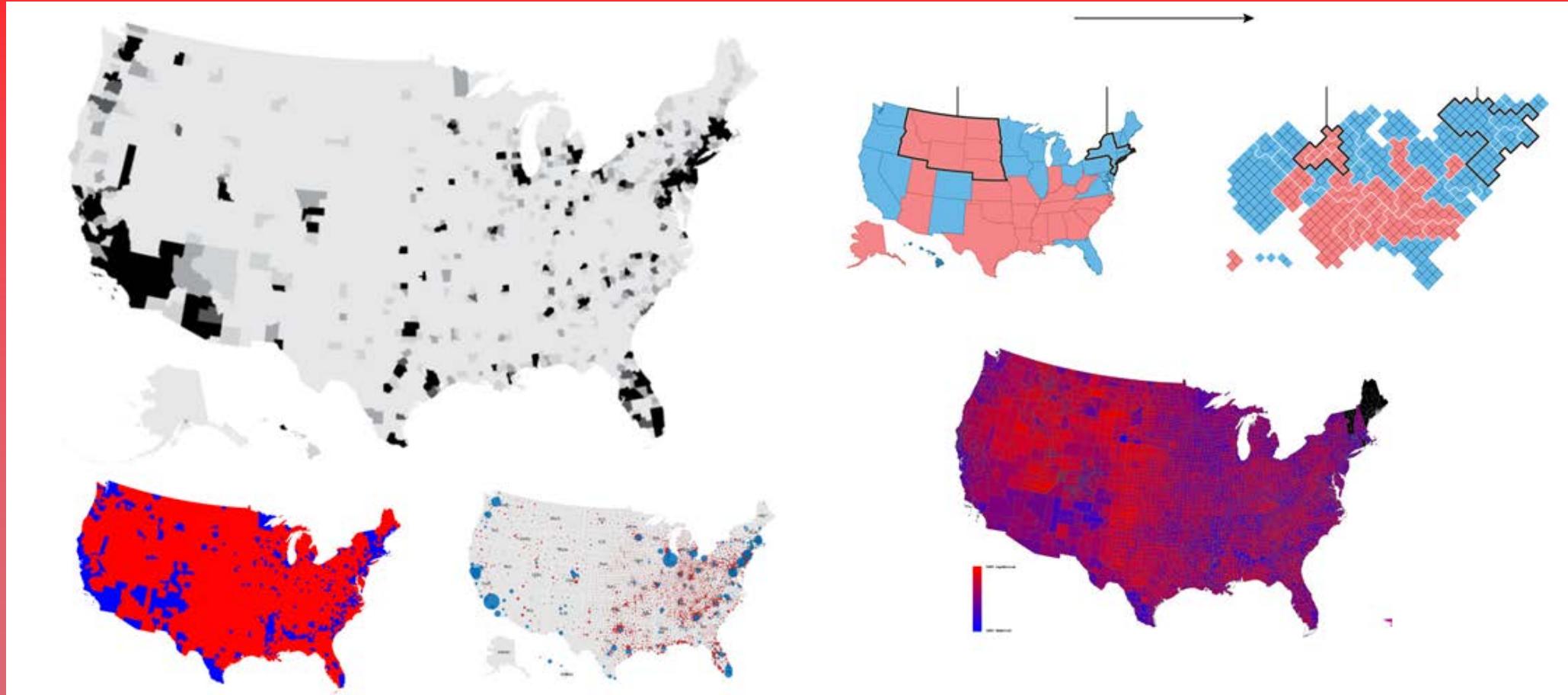


Before

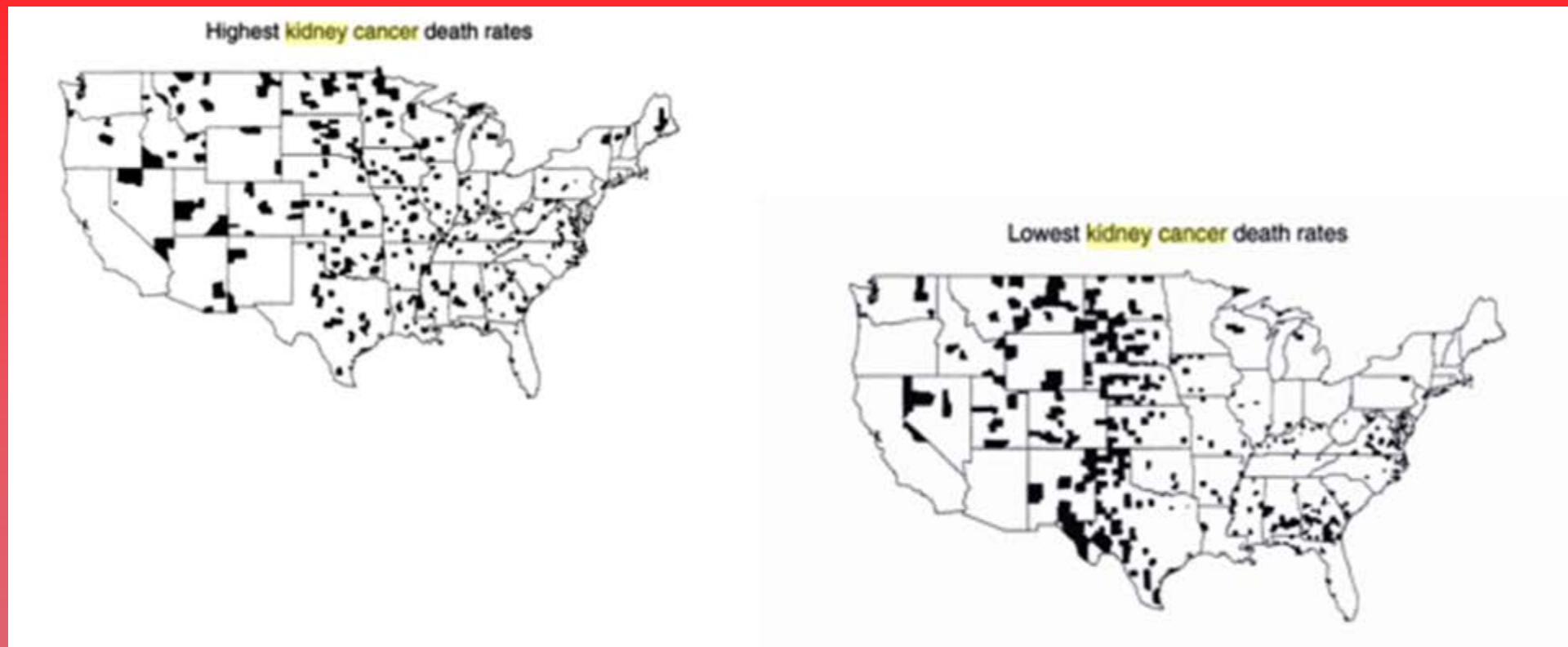


After

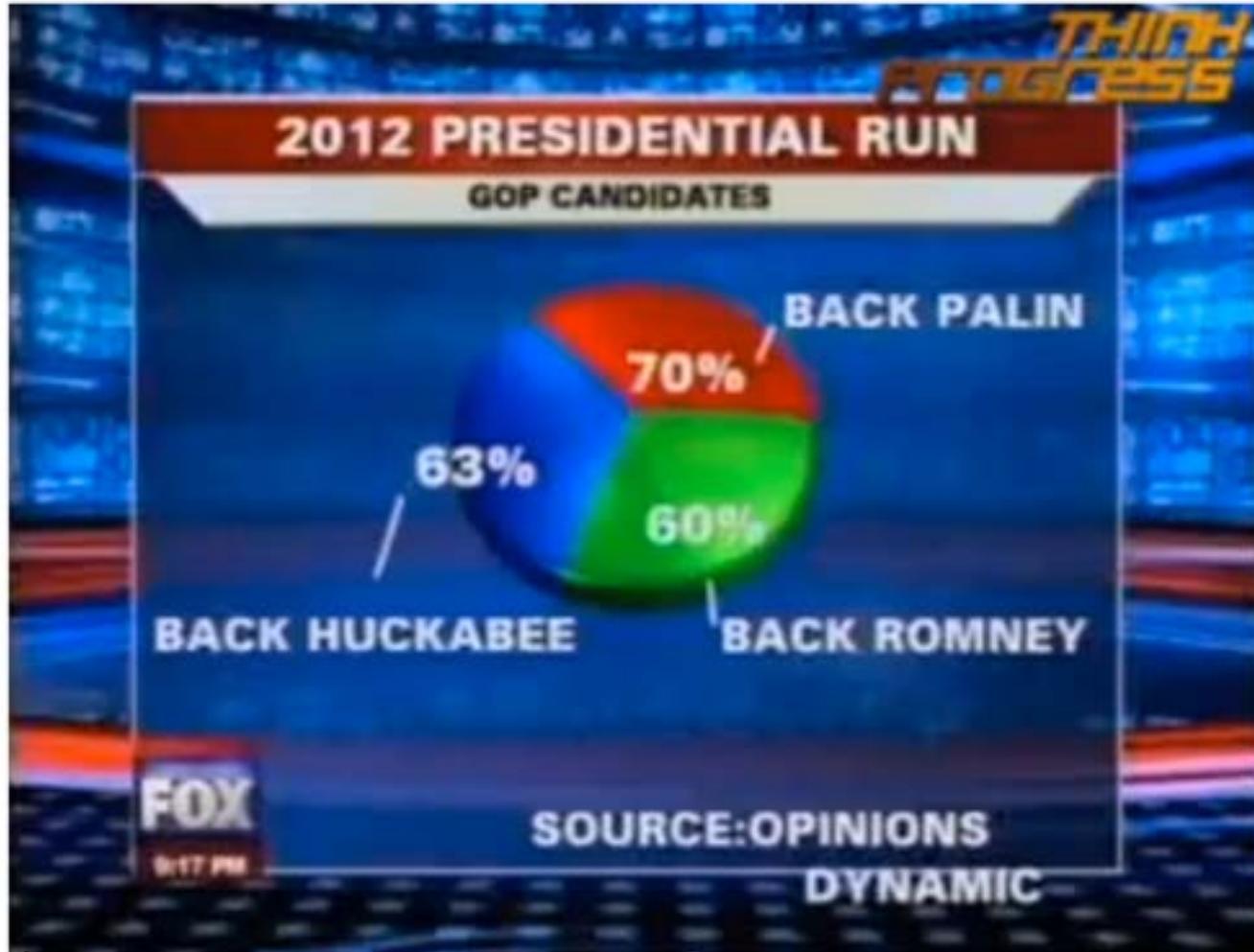
Don't oversimplify with aggregation



Small size effect



Basic arithmetic. Follow conventions

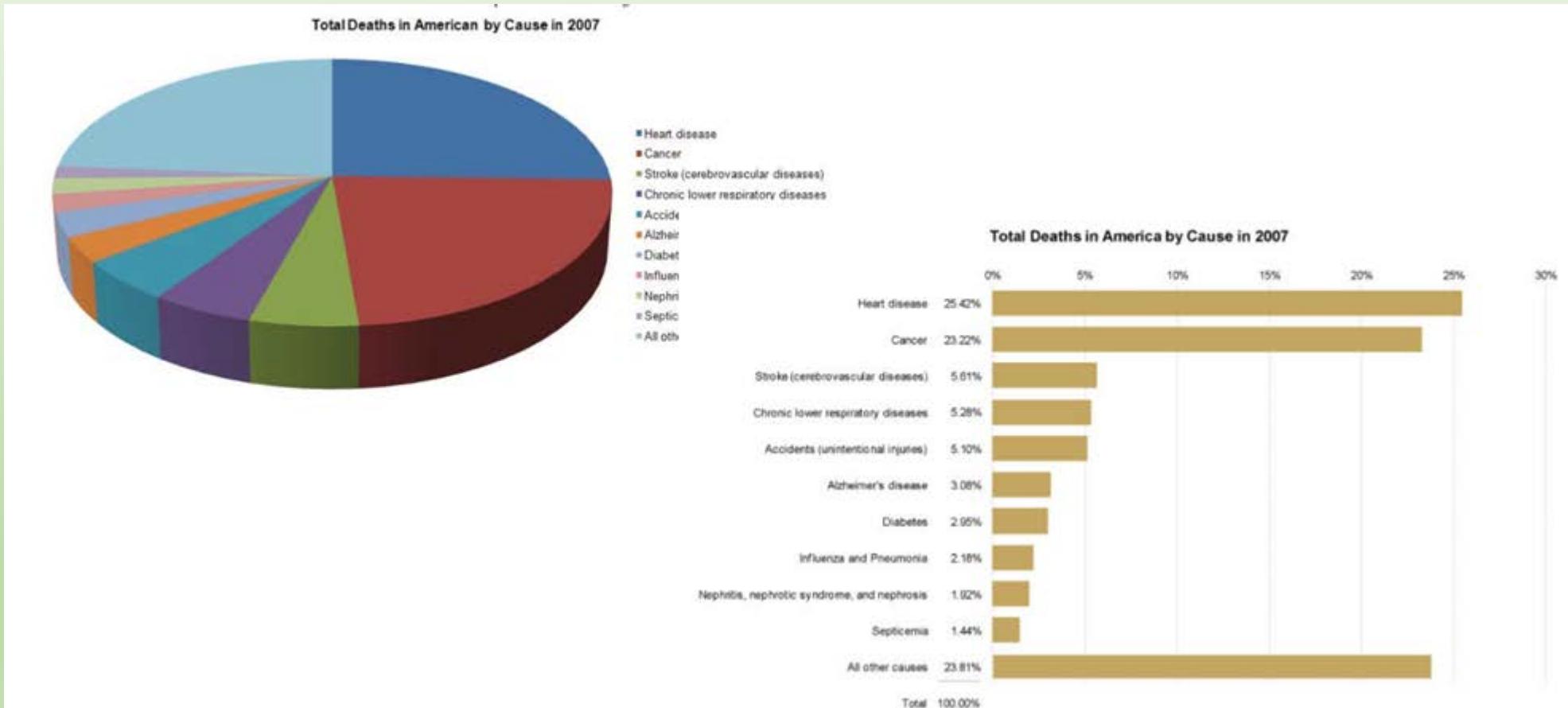


Truthful

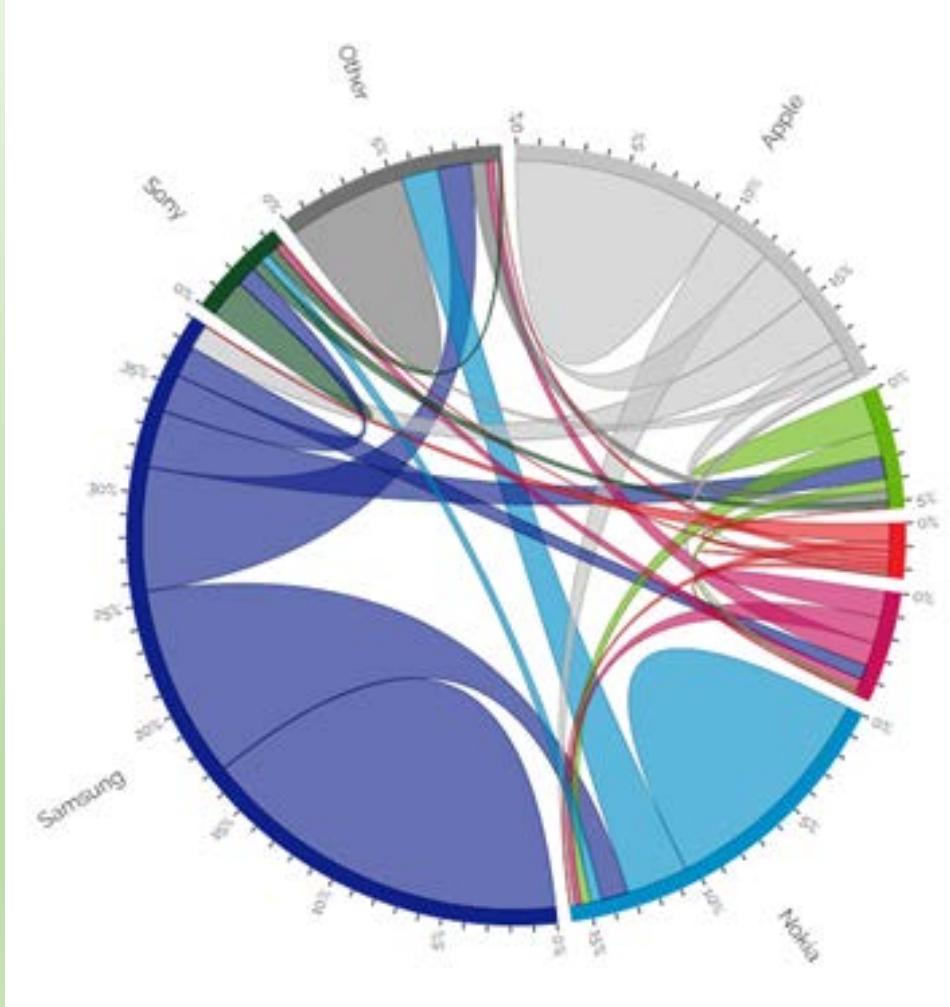
To communicate **clearly** you must follow some best practices

Best practices

Use the appropriate chart



Offer clear legends: title, key to encodings, axes



You may even [offer a tutorial](#), if the type of chart is not usual.

Tell uncertainty if it is relevant



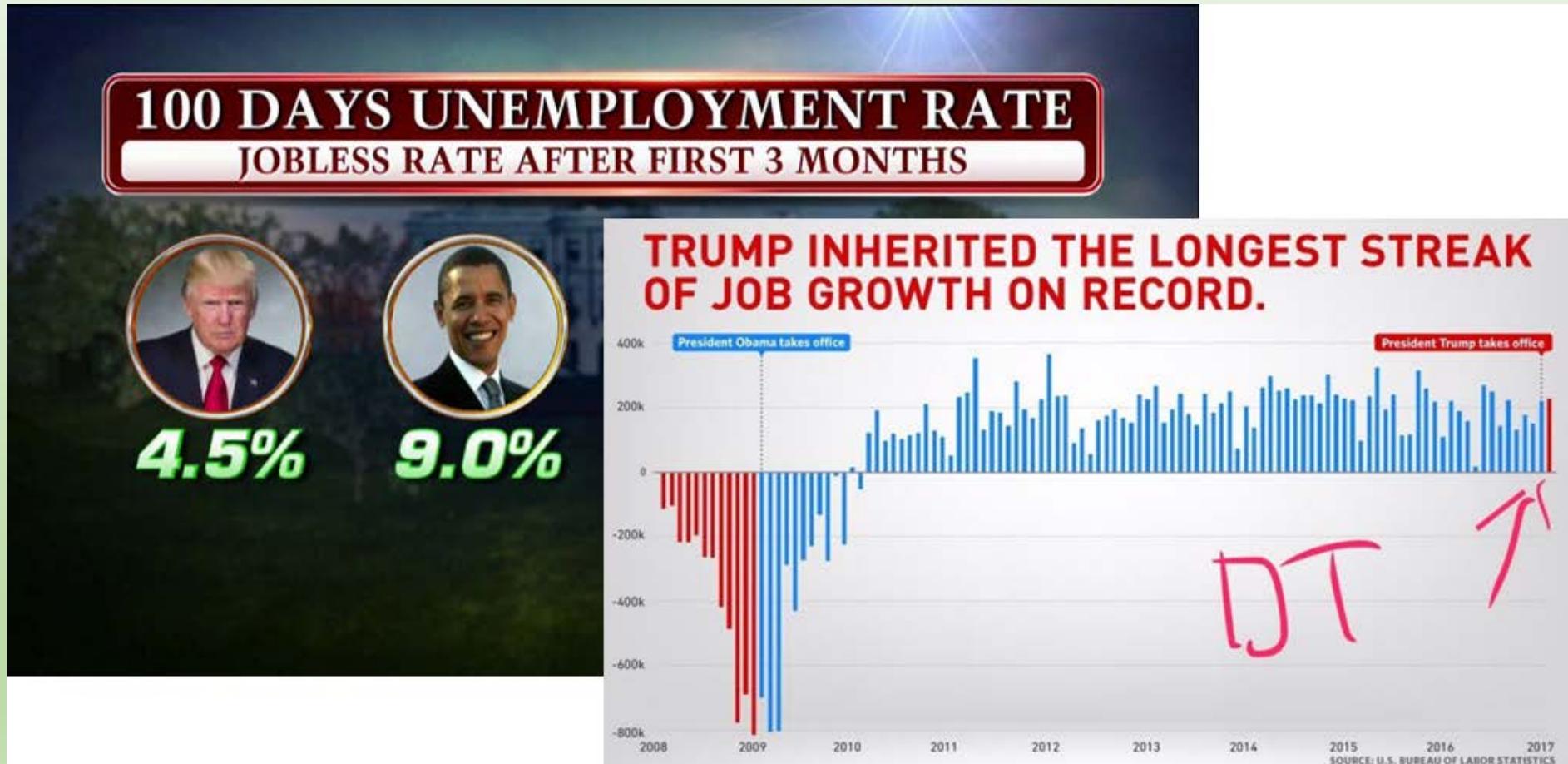
How do you interpret this graph?

Which areas will be affected by the hurricane?

Disclose the **origin** of your data

- Readers should be able to go to the facts behind your chart and check them
- Tell your sources
- Link to them if possible

Give context to your data



Ethics

- Become aware from your own biases
- Don't twist facts to fit your agenda
- Don't share before checking



Storytelling

Engage your users in your message

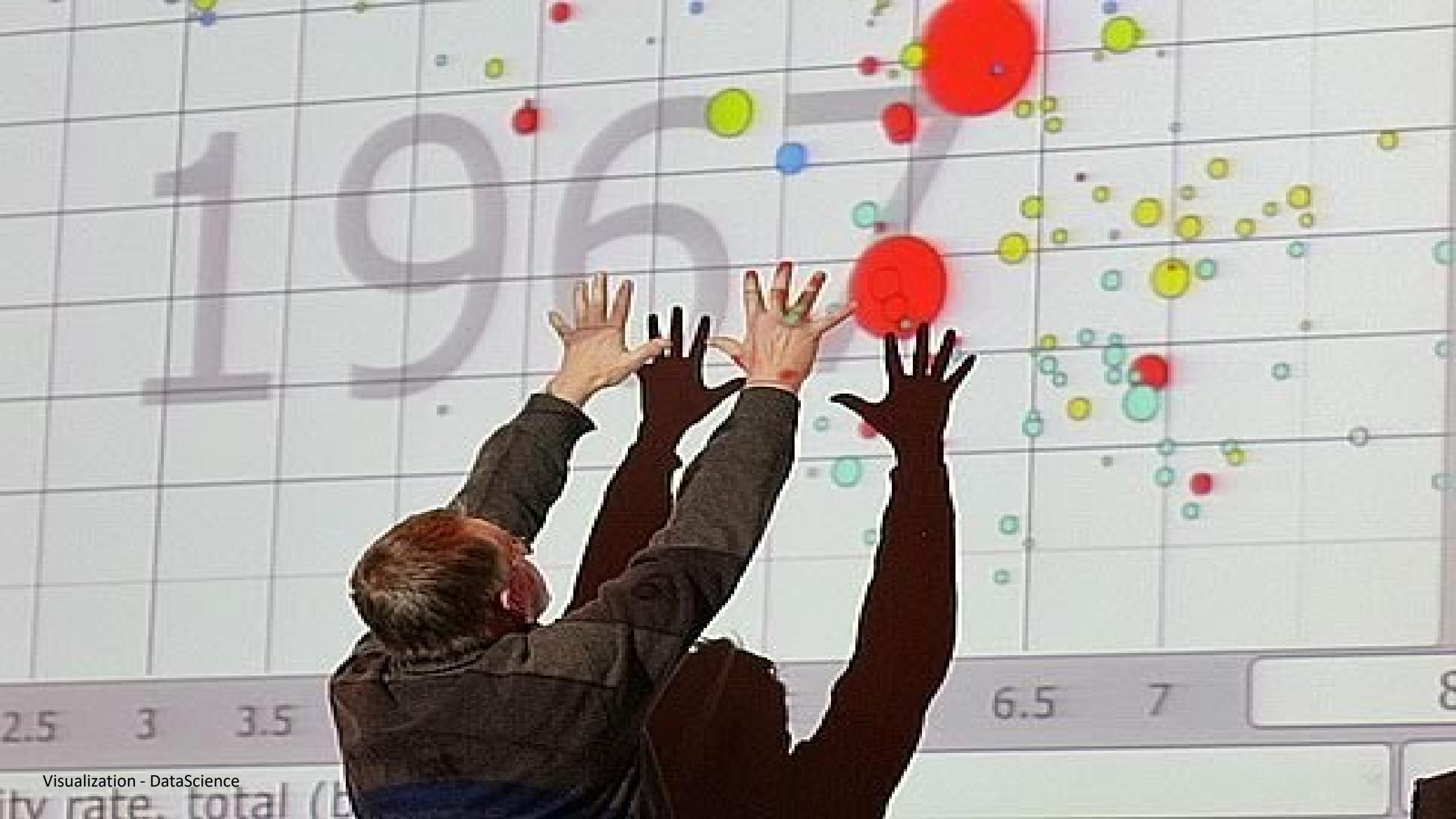


Engagement

Memorability

Emotional
connection

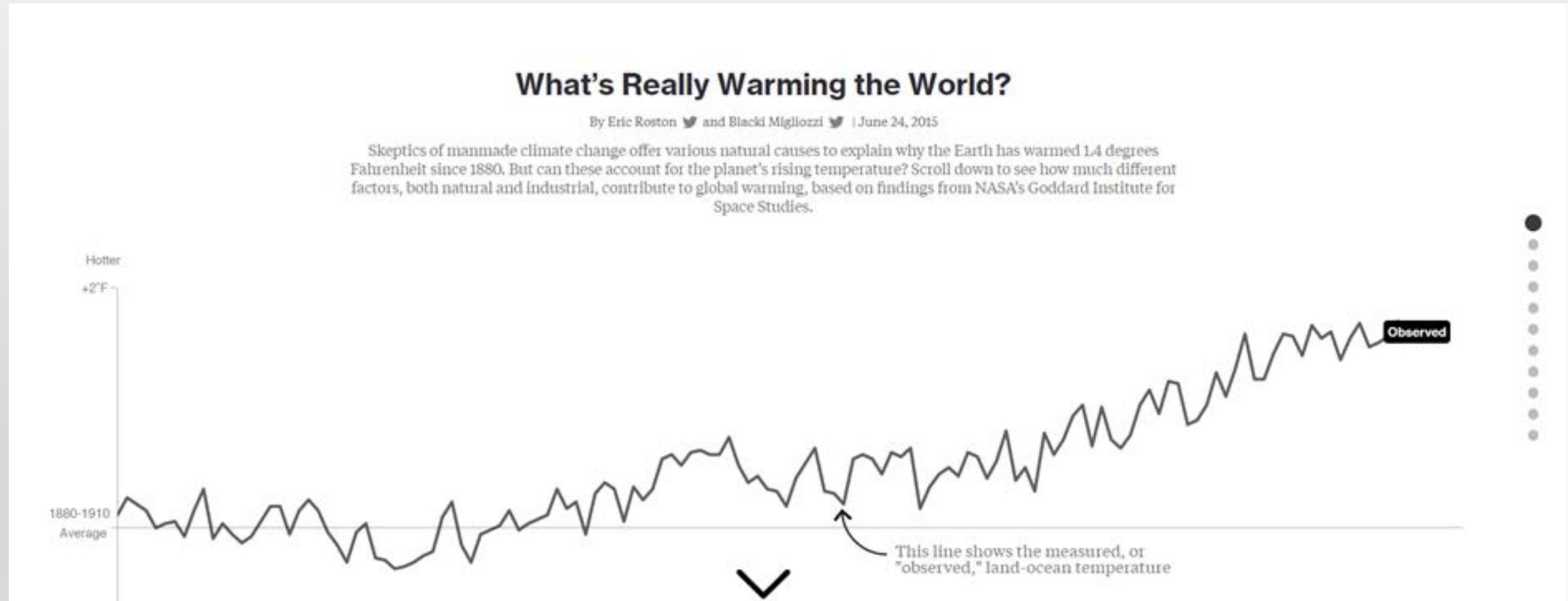
Storytelling goes beyond data understanding



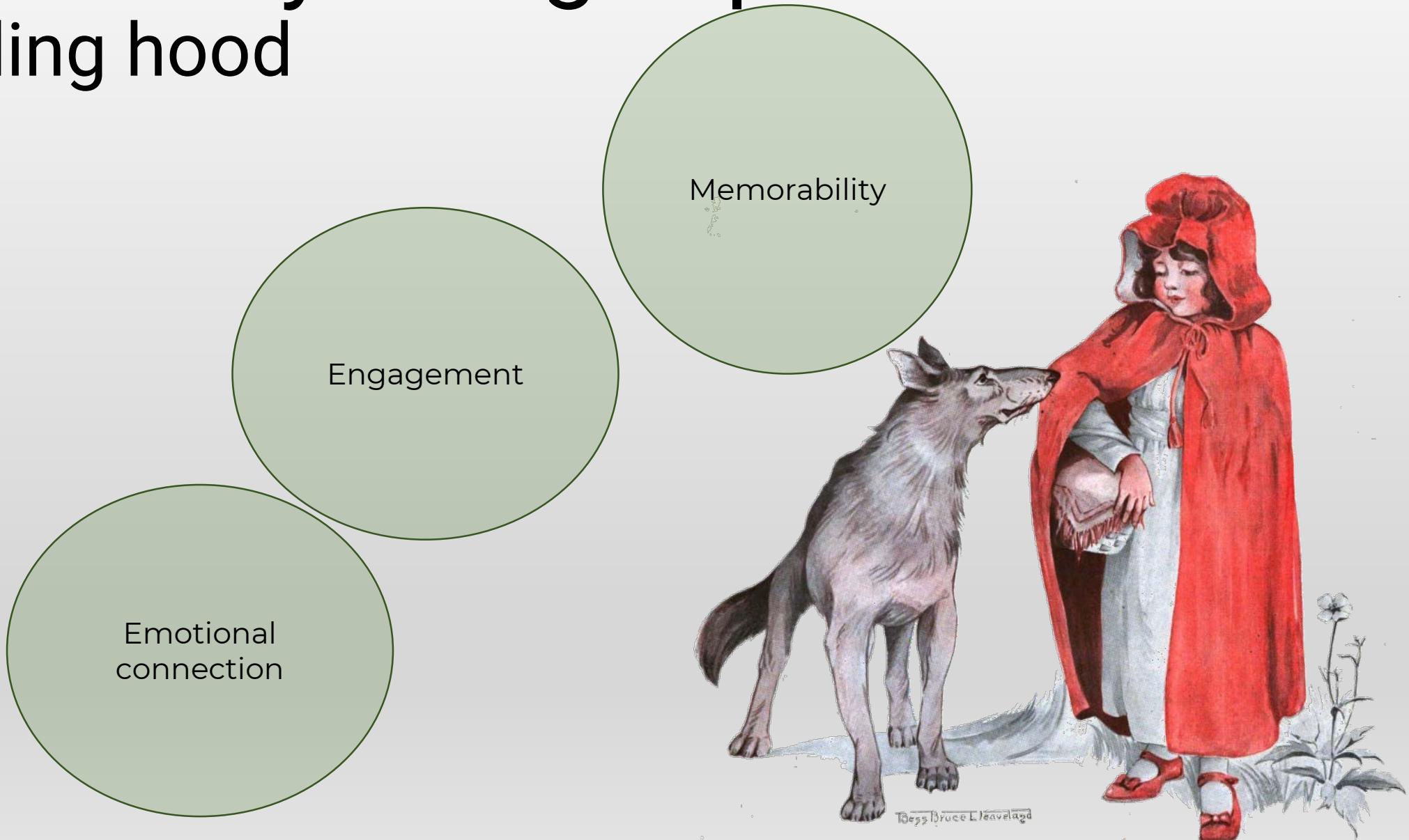
Wonders of storytelling

- Remembering is easy with a story
- Magic from Plot-Twist-End: data are stories
- Captivation, emotionally engage
- Takes you on a journey, you don't want to turn away

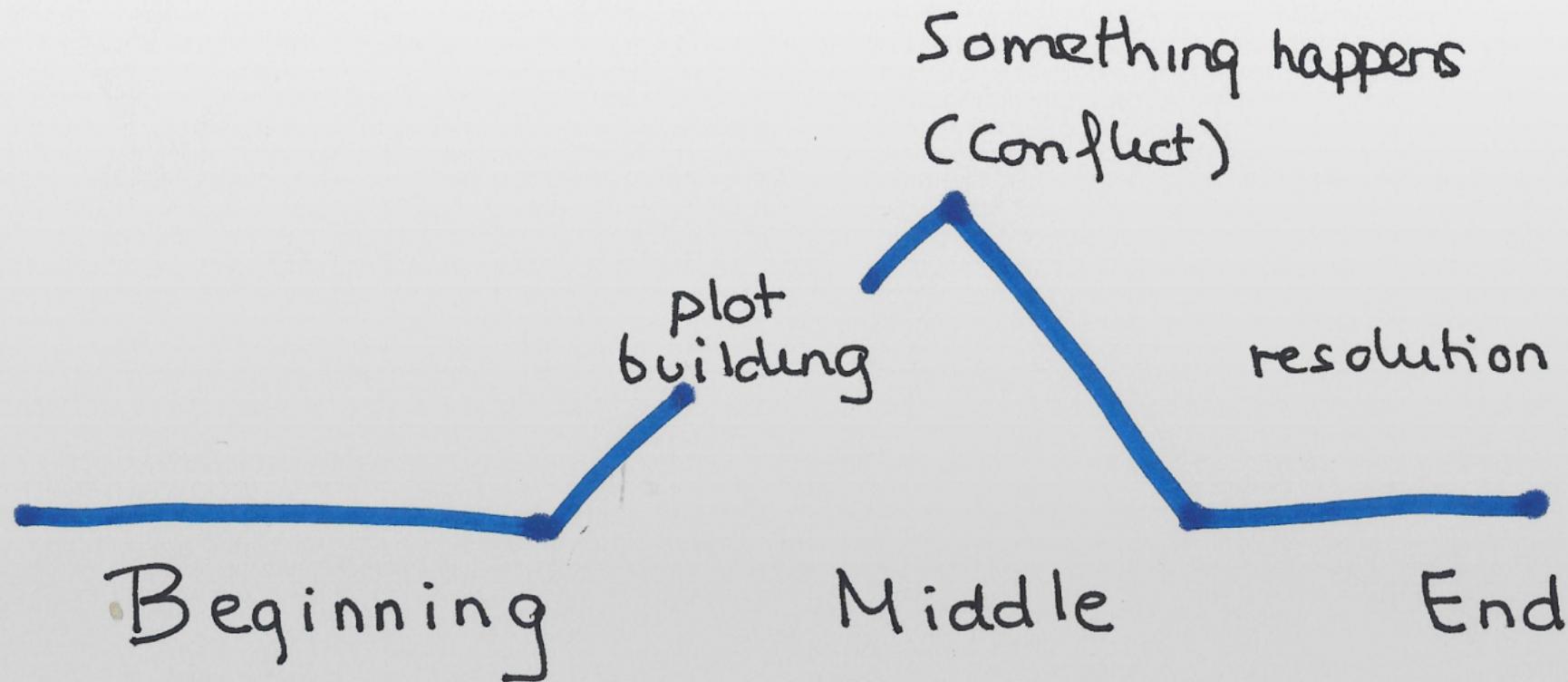
Storytelling example 2



A child storytelling experience: Red riding hood



The story



Identify
beginning-
middle-end

What tricks do
they use for
engagement?

- The interactive UK energy consumption guide
- How many slaves work for you

What is most
memorable?

Wrap-up story-telling in infovis

- Engagement
 - Use striking language / strong imaginary
 - Drive user focus
 - Identify emotional drivers
- Understanding
 - Users lack background information: provide context
 - Unclear visual encodings: explain piecemeal
 - Overwhelming: soft start

Wrap-up story-telling in infovis

- Memorability
 - People forgets the message: connect symbols to reality by text, iconography or actual photos
 - Offer a plot
- Emotional connection
 - Offer fun, Humanize stories
 - Prioritise authenticity: real stories, use details such as names, real pictures...



3-minute story rehearsal

Try to convey your story in 3-min

- It must articulate your unique point of view
- It must convey what's at stake
- It must be a complete sentence.

Knowledge discovery

Use visualization to help discover **trends, outliers, patterns**

Knowledge discovery 1

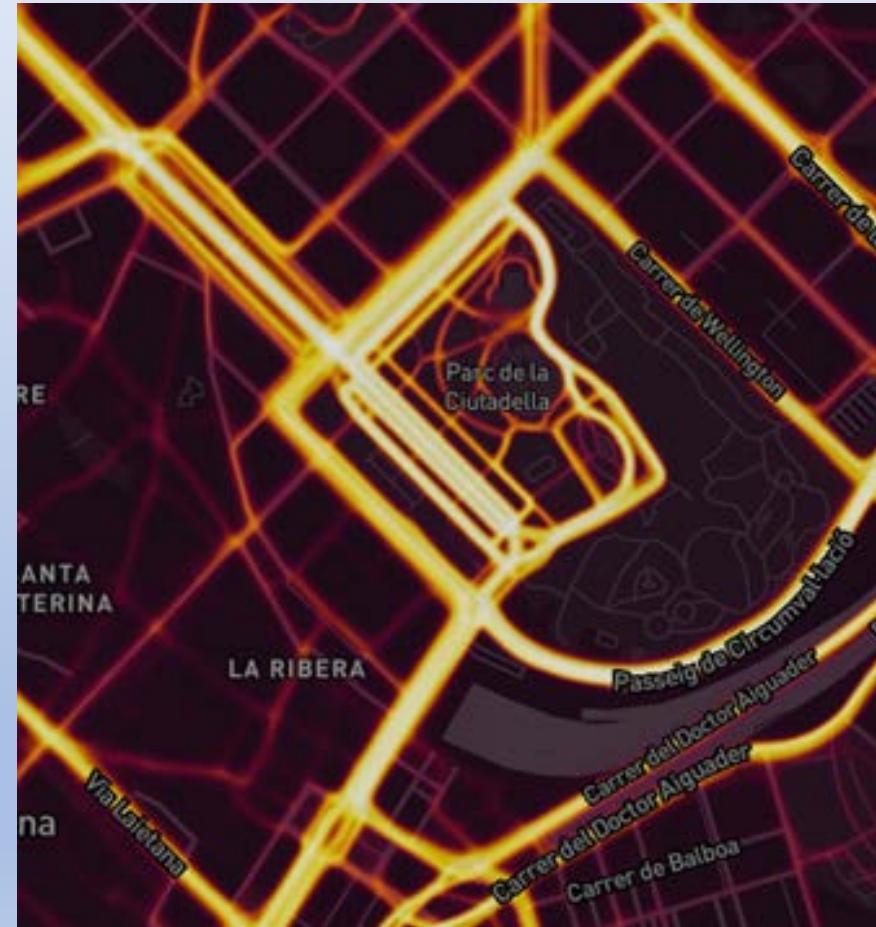
What was the cause of the cholera epidemics in London in 1854?

[John Snow](#) discovered it through visualization



Knowledge discovery 2 (incidental)

Strava heat map made visible [military bases](#)



Knowledge discovery 3

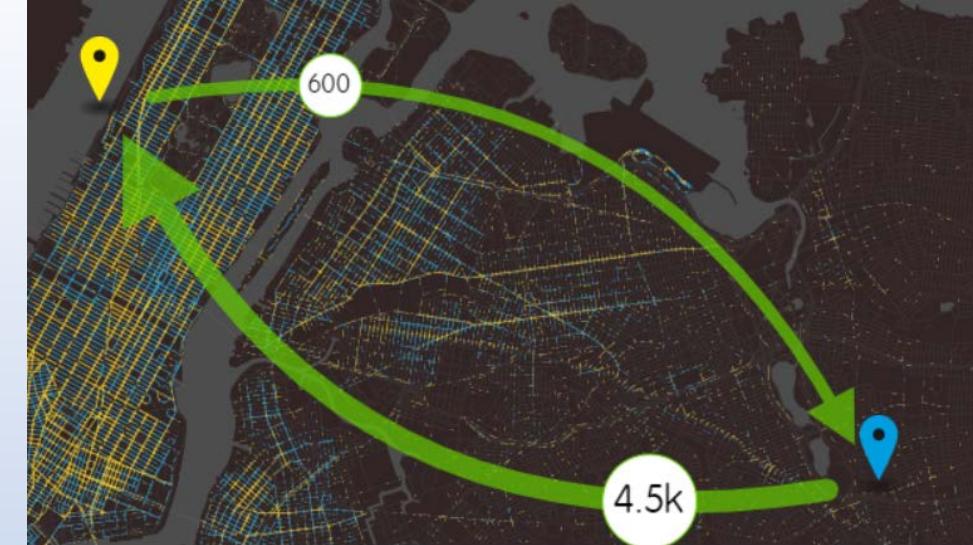
The New York Times

You Draw It: What Got Better or Worse During Obama's Presidency

By LARRY BUCHANAN, HAEYOUN PARK and ADAM PEARCE JAN. 15, 2017

NY Cabs open data

- Lots of interesting stuff to learn
 - Taxi GPS data helps researchers study Hurricane Sandy's effect on NYC
 - traffic <https://engineering.illinois.edu/news/article/9717>
 - Exploring New York City taxi trails and sharing our way to a more sustainable urban future
<http://hubcab.org/#13.00/40.7219/-73.9484>
 - Public NYC Taxicab Database Lets You See How Celebrities Tip
<http://gawker.com/the-public-nyc-taxicab-database-that-accidentally-track-1646724546>





Perception and colours

Gestalt laws

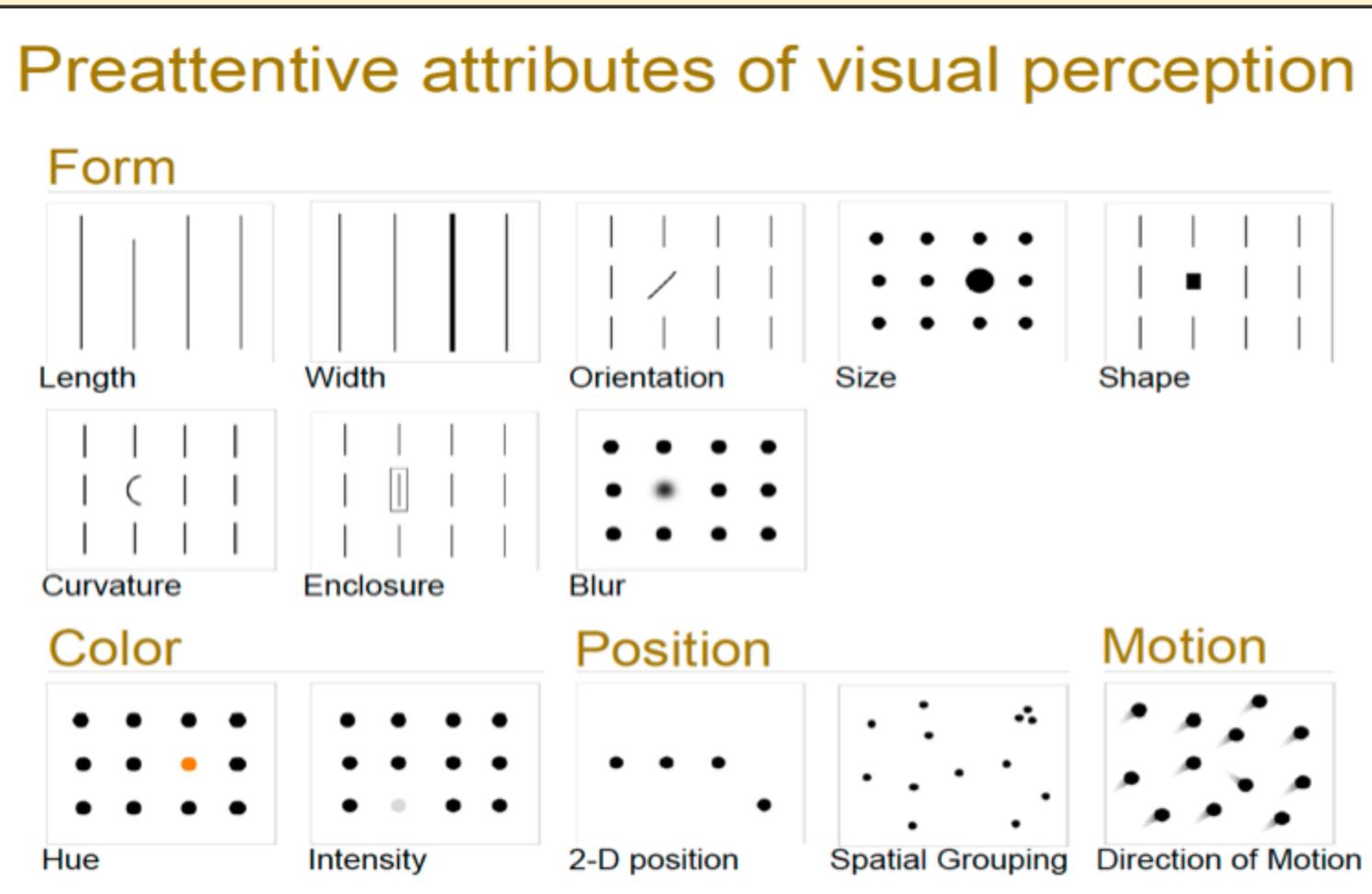
Preattentive properties

Colours

Preattentive properties

- Certain visual properties are detected immediately by low-level visual system
 - Immediately is <200-250 ms
- They “pop-out” without requiring serial search
- Not affected by distractors

Preattentive processing and processing channels



Test your abilities (3)

- Perception in visualization / Christopher G. Healey
<https://www.csc2.ncsu.edu/faculty/healey/PP/index.html>

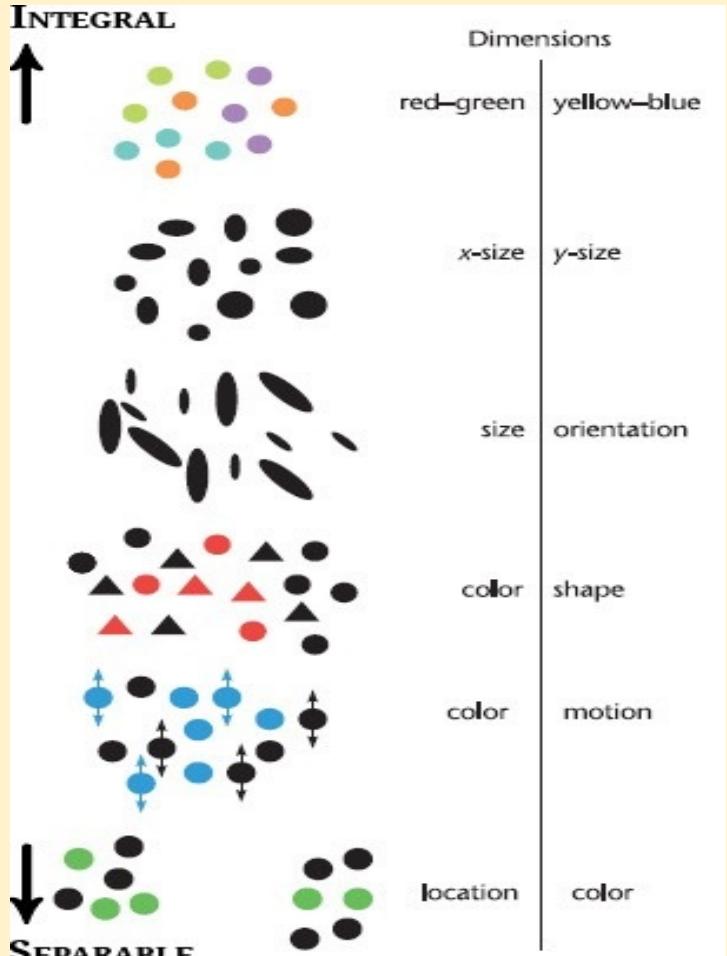
Design principles

- G5.2 “Use **different visual channels** to display aspects of **data** so that they are visually distinct”
- G5-7 “For **maximum popout** a symbol should be the **only object** in a display that is **distinctive** on a particular feature channel; for example, it might be the only item that is colored in a display where everything else is black and white.”

Design principles

- G5-8 “Use **positively asymmetric** preattentive cues for **highlighting**”
- G5-9 “For highlighting, use whatever feature dimension **is used least** in other parts of the design”
- G5-10 “When color and shape channels are already fully utilized, consider using **motion or blink highlighting**. Make the motion or blinking as subtle as possible, consistent with rapid visual search”

Combination of dimensions: integral and separable



- Integral dimensions are seen together
- Separable dimensions are seen individually

Design principles

- G5.14 “If it is important for people to respond holistically to a combination of two variables in a set of glyphs, map the variables to integral glyphs properties”
- G5.15 “If it is important for people to respond analytically to a combination of variables, making separate judgments on the basis of one variable or the other, map the variables to separable glyph properties”

Design principles

- G5.11 “To make symbols in a set **maximally distinctive**, use **redundant coding** wherever possible; for example, make symbols differ in both shape and color”
- When the visual query implies a **conjunction query** (searching for two attributes at the same time) G5.13 “consider coding one using **motion or special grouping** and the other using a property such as **color or shape**”

Gestalt laws: Simplest forms

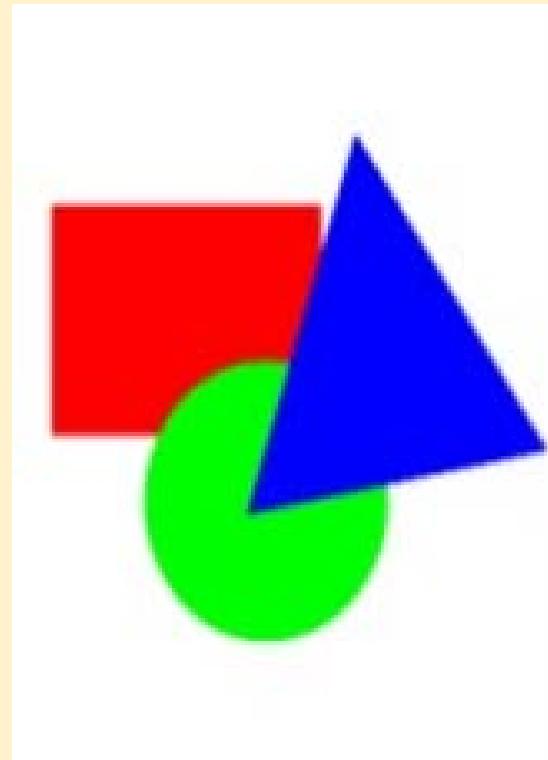
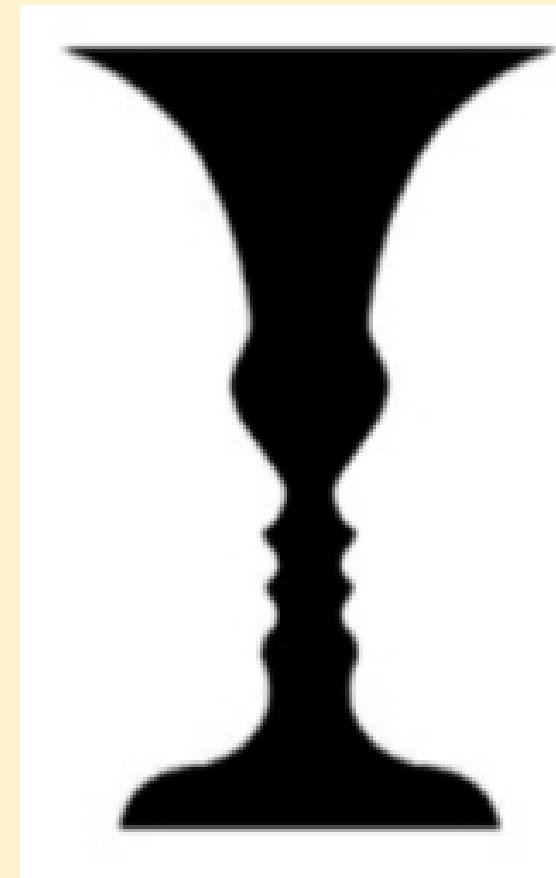
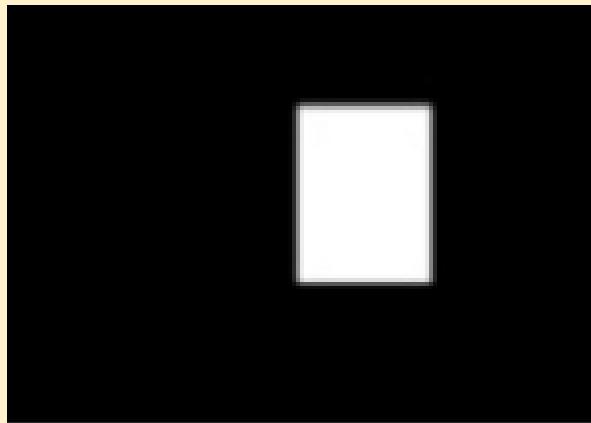


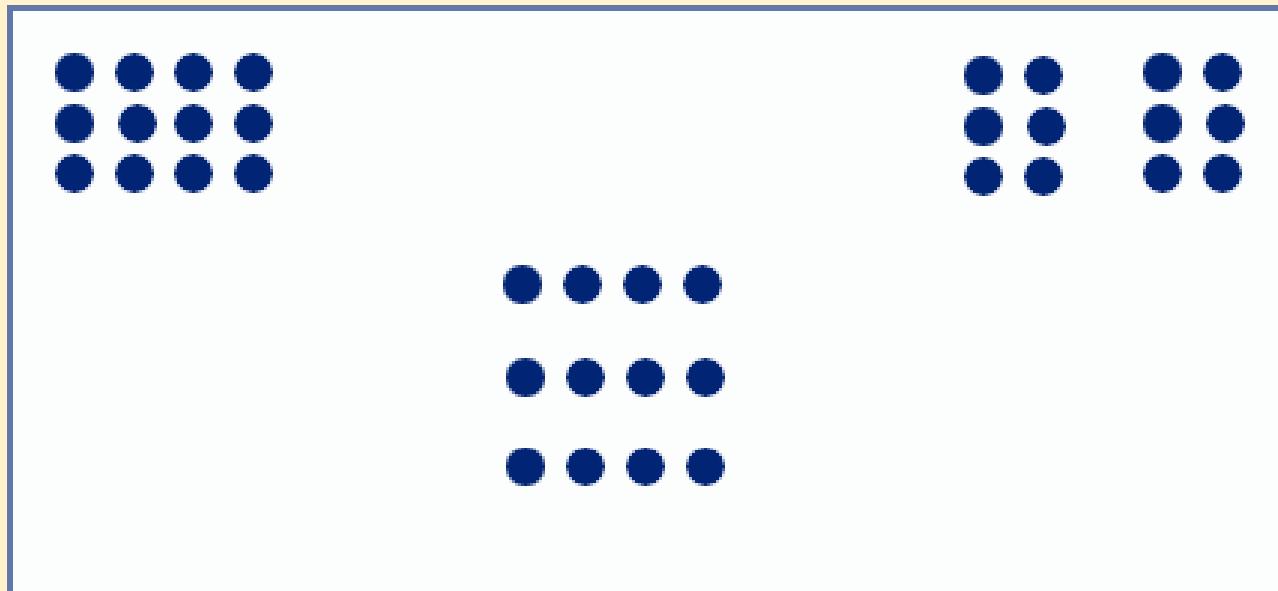
Figure and ground



Design principle

- G5.3 “To make *symbols* easy to find, make them *distinct* from their background and from other symbols”.

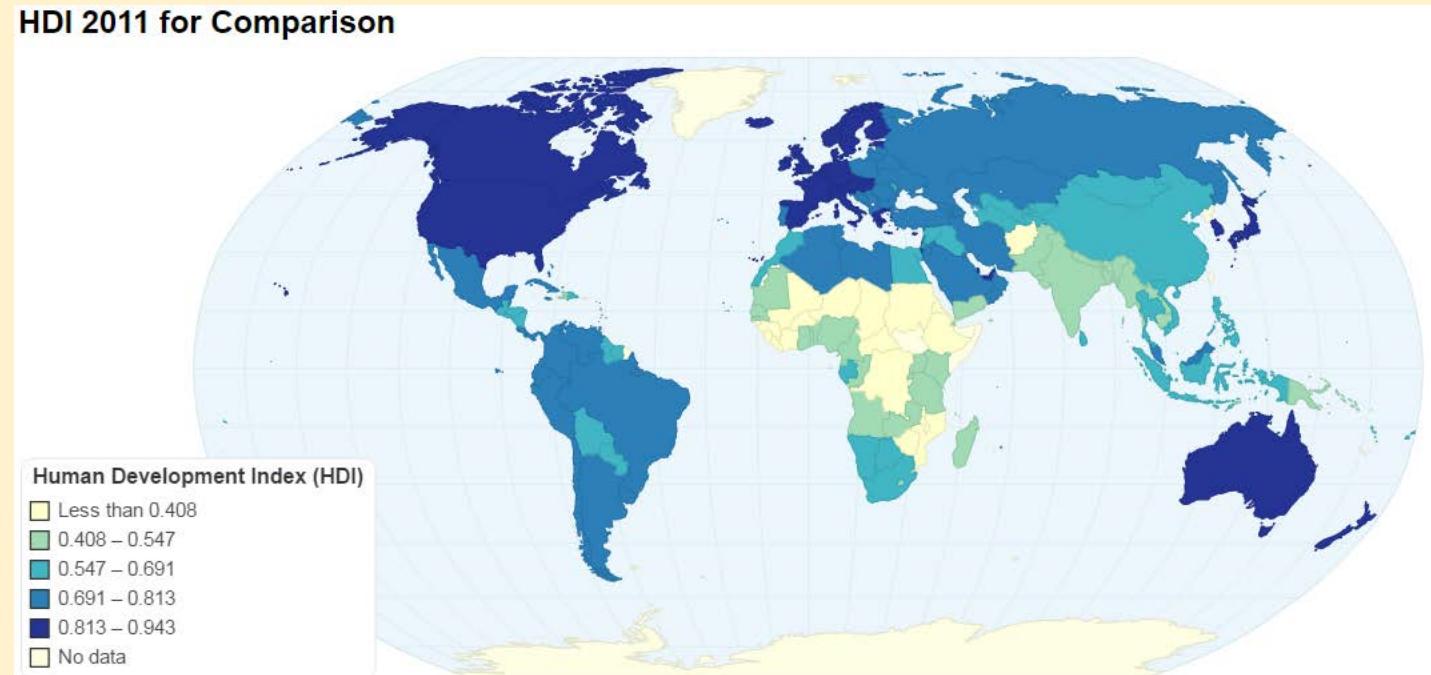
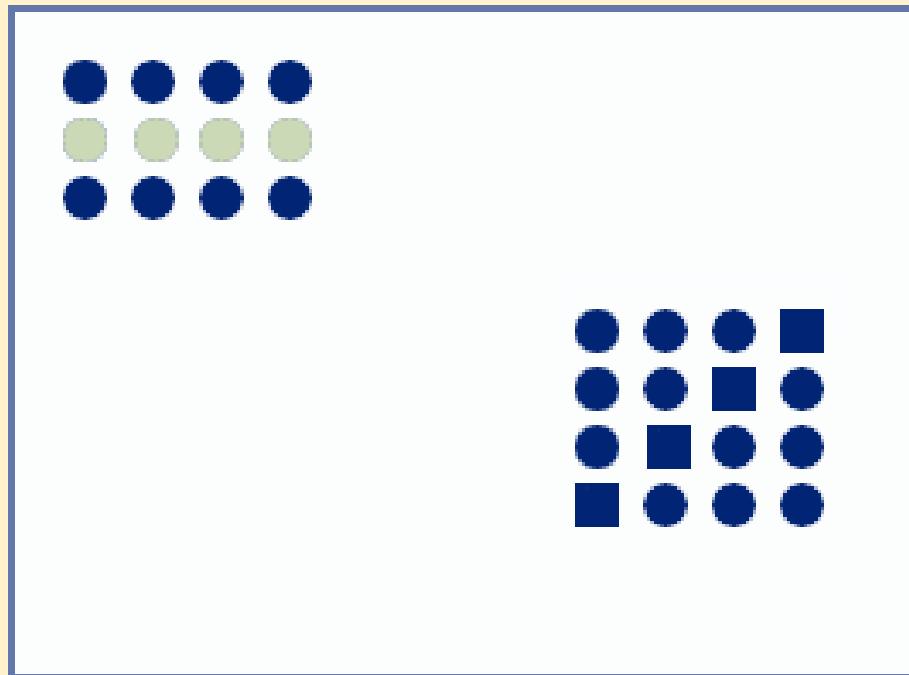
Proximity



Design principle

- G6.1 “Place symbols and glyphs representing related information close together”

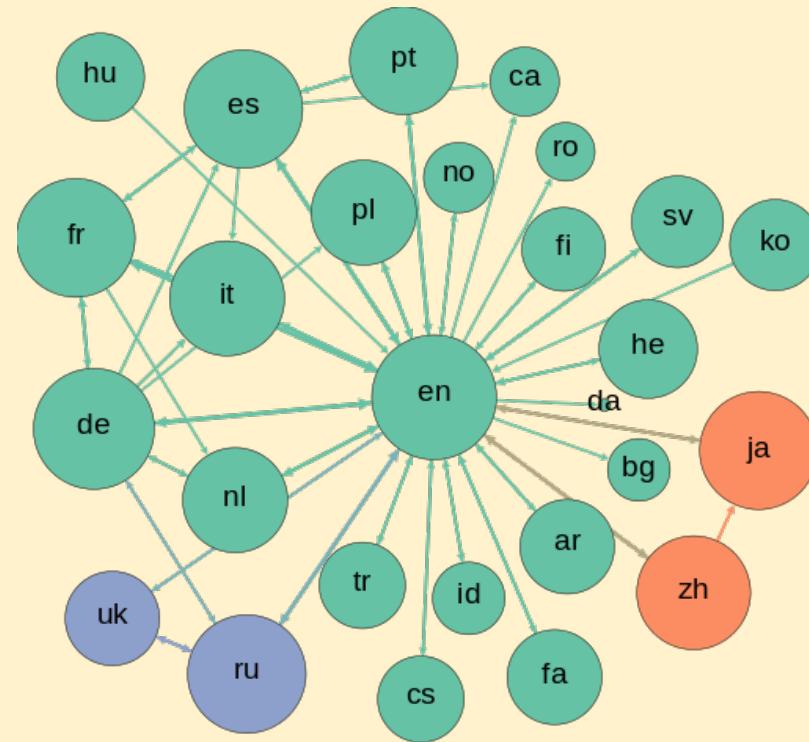
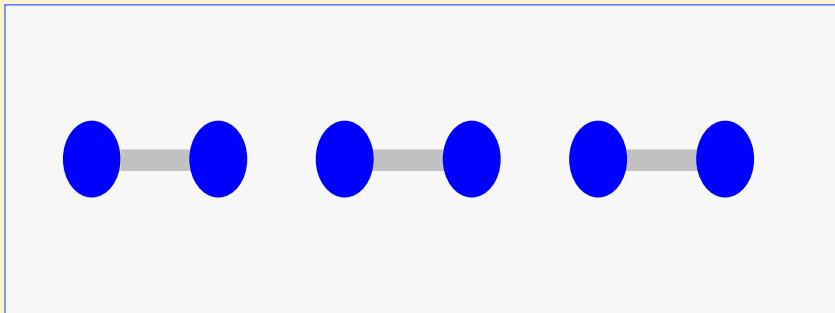
Similarity



Design principle

- G6.2 “When designing a **grid layout** of a data set, consider coding rows and/or columns using low-level visual channel properties, such as **color and texture**”

Connectedness



Source: Computermacgyver (Own work)

[CC BY-SA 3.0 (<http://creativecommons.org/licenses/by-sa/3.0>)], via Wikimedia Commons

Design principle

- G6.3 “To show **relationships** between entities, consider **linking** graphical representations of data objects **using lines or ribbons** of colour”

Continuity



Common fate (synchrony)



Symmetry

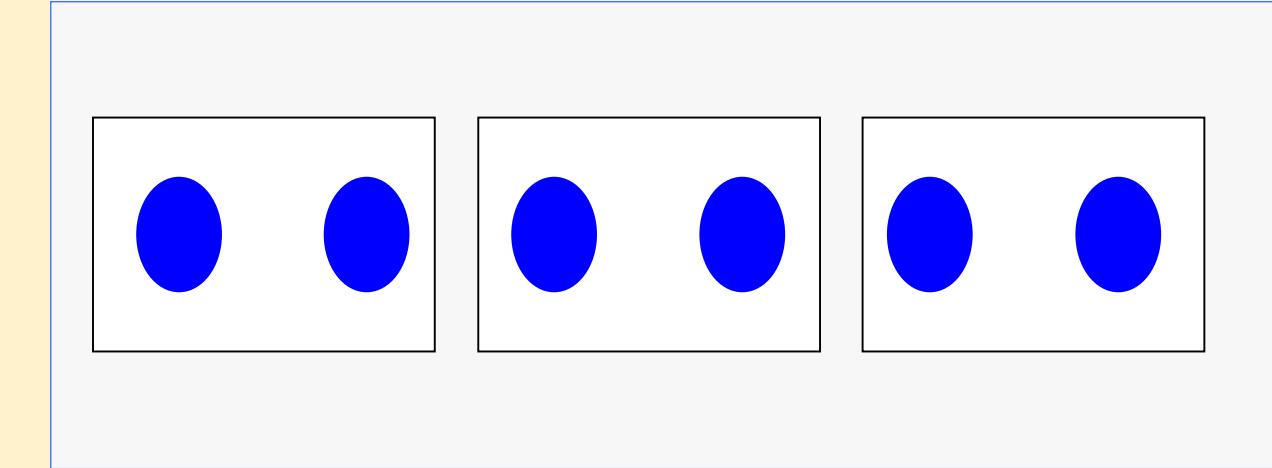
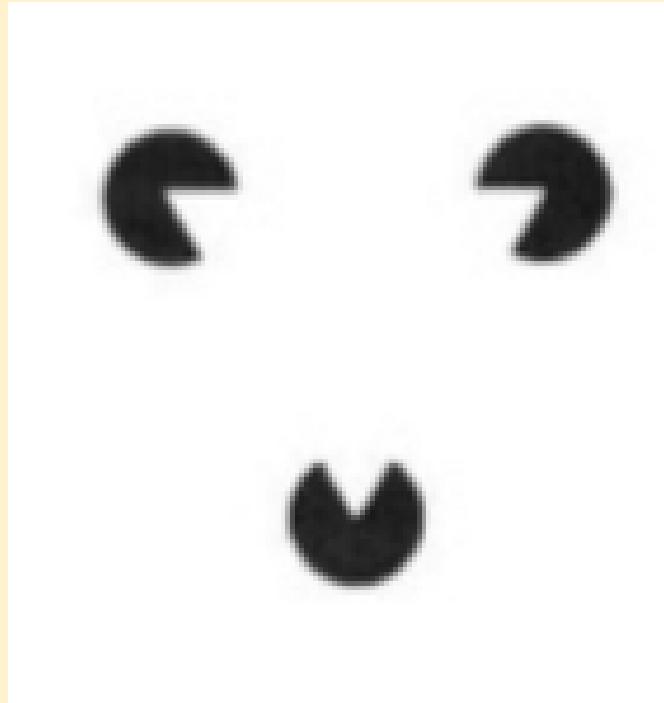
{ } [] ()

Design principle

- G6.4 Consider using **symmetry** to make **pattern comparisons** easier, but be sure that the patterns to be compared are small in terms of visual angle (<1 degree horizontally and <2 degrees vertically).

Symmetrical relations should be arranged on horizontal or vertical axes unless some framing pattern is used.

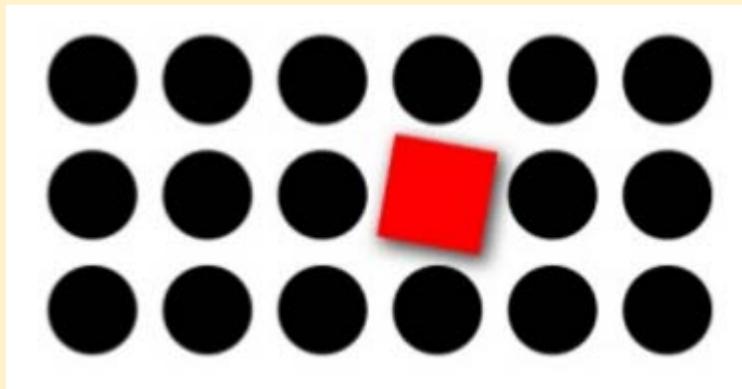
Closure and common region



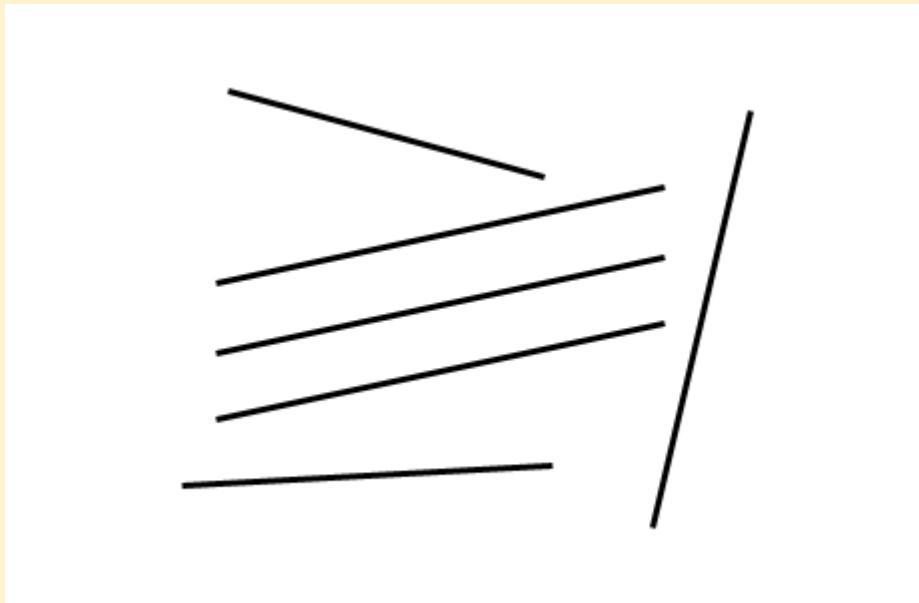
Design principle

- G6.5 “Consider putting **related information inside a closed contour**. A line is adequate for regions having a simple shape. Color or texture can be used to define regions that have more complex shapes”.
- G6.6 “To define **multiple overlapping regions**, consider **using a combination of line contour, color, texture, and sweet contours**”

Focal point



Parallelism



Design principle

- Combining preattentive processing properties and Gestalt laws we can derive best practices to represent quantity, intensity or to provide visual salience

Combining to represent QUANTITY

- size:
 - *length or height,*
 - *area* (radio),
 - never *volume*
- lightness, darker = bigger
- hue saturation, saturated = bigger
- vertical position, higher = bigger

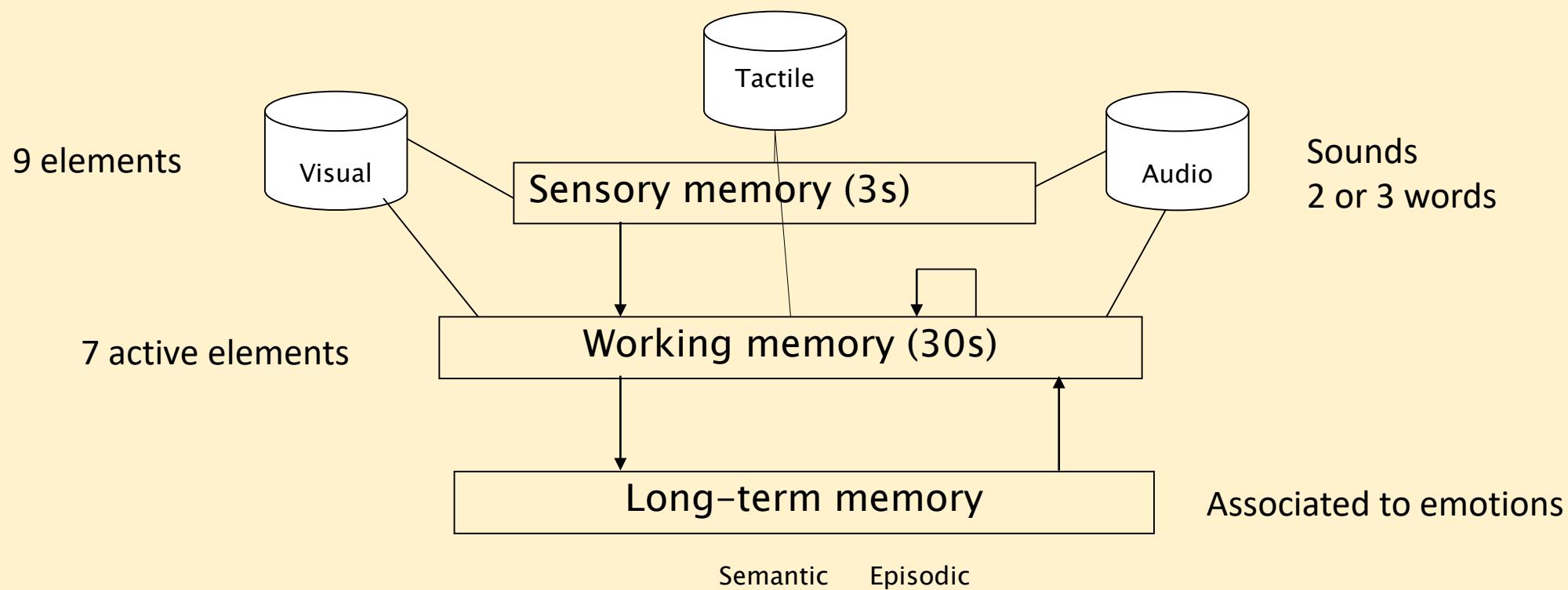
Combining to represent INTENSITY

- Darker or more saturated
- Bigger
- Thicker

Combining to represent VISUAL SALIENCE

- Distinct from the norm: in hue, orientation
- Enclosure: by line or background colour
- Added marks

Memory



Automatic Teller Machine (ATM)

- What do you have to take first: money or card?

WHY?

Design principles

- Important information should receive focused attention, it shall appear in preeminent locations and have visual salience
- Secondary information may be on secondary locations or hidden, only visible on demand

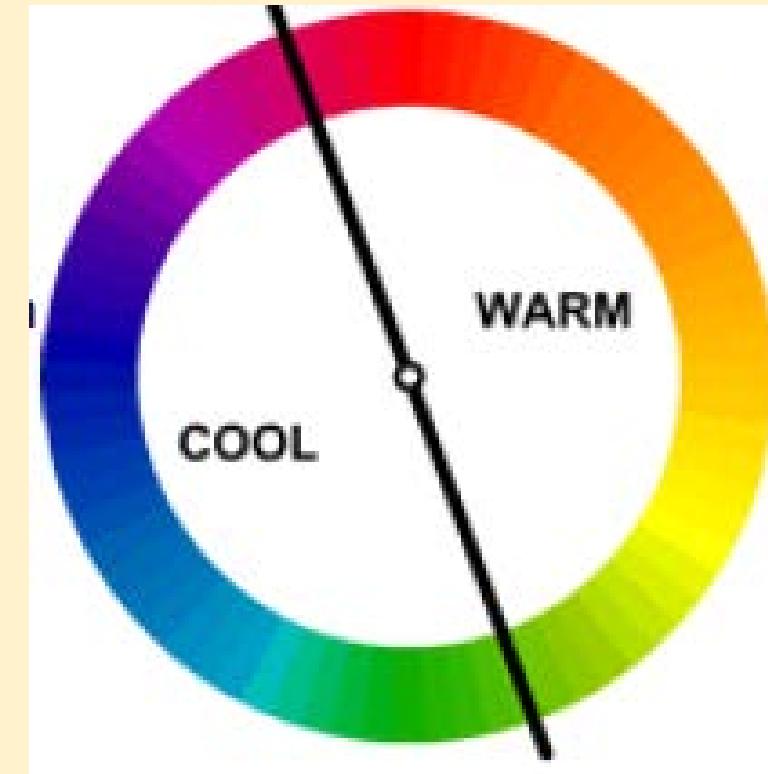
Specification of a colour: perceptual dimensions HSL

- **Hue** : what we associate to colour names
 - **Saturation (Chroma)**: Purity of the colour (vividness)
 - **Luminance / Lightness / Value** : (it is relative) how much light appears to reflect an object in relation to the White on the scene
- <http://hslpicker.com/>
 - <http://colorizer.org/>

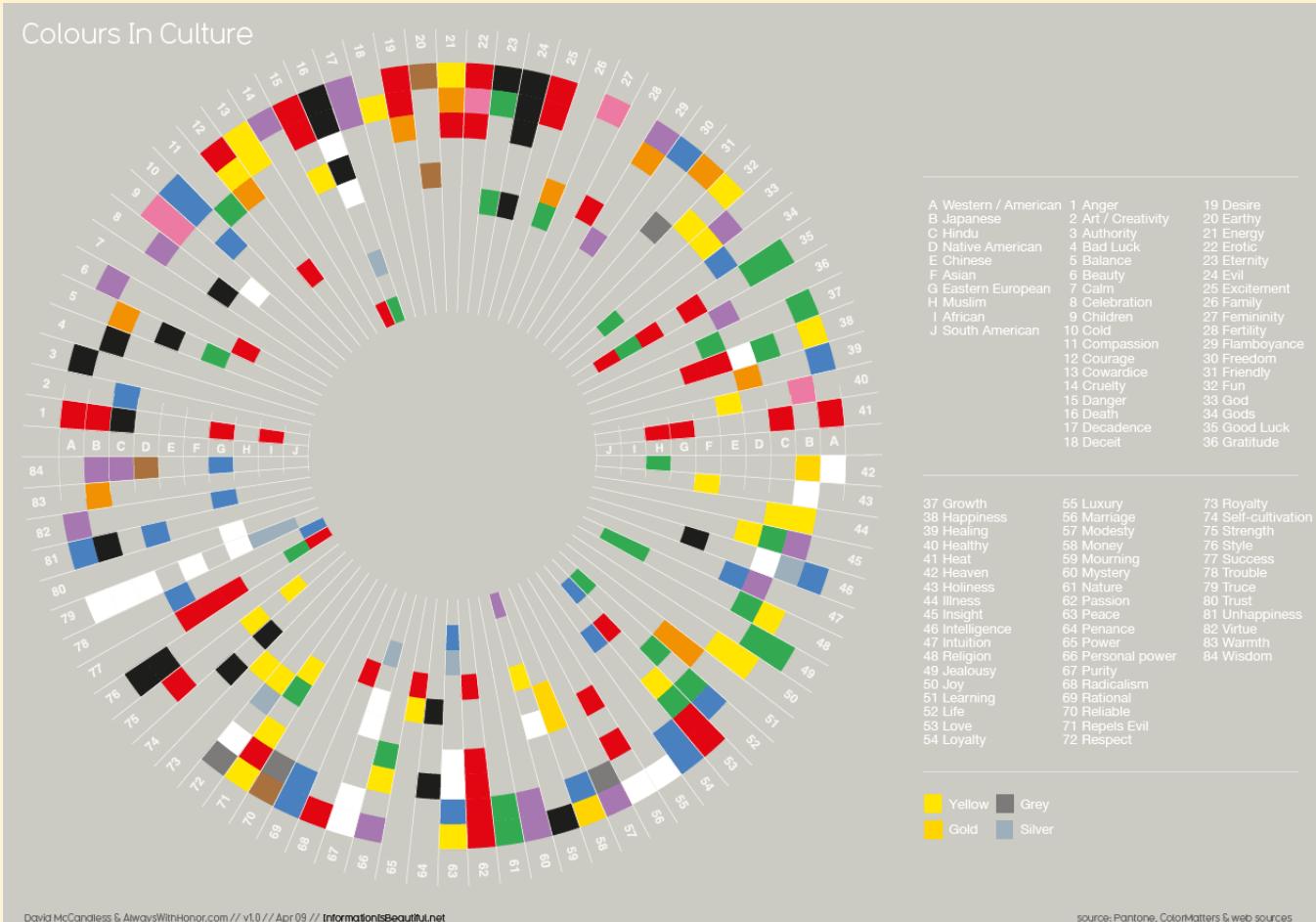


Colours affect our moods

- Colours **affect us** in numerous ways, both mentally and physically
- Warm colours are **energetic**, and tend to advance in space.
- Cool colours **give calm**, and tend to work better as background.

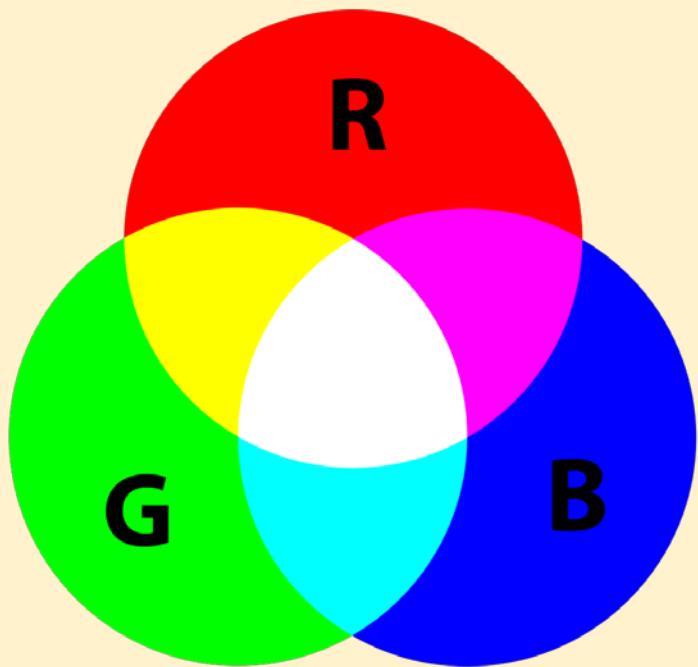


Colour meaning is a cultural issue

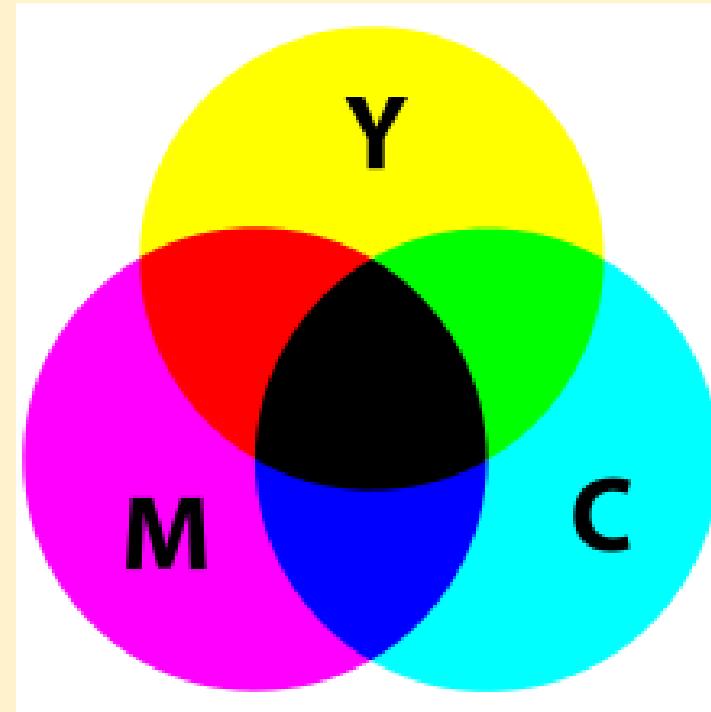


Specification of a colour

Additive model: screen



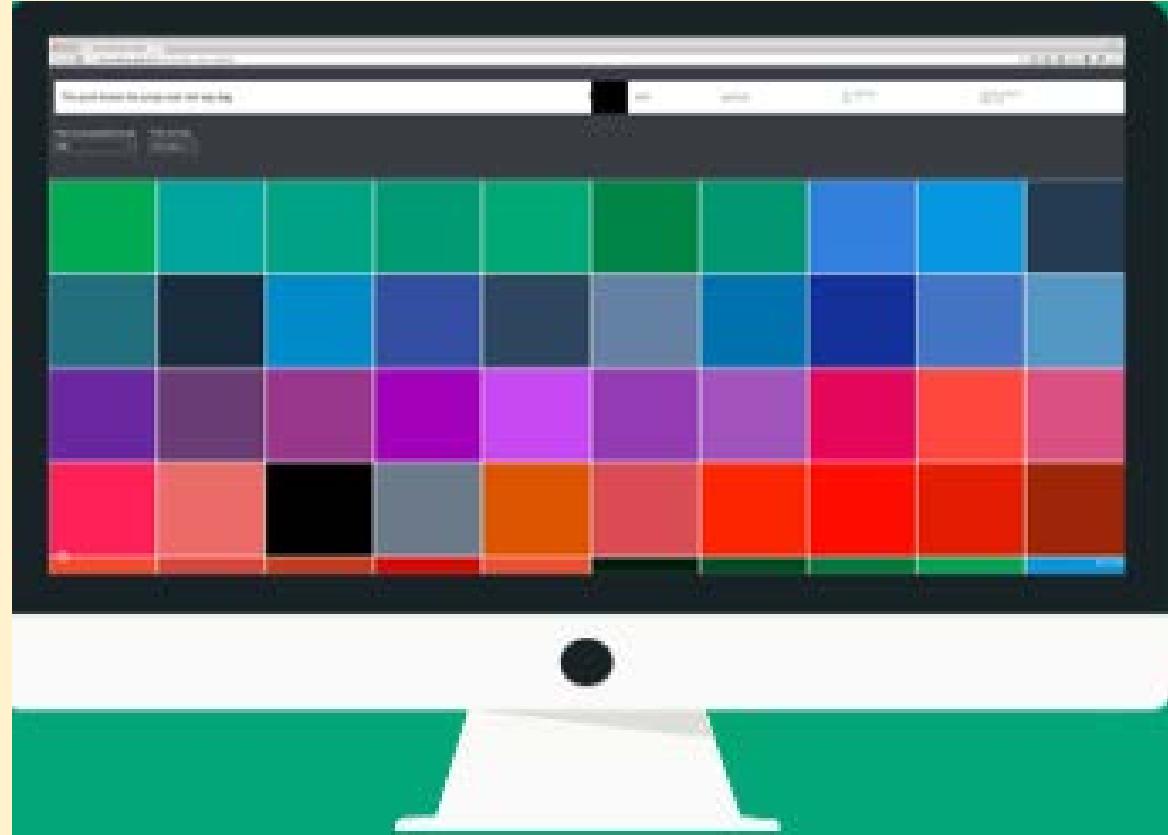
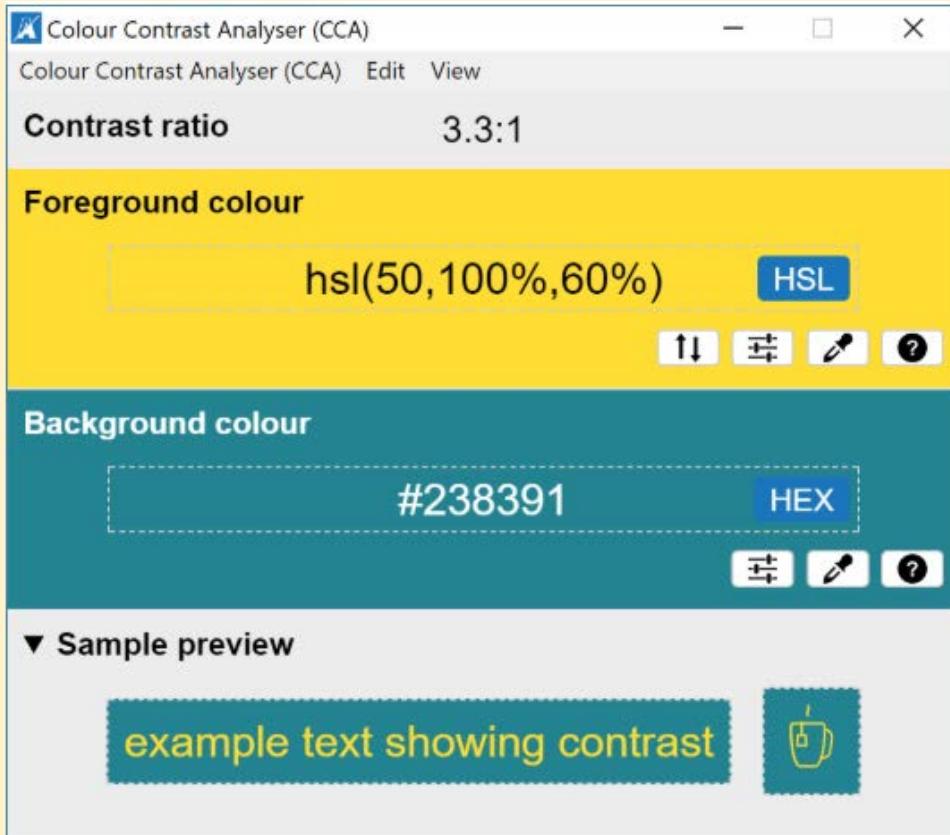
Subtractive model: printing



Age, colour blindness and contrast

- Colour perception **decreases with age**
- Sight decrease affects both rods and cones
- As we have much more rods, **elders perceive much better luminance differences than hue differences.**
-
- It is therefore important to **keep contrast differences** in every colour system.

Contrast: Some tools



LINUX: <https://contrast-ratio.com>

Colours for charts

- Assign colour according to function:
 - Use contrast to highlight
 - Analogous colours to group
 - Use greys for context and axis when labelling with colour

Colour principles (1)

- G4.7 If using colour saturation to encode numerical quantity, use **greater saturation** to represent **greater numerical quantities**. Avoid using a saturation sequence to encode more than three values.

Colour principles (2)

- G4.16 Use low-saturation colours to colour code large areas.

Generally, light colours will be best because there is more room in colour space in the high-lightness region than in the low-lightness region.

Colour principles (3)

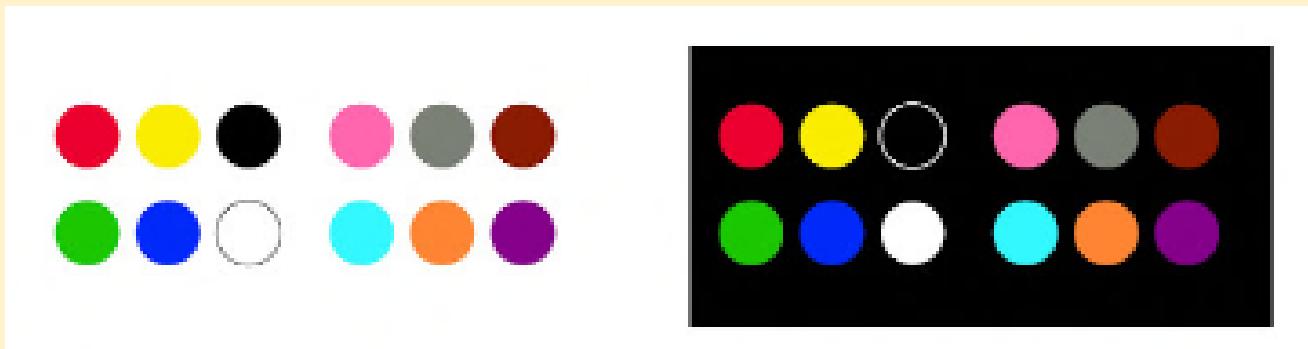
- G4.17 When colour coding large background areas overlaid with small coloured symbols, consider using all low-saturation, high-value (pastel) colours for the background, together with high-saturation symbols on the foreground.

Colour principles (4)

- G4.18 When **highlighting text** by changing the colour of the font, it is important to **maintain luminance contrast** with the background.

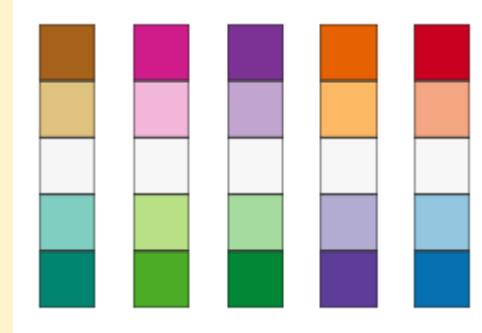
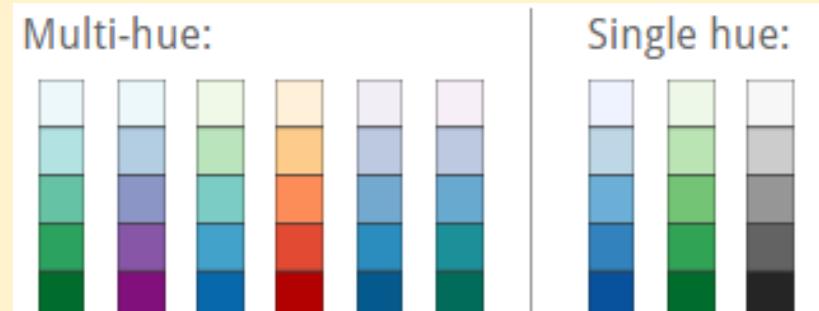
Colours for labelling. Qualitative

- Small set: red, green, yellow, blue (opponent theory)
- 12 cross-cultural safe colours (see figure)
- Different hues have no order

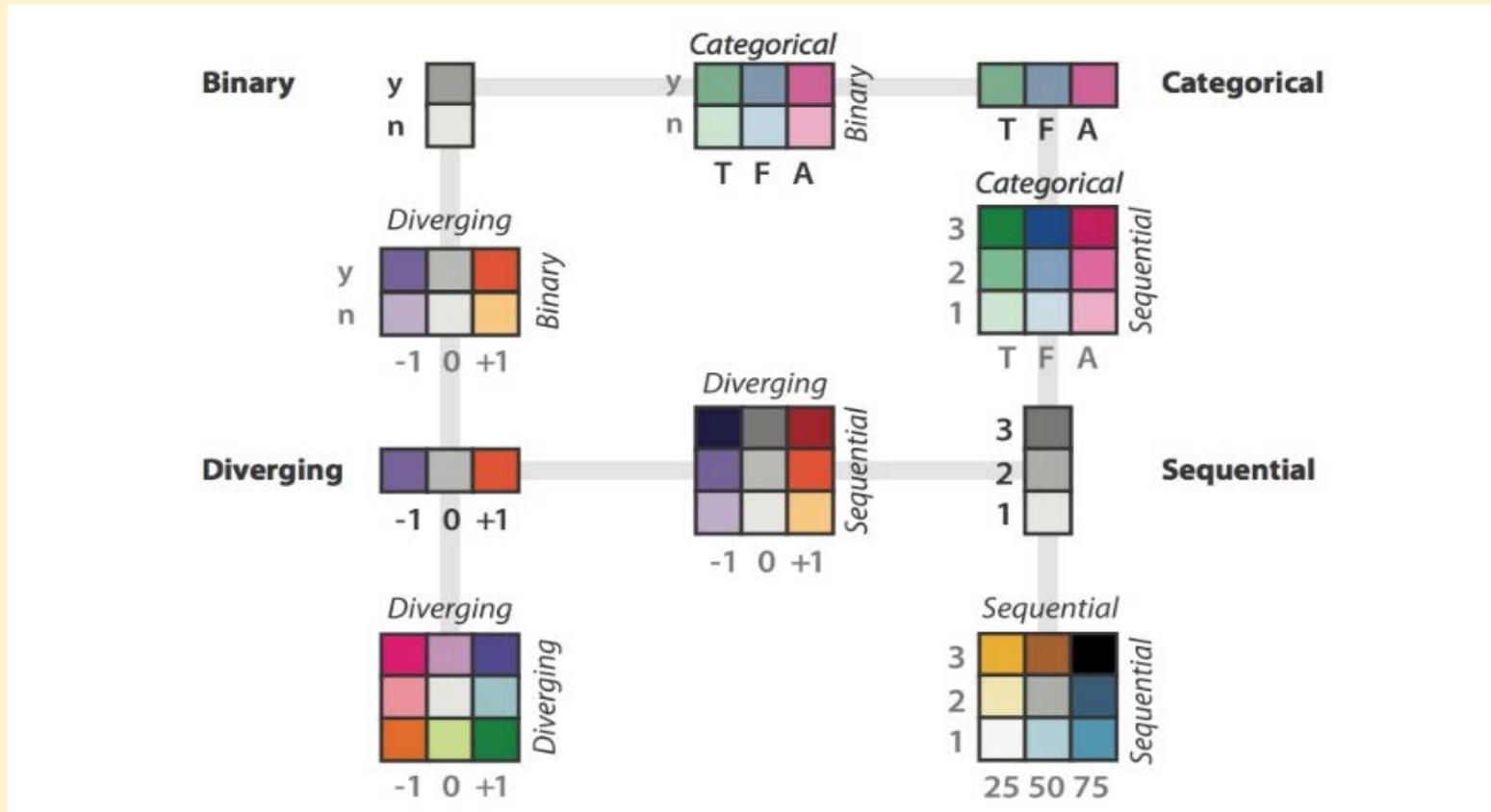


Colours for labelling. Quantitative Scales

- Sequential: each step differs in saturation or in saturation and lightness
- Diverging: two hues, a neutral hue in the middle. Suited for opposite values



Colour mapping, combinations



Colours for text

- For highlighting, contrast is the most relevant issue

Colours for maps

- Big areas: low saturation;
- Small areas: highly saturated
- Ensure hue and luminance contrast with the background (use a border if needed)
- For colour-blindness assure yellow-blue distinction
- See Cynthia Brewer [ColorBrewer tool](#)

Choosing the right chart

Visual vocabulary

Charts handout

