THE GESTALT PRINCIPLES

PART II – BEST PRACTICES IN DATA VISUALIZATION

VISUAL PROCESSING

Perception is fragmented – eyes are continuously scanning.

Visual thinking seeks patterns

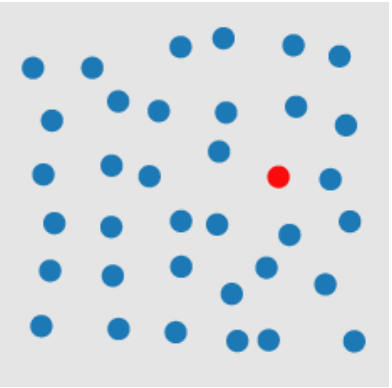
- **Pre-attentive processes:** fast, instinctive, efficient, multitasking gather information and build patterns:

  features → patterns → objects

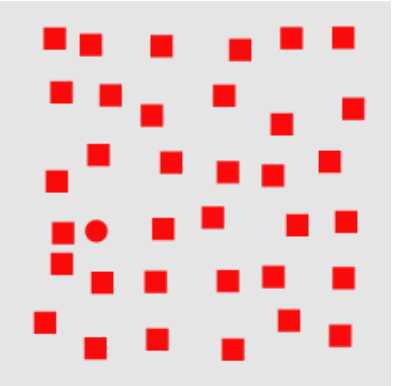
- **Attentive processes:** slow, deliberate, focused discover features in the patterns:

  objects → patterns → features

pre-attentive



attentive



PRE-ATTENTIVE ATTRIBUTES

How many 6's
In the next slide?

2869408609876

9348586748676

2967303986739

3967496749674

2869408609876

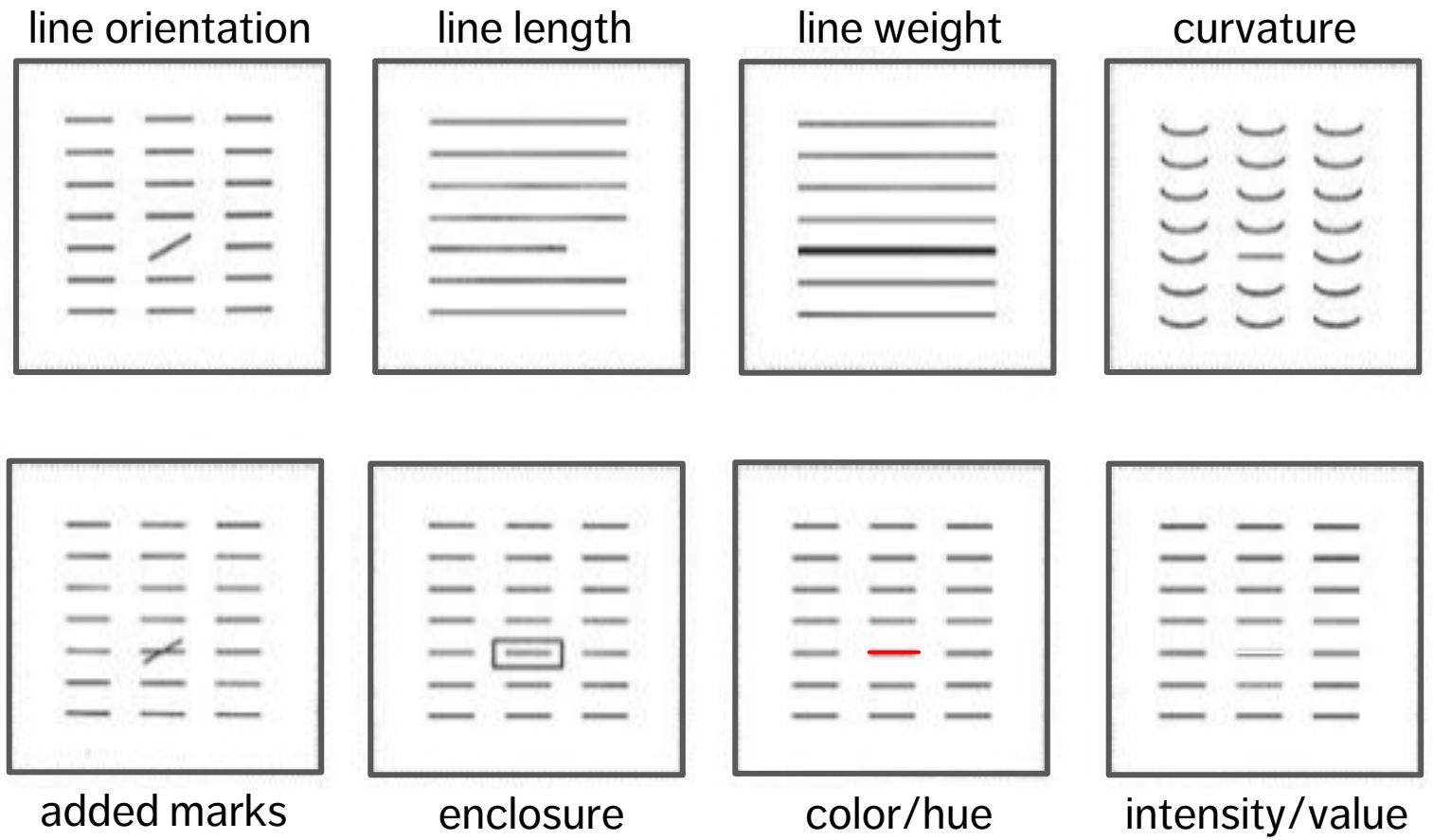
9348586748676

2967303986739

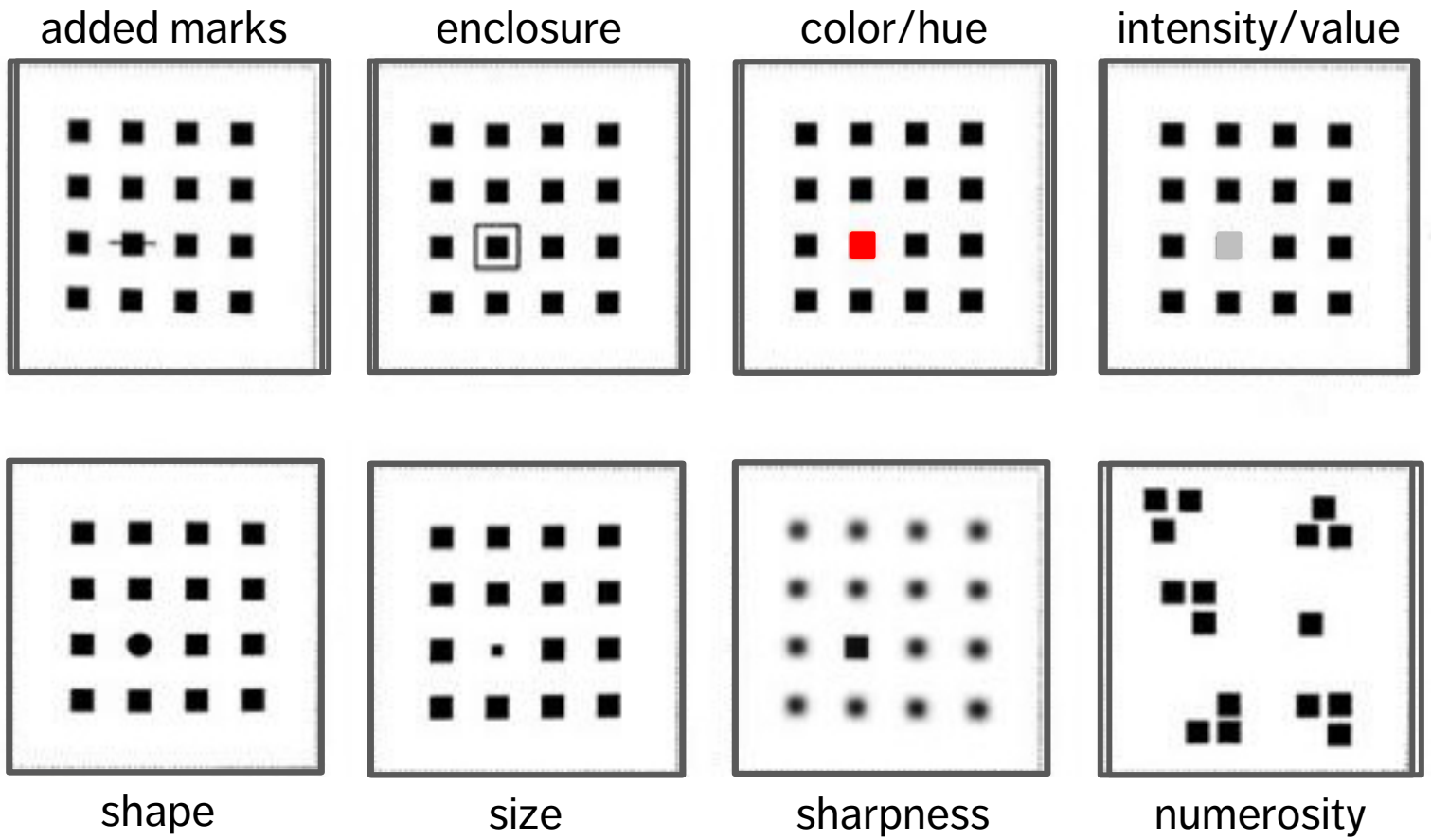
3967496749674

[I. Meirelles, Design for Information]

PRE-ATTENTIVE ATTRIBUTES



PRE-ATTENTIVE ATTRIBUTES



PRE-ATTENTIVE ATTRIBUTES

Pre-attentive attributes are the domain of iconic memory (brief): they

- help to define a hierarchy of focus
- push non-message impacting components into the background

Use pre-attentive attributes to help **emphasize the story** (but don't overdo them):

- easier to do in Excel and R, harder in Power BI

Challenge: highlighting one aspect of a chart can make other aspects harder to see.

[www.interaction-design.org/literature/topics/gestalt-principles]

GESTALT PRINCIPLES

What are the Gestalt Principles?

- Principles/laws of human perception.
- They describe how humans group similar elements, recognize patterns and simplify complex images when they perceive objects.
- Designers use them to organize content on charts, dashboards, websites, and other interfaces so that they be **aesthetically pleasing** and **easy to understand**.

[www.interaction-design.org/literature/topics/gestalt-principles]

GESTALT PRINCIPLES

Background:

- "Gestalt" is German for "unified whole".
- The first principles were devised in the 1920s by German psychologists Wertheimer, Koffka ("the whole is greater than the sum of the parts") and Kohler
- Their aim: understand how humans gain meaning from the chaotic stimuli around them.
- They identified a set of laws which address the natural compulsion to find order in disorder.
- According to this, the mind "informs" what the eye sees by **perceiving a series of individual elements as a whole**.

GESTALT PRINCIPLES

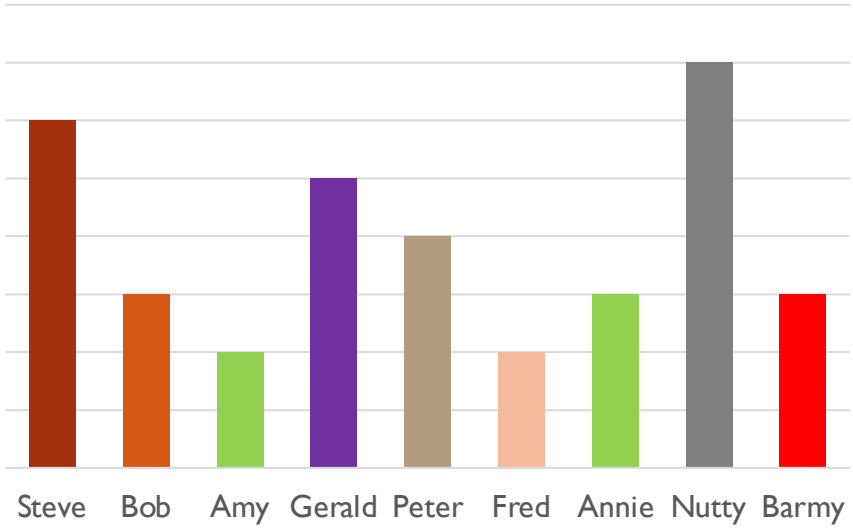
Principles:

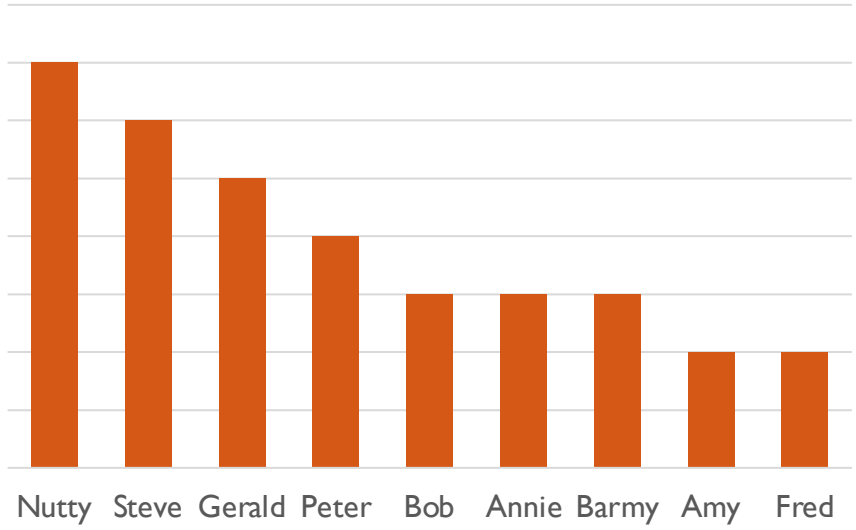
- simplicity
- continuation
- proximity
- similarity (invariance)
- focal point
- isomorphic correspondence
- figure / ground duality
- common fate
- closure*
- uniform connectedness*

SIMPLICITY

The brain has a preference for **simplicity** – it tends to process simple patterns faster than patterns that are more complex.

Lesson: arrange data simply and logically wherever possible.



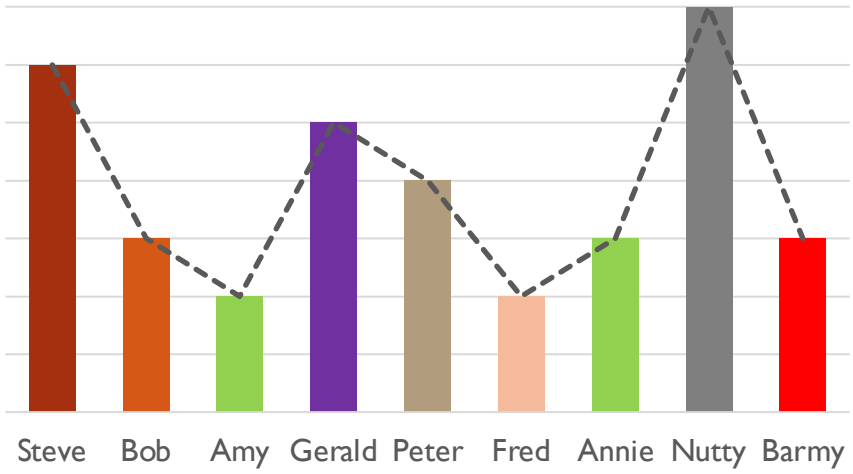


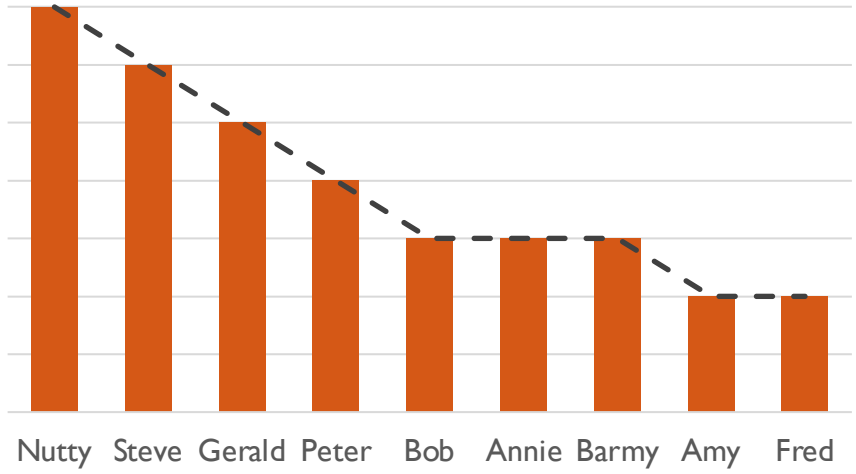
CONTINUATION

Our eyes group things that are **aligned** (e.g. sorted from high to low) with each other.

In the chart on the right the eyes follow a **continuous path**; it makes the whole chart more readable because of the continuous downward direction

Lesson: arrange objects in a line to facilitate grouping and comparison.





PROXIMITY

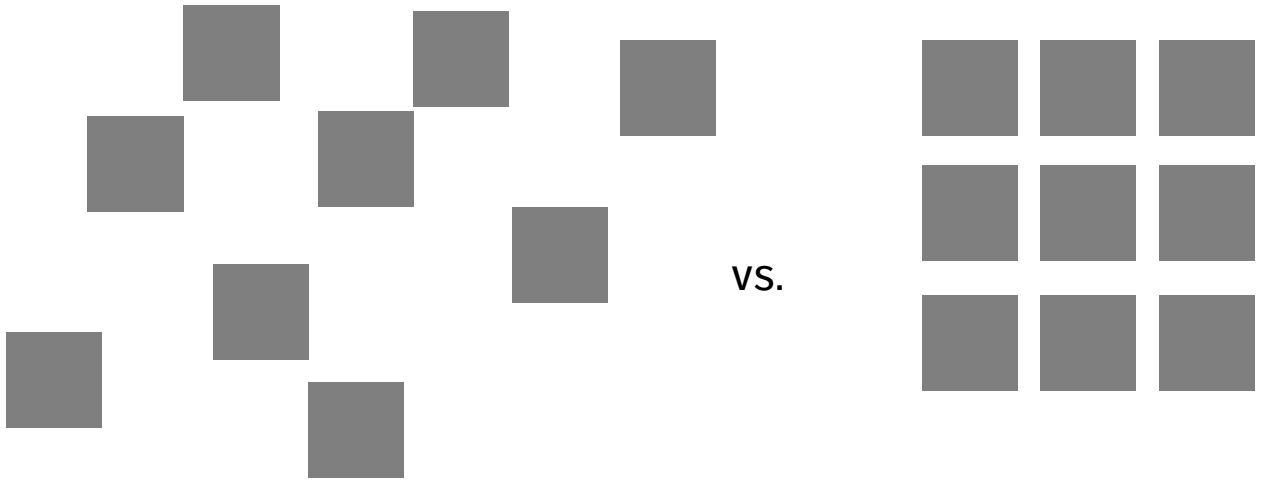
Objects/shapes that are **in proximity** (close) to one another appear to form **groups**.

The effect generated by the collected group is more “powerful” than that generated by separate elements.

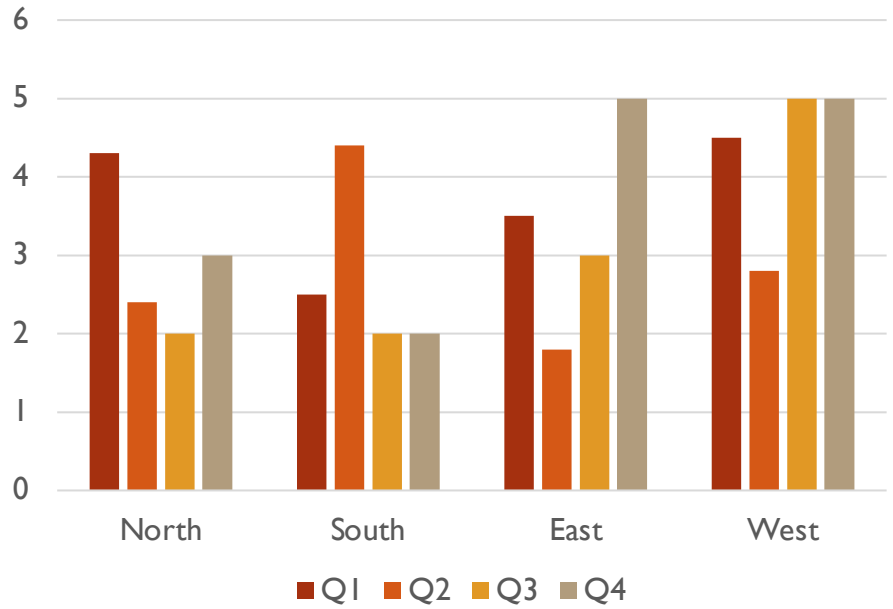
Elements which are grouped together create the **illusion** of shapes/planes in space, even if the elements are not touching.

Lesson: understand the chart’s priorities and create groupings through proximity that support those priorities.

PROXIMITY



vs.



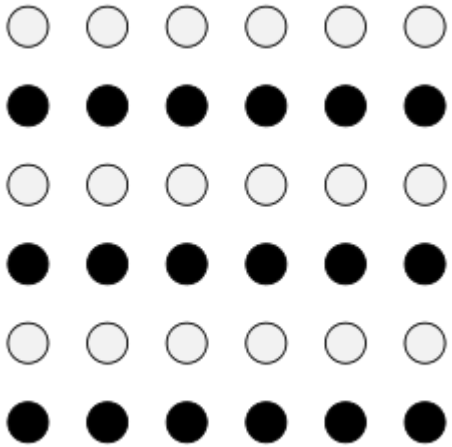
SIMILARITY (INVARIANCE)

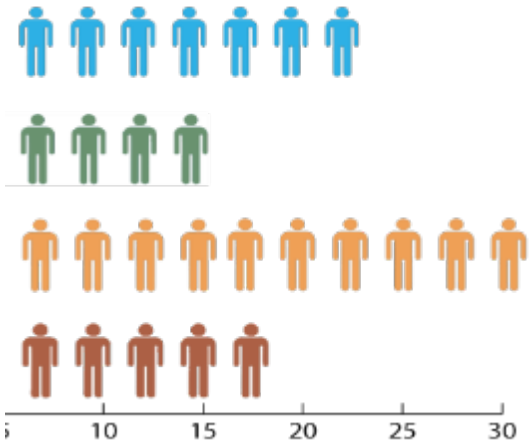
Similarity: stimuli that physically resemble each other are viewed as part of the same object; stimuli that don't are viewed as part of a different object.

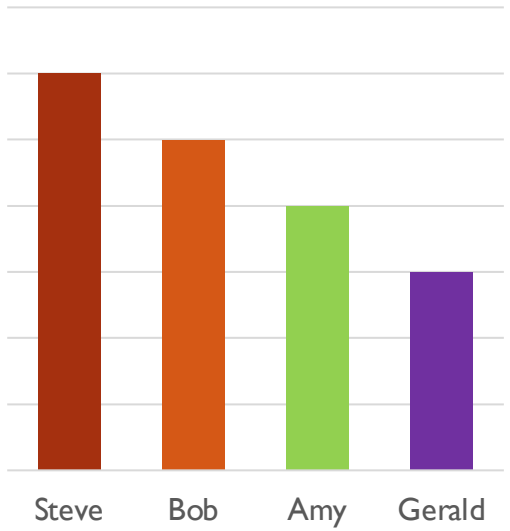
Similarity and proximity often come together to form a **Visual Hierarchy**. Either principle can dominate the other, depending on their application and combination.

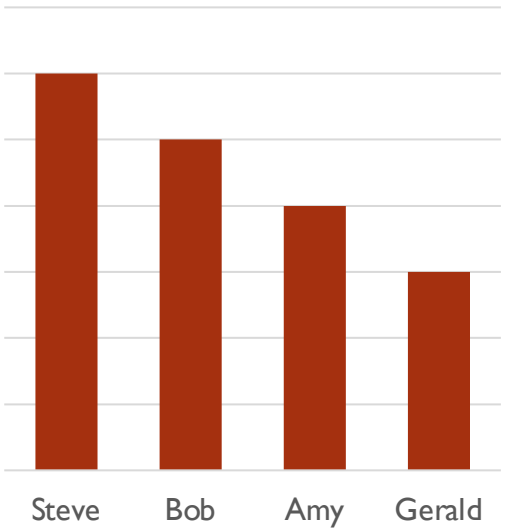
Lesson: use similar characteristics to establish relationships and to encourage groupings of objects.

SIMILARITY (INVARIANCE)









In the examples above, similarity dominates over proximity: we see rows before we see columns.

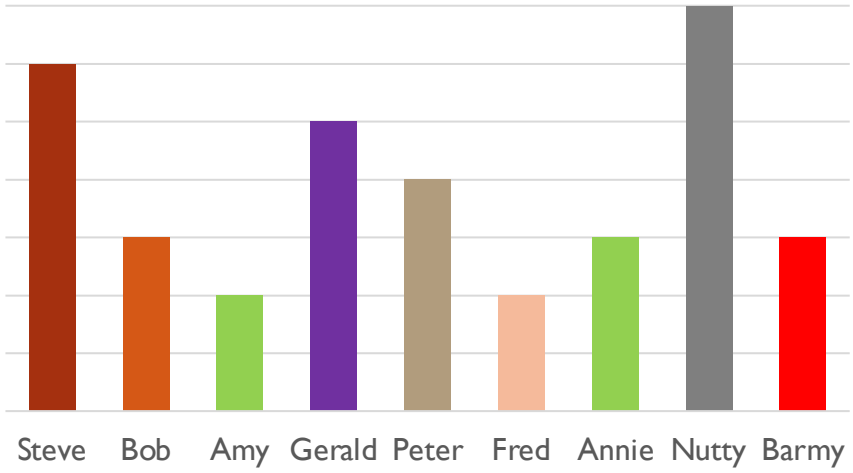
Making things similar can reduce cognitive load (cf. last graph colour).

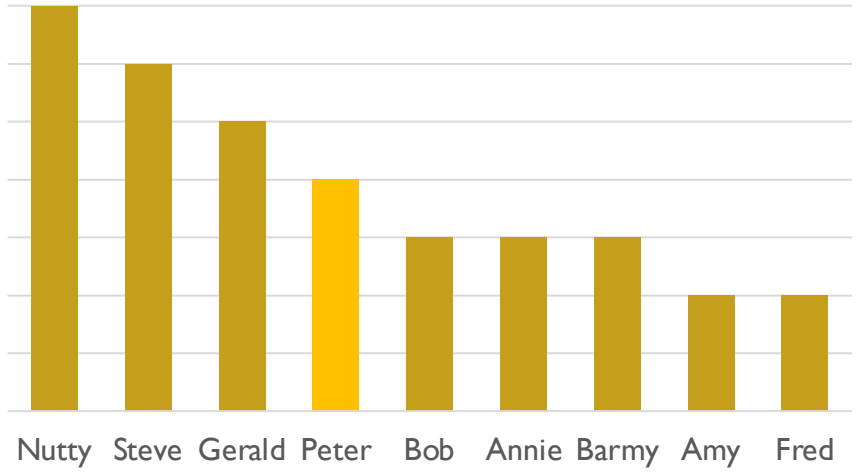
FOCAL POINT

In opposition to similarity, the **focal point** principle states that distinctive-looking objects can create a focal point.

To highlight one salesperson's performance, make their bar graph color different.

Lesson: use different characteristics to highlight and create focal points.





ISOMORPHIC CORRESPONDENCE

People interpret and respond to images based on past/shared experiences (in particular, for the selection of chart colours).

Red is often associated with **bad** and **green** with **good** (colour-blindness?). We can colour-code charts accordingly.

Lesson: stick to well-established conventions and best practices (even if boring!)

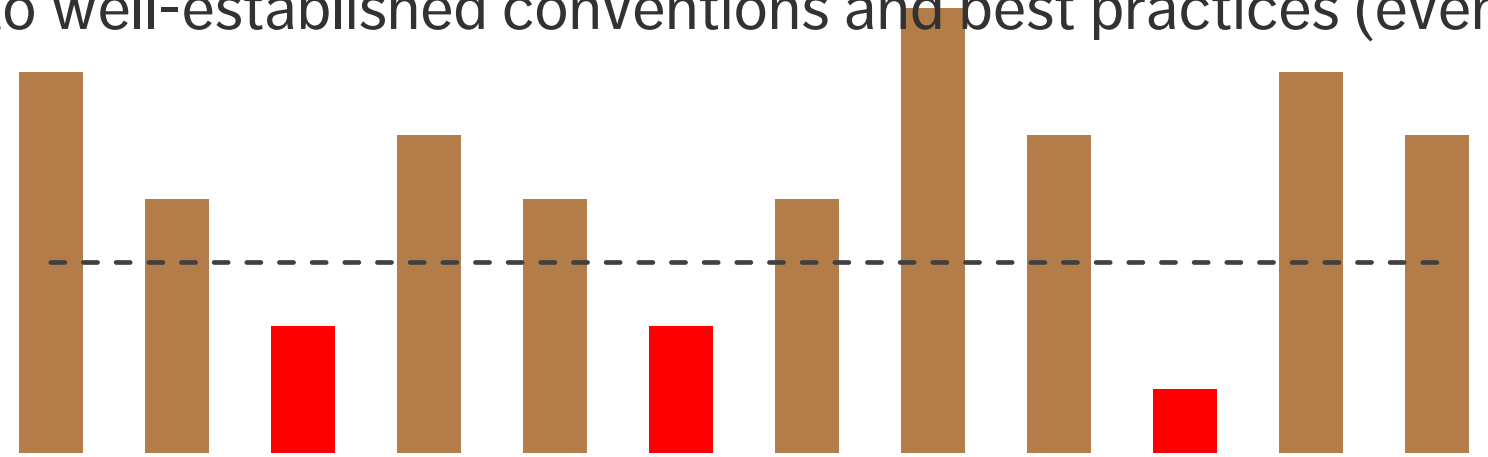


FIGURE / GROUND DUALITY

Chart elements are either perceived as **figures** (focus) or as (back)**ground**.

Foreground objects are **promoted** by the brain, background objects are **demoted**.

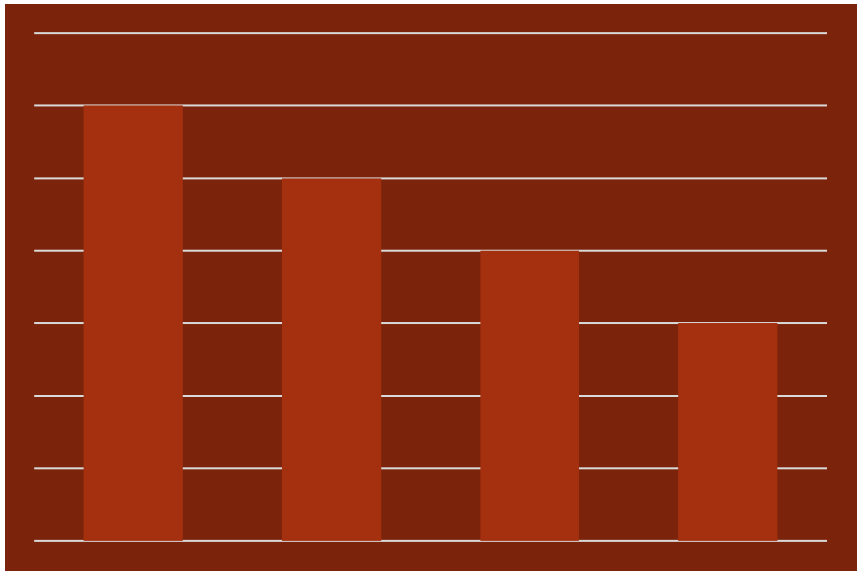
Strong contrast makes it easier to distinguish between the two types of objects.

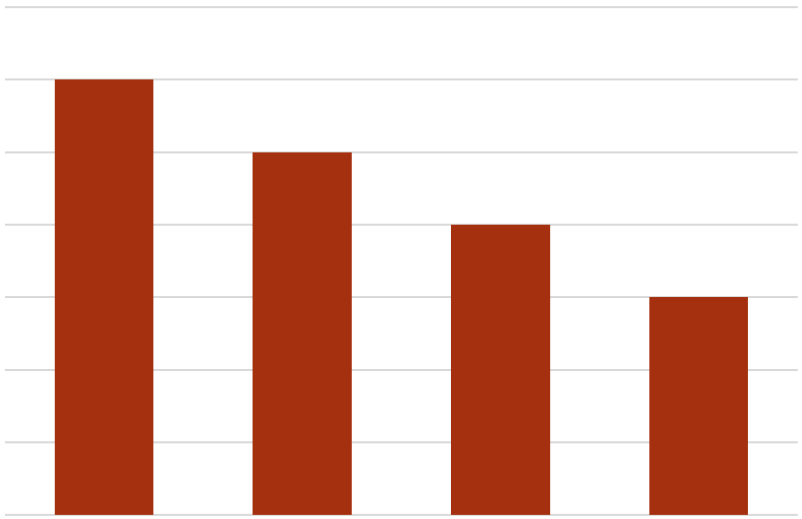
Lesson: ensure there is enough contrast between the chart foreground (figures) and their background.

FIGURE / GROUND DUALITY

Because of the low contrast between the figure and background in the chart on the left, there is an **additional cognitive load**.

Increasing the contrast on the right improves readability.





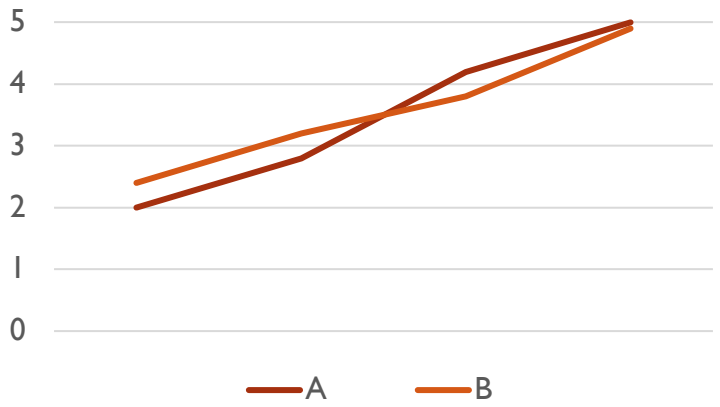
COMMON FATE

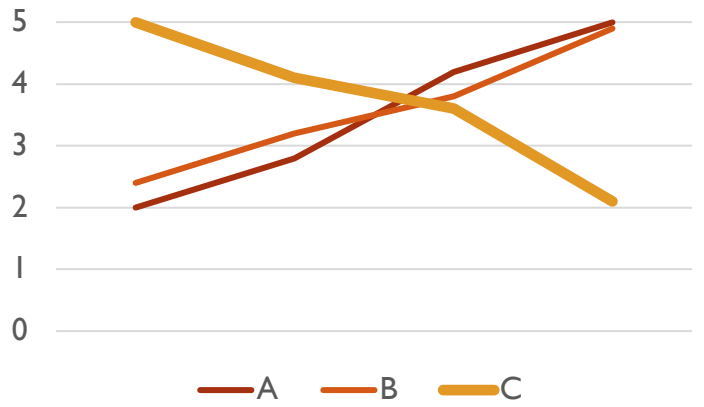
When lines or shapes **come together** (direction, location), a relationship is implied.

Askew lines or shapes are perceived as unrelated or less related.

In the graph “C” seems to belong to a different group than “A” or “B”.

Lesson: use direction and/or movement to establish or negate relationships.





DECLUTTERING

DECLUTTERING

CLUTTER IS THE ENEMY!

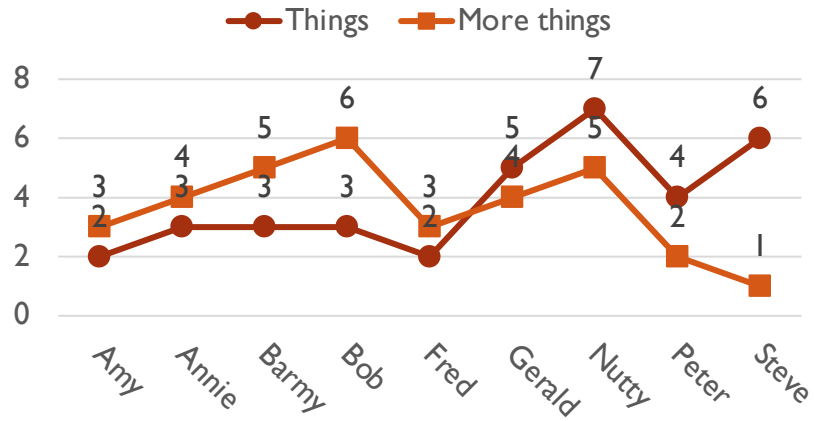
- every element on a page adds **cognitive load**
- identify anything that isn't adding value and **remove**
- think of cognitive load as mental effort required to process information (lower is better)
- Tufte refers to the **data to ink ratio** – "the larger the share of a graphic's ink devoted to data, the better"
- in *Resonate*, Duarte refers to this as "**maximizing the signal-to-noise ratio**" where the signal is the information or the story we want to communicate.

DECLUTTERING

Use the **Gestalt Principles** to organize/highlight data in the chart.

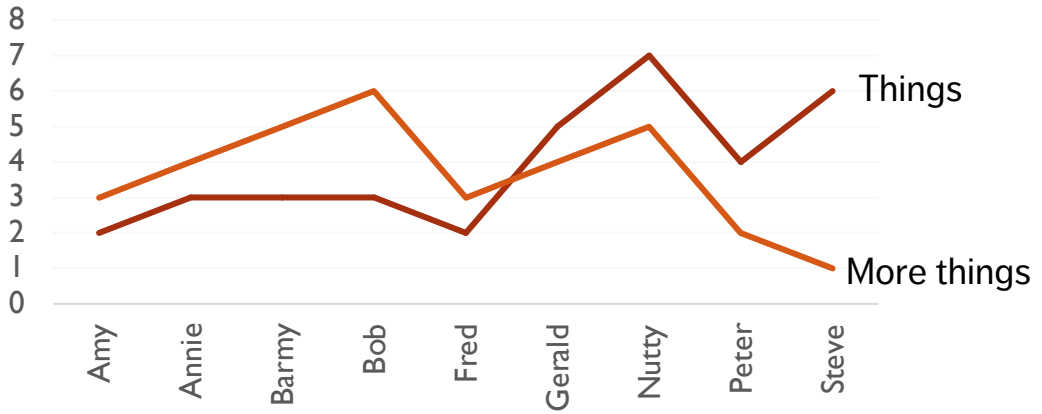
Align all the elements (graphs, text, lines, titles etc).

- DON'T rely on eye, use position boxes and values



Charts:

- remove border, gridlines, data markers
- clean up axis labels
- label data directly



DECLUTTERING

Use **consistent** font, font size, colour and alignment.

Don’t rotate text to anything other than 0 or 90 degrees.

Use **white space:**

- margins should remain free of text and visuals
- don’t stretch visuals to edge of page or too close to other visuals
- think of white space as a border

EXERCISE

Select a few charts (either among the examples we have seen so far, or something you have seen at work).

Are they too cluttered?

Does the answer depend on the audience?

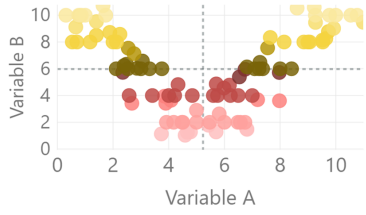
Provide some decluttering suggestions.

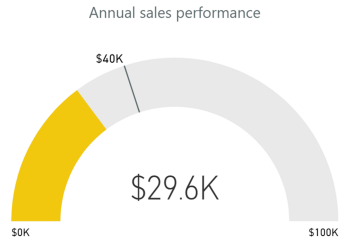
SIZE, COLOUR, AND POSITION

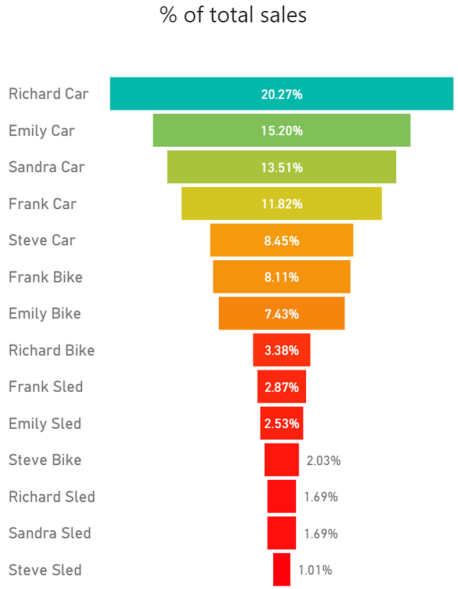
SIZE

Size: assuming that the chart has been decluttered

- things of equal importance size similarly
- other things scale to importance







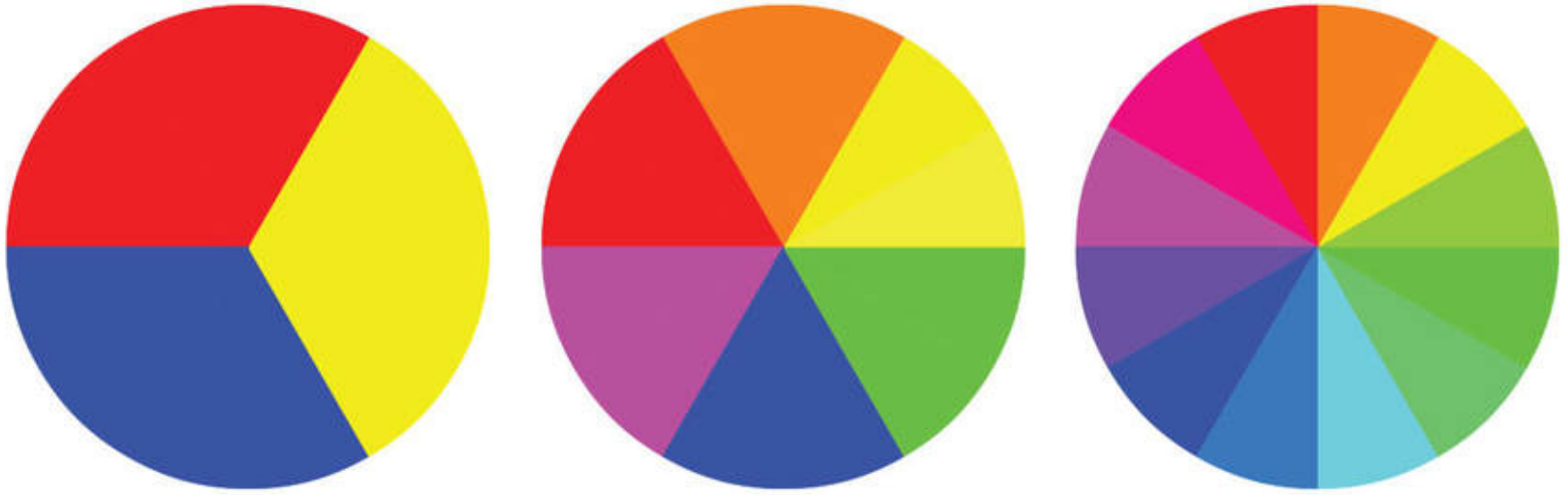
[akshaymishra.weebly.com/colour-theory.html]

COLOUR THEORY

Colour theory (complicated topic – here is a start):

- http://www.deanenettles.com/webexamples/colorexamples/
- https://www.sessions.edu/color-calculator/

Colour wheels:



Primary Colours

Secondary Colours

Tertiary Colours

[http://www.deanenettles.com/webexamples/colorexamples]

COLOUR SCHEMES

Achromatic (colourless, using only blacks, whites and grays)

Monochromatic (1-colour schemes)

Complementary (colours directly across from each other on the colour wheel)

Split complementary (2 of the 3 colors are adjacent; 1 of the colours is opposite)

[http://www.deanenettles.com/webexamples/colorexamples]

COLOUR SCHEMES

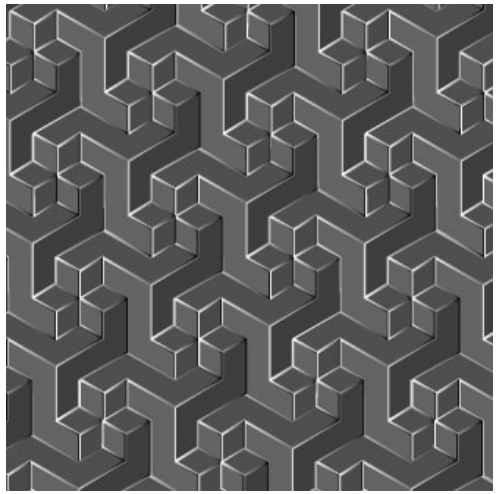
Split-Left and ***Split-Right Complementary*** ("split" colours are either to the left or right of the complementary colour)

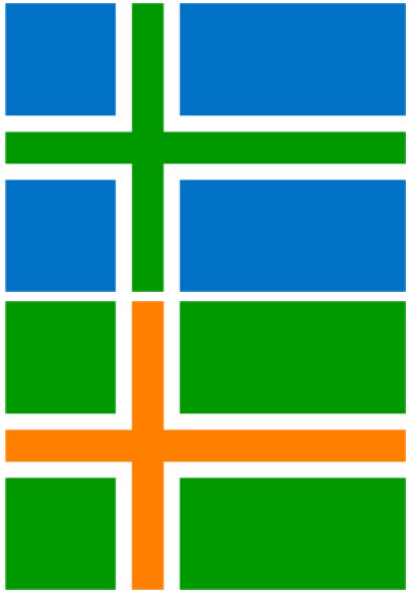
Analogous (any 3 adjacent primary, secondary, or tertiary colours on the colour wheel)

Colour Died (2 colours that are 2 colours apart on the color wheel)

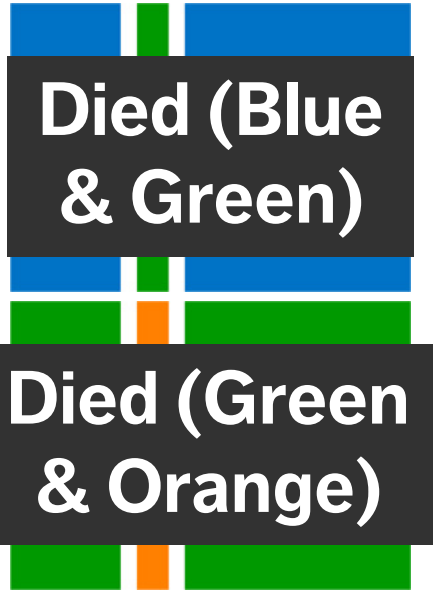
Colour Triad (3 colours, equally distant from each other on the colour wheel)

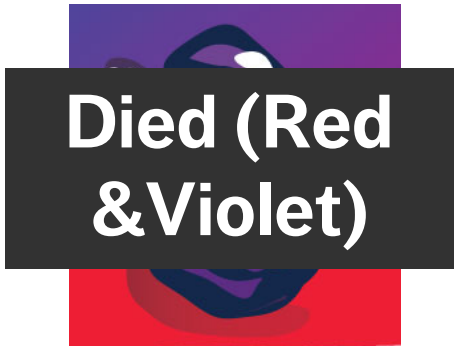
Colour Tetrad (4 or more colors on the colour wheel)





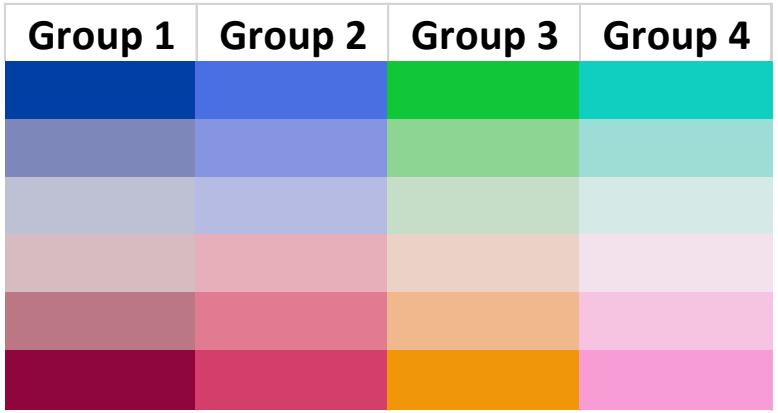
Can you identify the colour schemes underlying each of these images?





Can you identify the colour schemes underlying each of these images?

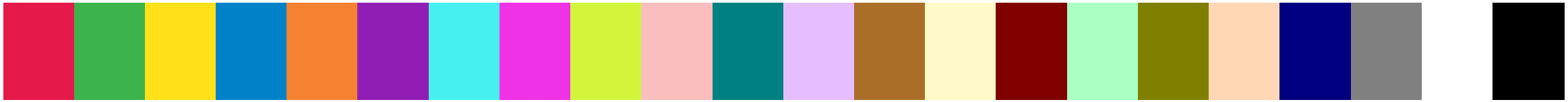
COLOUR PALETTES



Zeileis, Hornik & Murrell
24 Distinct Colours

Hex	RGB	Display	Group	Hex	RGB	Display	Group
#023FA5	(2,63,165)		1	#11C638	(17,198,56)		3
#7D87B9	(125,135,185)		1	#8DD593	(141,213,147)		3
#BEC1D4	(190,193,212)		1	#C6DEC7	(198,222,199)		3
#D6BCC0	(214,188,192)		1	#EAD3C6	(234,211,198)		3
#BB7784	(187,119,132)		1	#F0B98D	(240,185,141)		3
#8E063B	(142,6,59)		1	#EF9708	(239,151,8)		3
#4A6FE3	(74,111,227)		2	#0FCFC0	(15,207,192)		4
#8595E1	(133,149,225)		2	#9CDED6	(156,222,214)		4
#B5BBE3	(181,187,227)		2	#D5EAE7	(213,234,231)		4
#E6AFB9	(230,175,185)		2	#F3E1EB	(243,225,235)		4
#E07B91	(224,123,145)		2	#F6C4E1	(246,196,225)		4
#D33F6A	(211,63,106)		2	#F79CD4	(247,156,212)		4

COLOUR PALETTES



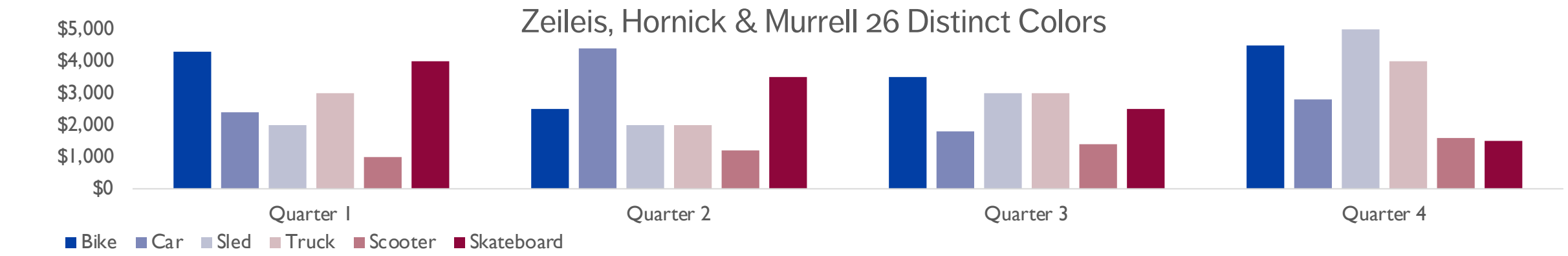
Kelly's 22 Colours of Maximum Contrast

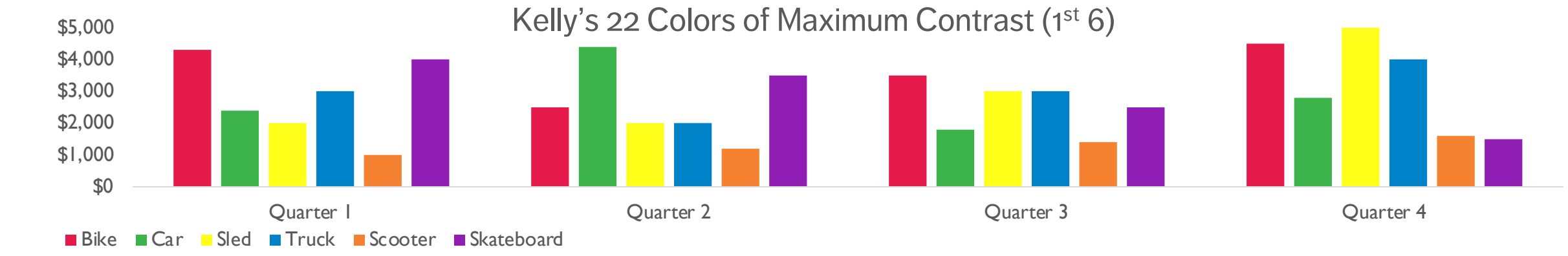
Name	Hex	RGB	Display	Name	Hex	RGB	Display
Red	#e6194b	(230, 25, 75)		Lavender	#e6beff	(230, 190, 255)	
Green	#3cb44b	(60, 180, 75)		Brown	#aa6e28	(170, 110, 40)	
Yellow	#ffe119	(255, 225, 25)		Beige	#fffac8	(255, 250, 200)	
Blue	#0082c8	(0, 130, 200)		Maroon	#800000	(128, 0, 0)	
Orange	#f58231	(245, 130, 48)		Mint	#aaffc3	(170, 255, 195)	
Purple	#911eb4	(145, 30, 180)		Olive	#808000	(128, 128, 0)	
Cyan	#46f0f0	(70, 240, 240)		Coral	#ffd8b1	(255, 215, 180)	
Magenta	#f032e6	(240, 50, 230)		Navy	#800000	(0, 0, 128)	
Lime	#d2f53c	(210, 245, 60)		Grey	#808080	(128, 128, 128)	
Pink	#fabebe	(250, 190, 190)		White	#FFFFFF	(255, 255, 255)	
Teal	#008080	(0, 128, 128)		Black	#000000	(0, 0, 0)	

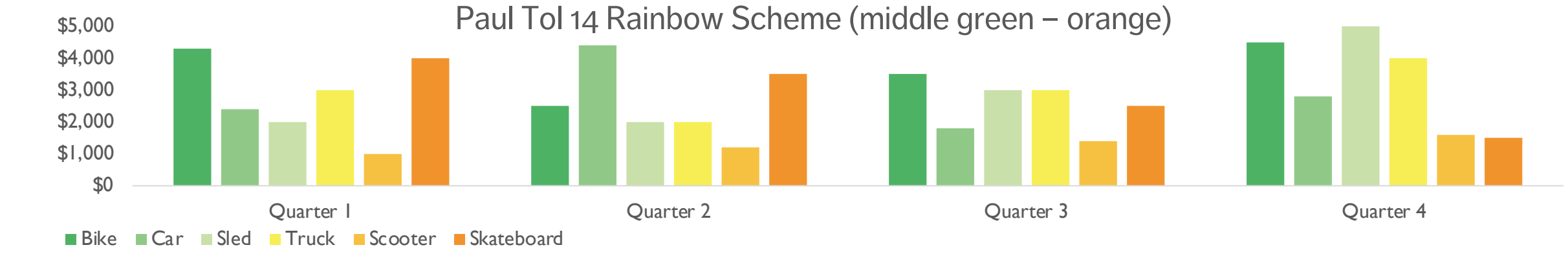
COLOUR PALETTES

Paul Tol
14 Colour
Rainbow Scheme

Hex	RGB	Display	Hex	RGB	Display
#882E72	(136,46,114)		#90C987	(144,201,135)	
#B178A6	(177,120,166)		#CAE0AB	(202,224,171)	
#D6C1DE	(214,193,222)		#F7EE55	(247,238,85)	
#1965B0	(25,101,176)		#F6C141	(246,193,65)	
#5289C7	(82,137,199)		#F1932D	(241,147,45)	
#7BAFDE	(123,175,222)		#E8601C	(232,96,28)	
#4EB265	(78,178,101)		#DC050C	(220,5,12)	


Zeileis, Hornick & Murrell 26 Distinct Colors
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Quarter 1
Quarter 2
Quarter 3
Quarter 4
Bike
Car
Sled
Truck
Scooter
Skateboard


Kelly's 22 Colors of Maximum Contrast (1st 6)
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Quarter 1
Quarter 2
Quarter 3
Quarter 4
Bike
Car
Sled
Truck
Scooter
Skateboard


Paul Tol 14 Rainbow Scheme (middle green – orange)
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Quarter 1
Quarter 2
Quarter 3
Quarter 4
Bike
Car
Sled
Truck
Scooter
Skateboard

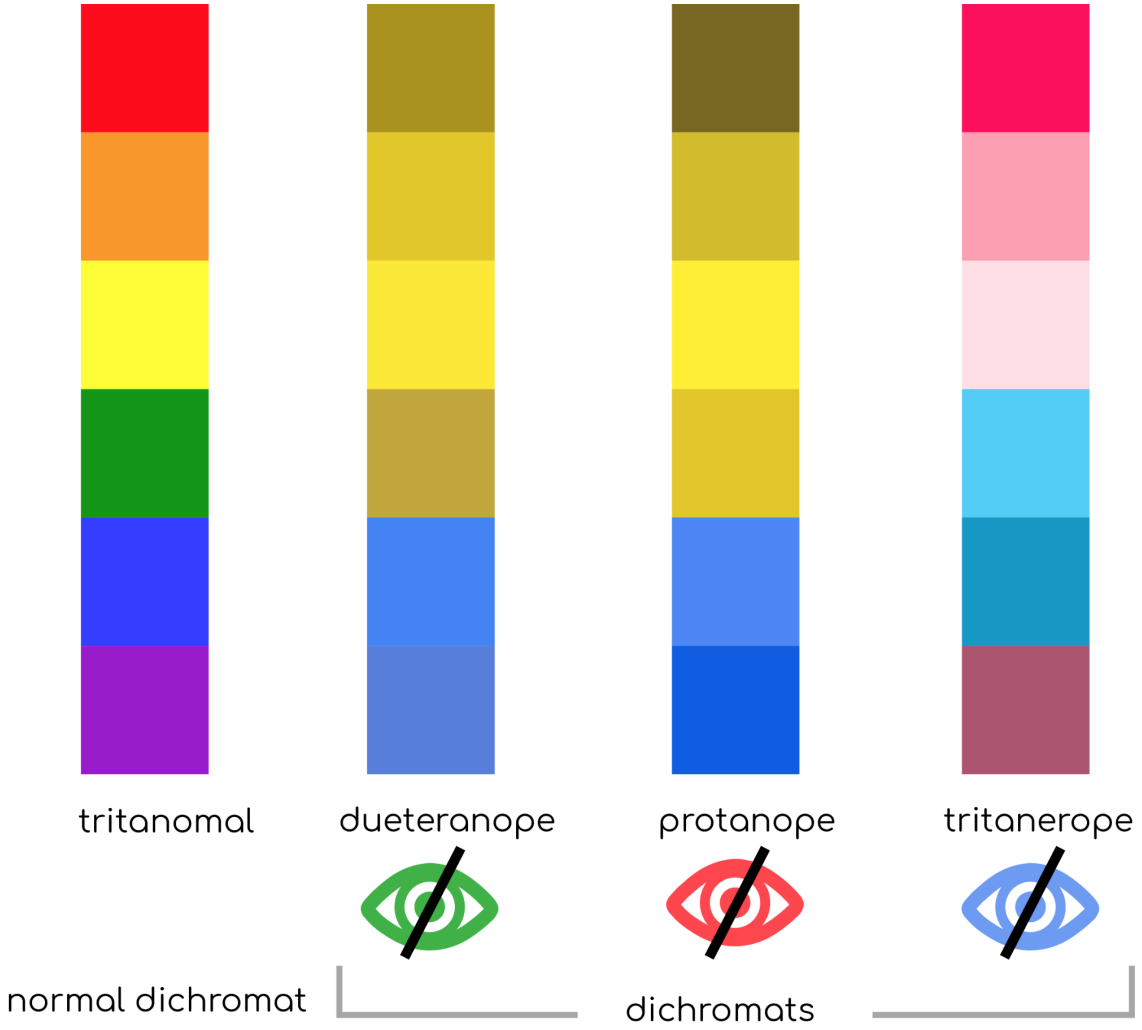
[https://www.uxbooth.com/articles/accessibility-visual-design]

COLOURBLINDNESS

A sizeable proportion of the population (~8%) is **colourblind**, to some degree.

Charts that rely on colours might fail to convey the full extent of the data story to a significant proportion of the audience.

Consider using **contrast-friendly** palettes, and **not using colour alone** to convey the data story.



IDLEWYLD Sysabee DAVHILL uOttawa

COLOUR TIPS

When it comes to colour, **less is more**: use it sparingly (graphic designers are taught to “get it right, in black and white”).

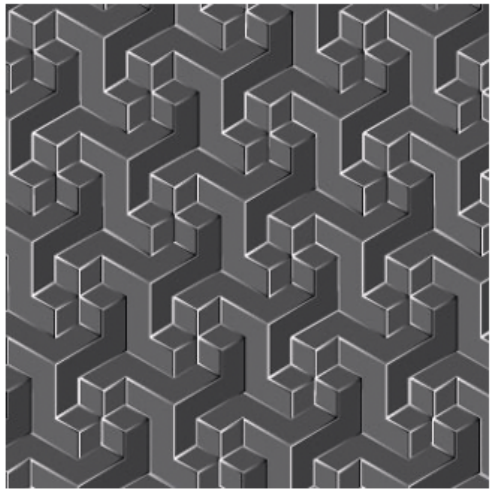
Based on the Gestalt Principles, **monochrome** schemes can be particularly effective.

When appropriate, pick scheme based on corporate identity (this maximizes buy in).

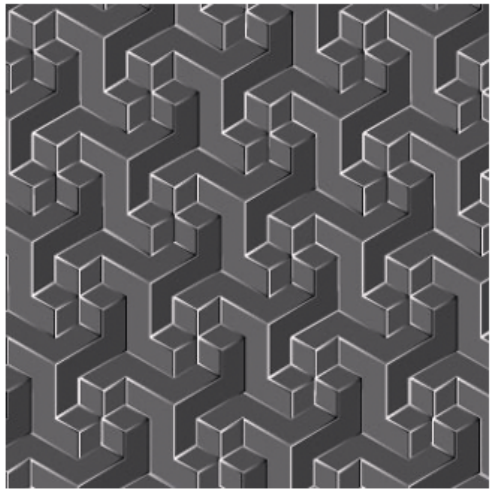
Create a template (and stick to it).

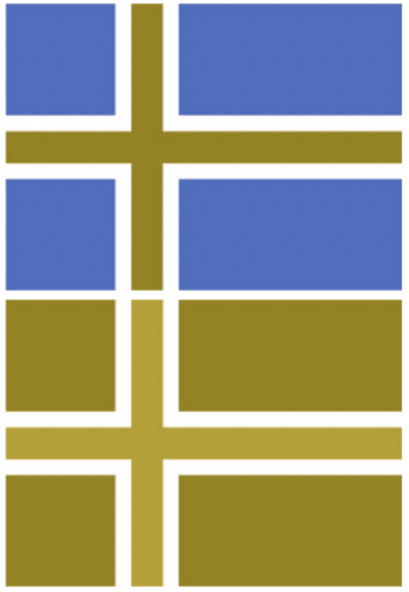
Upload images to see what charts look like in various flavours of colour-blindness:

- https://www.color-blindness.com/coblis-color-blindness-simulator (there are other tools)

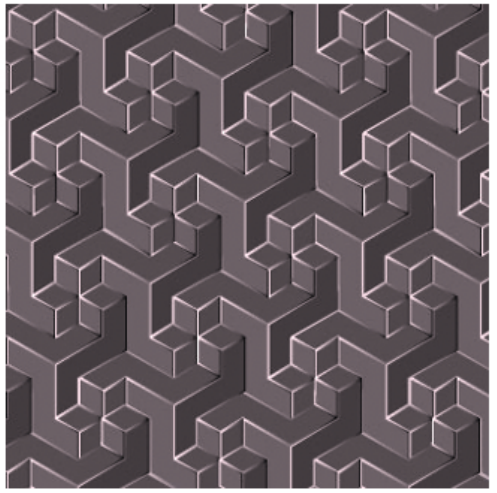


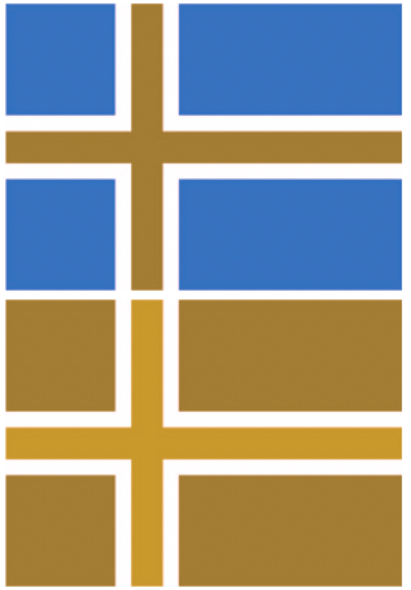
Anomalous trichomancy (red-weak)





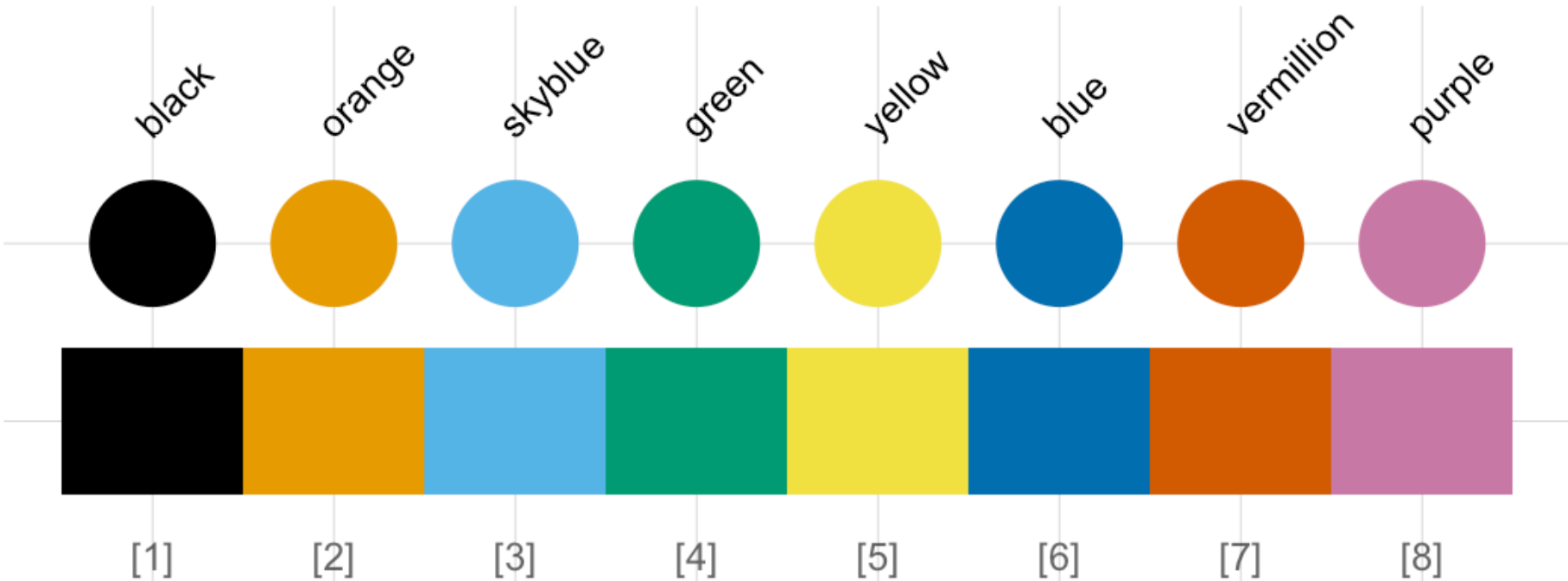
Dichromatic protanopia (red-blind)





Dichromatic deuteranopia (green-blind)

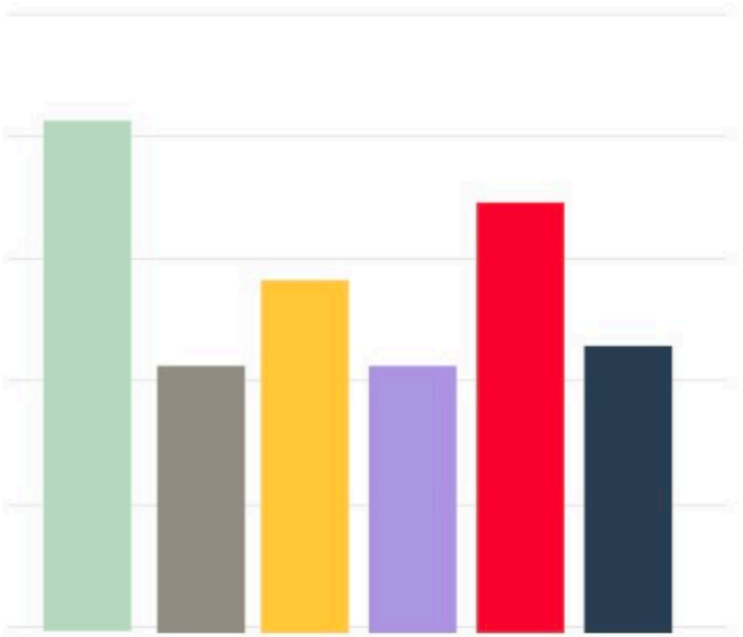
Color-blind friendly color scale (Okabe & Ito, 2002)

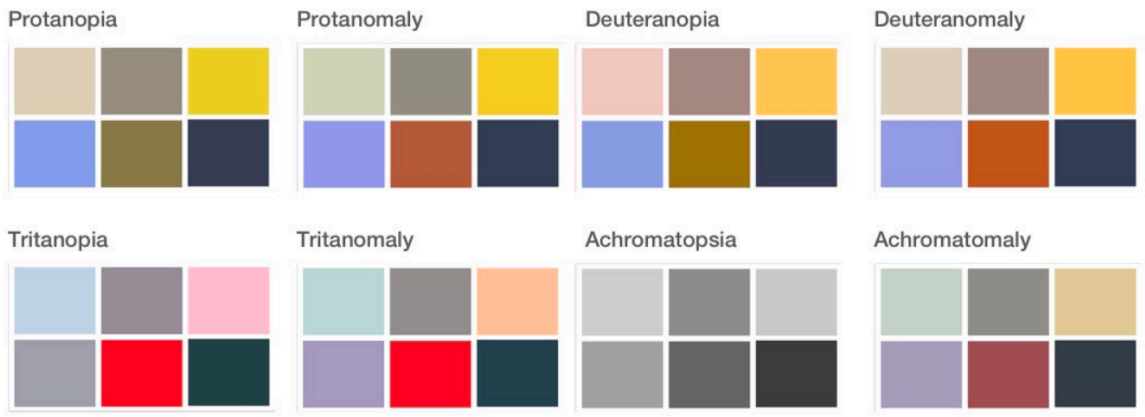


	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Hex:	#000000	#E69F00	#56B4E9	#009E73	#F0E442	#0072B2	#D55E00	#CC79A7
R:	0	230	86	0	240	0	213	204
G:	0	159	180	158	228	114	94	121
B:	0	0	233	115	66	178	0	167

[A. Ofisher, https://medium.com/cafe-pixo/inclusive-color-palettes-for-the-web-bbfe8cf2410e]

#BDD9BF, #929084, #FFC857 #A997DF, #E5323B, #2E4052





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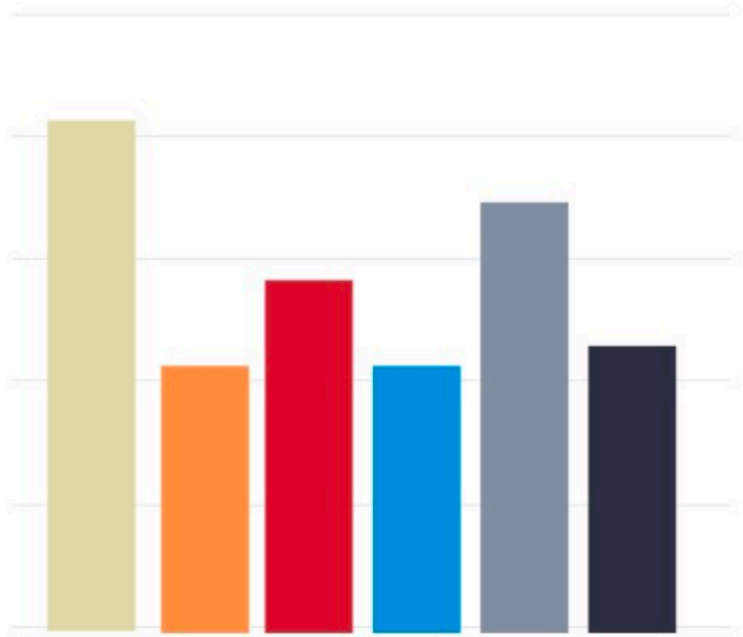
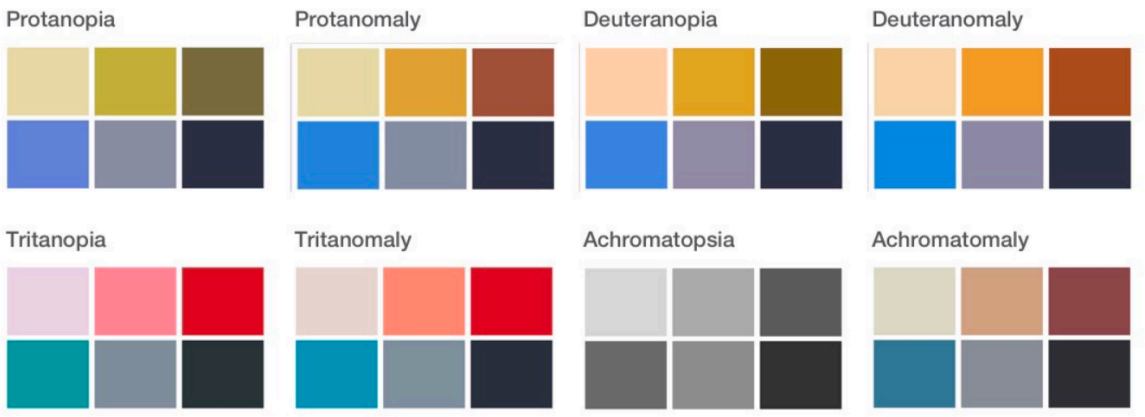
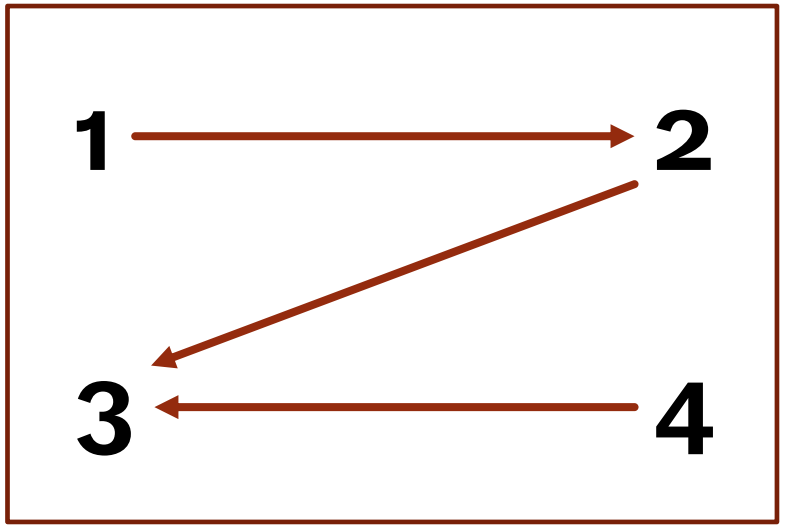




SIZE, COLOUR, AND POSITION

How should the elements be placed in a chart or a dashboard?

In the West, most people start at the top left and zig-zag all the way to the bottom right.



Simple rule: don't make people work too hard

- main message: top right
- info in order of preference
- people concentrate less as they scan so get less complex as you move to bottom corner

ACCESSIBILITY

PART II – BEST PRACTICES IN DATA VISUALIZATION

A WORD ABOUT ACCESSIBILITY

A table can be translated to Braille, but that's not always possible for charts.

Describing the features and emerging structures in a visualization is a possible solution... **if they can be spotted.**

Analysts must produce clear and meaningful visualizations, but they must also describe them and their features in a fashion that allows all to "see" the insights.

This requires them to have "seen" all the insights, which is not always necessarily the case (if at all possible).

A WORD ABOUT ACCESSIBILITY

Data Perception:

- texture-based representations
- text-to-speech
- sound/music
- odor-based or taste-based representations (?!?)

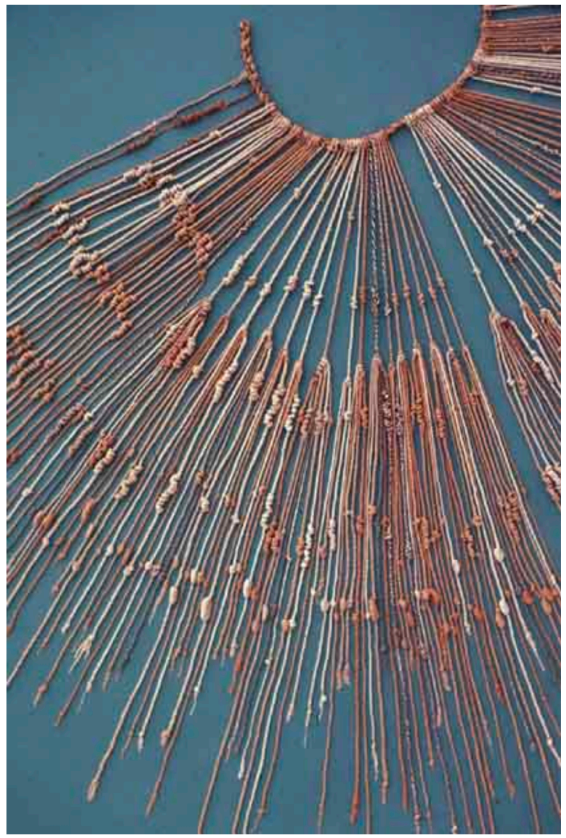
Sonifications:

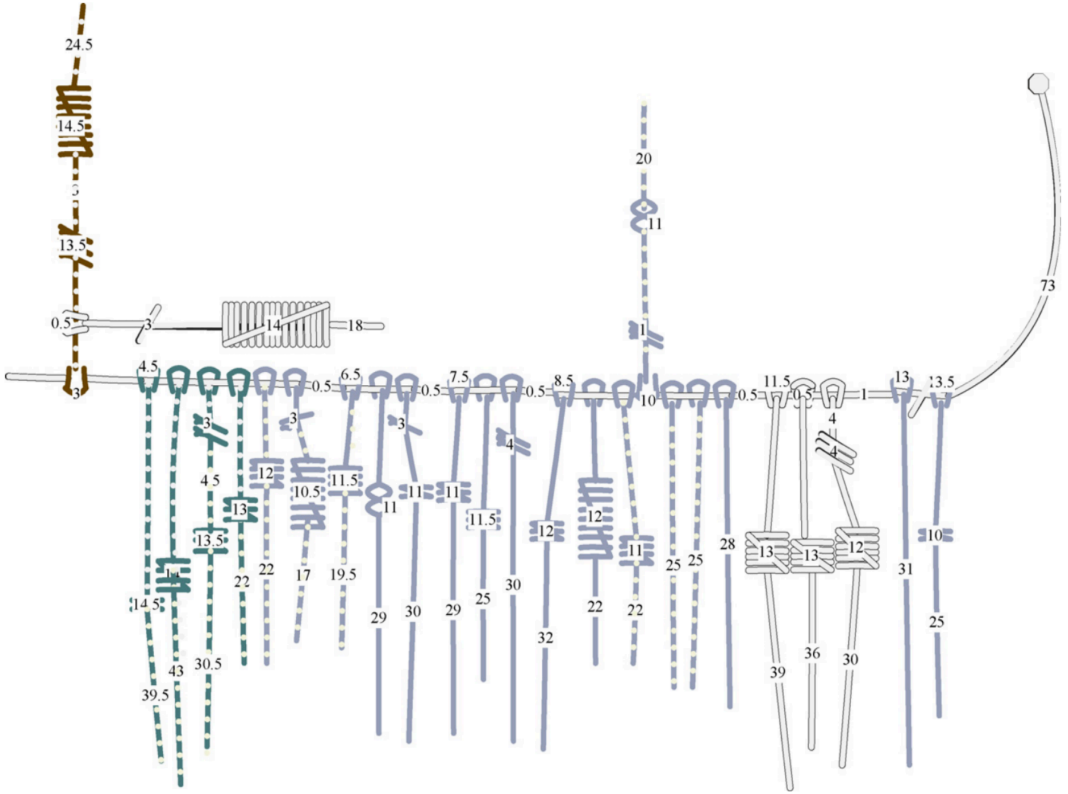
- TRAPPIST Sounds : TRAPPIST-1 Planetary System Translated Directly Into Music
- Listening to data from the Large Hadron Collider, L. Asquith

PHYSICALIZATIONS

Inca Quipus

- used as a data storage device
- it is believed that **color**, **relative position of knots**, **knot types**, and **rope length** were used to encode the variables.

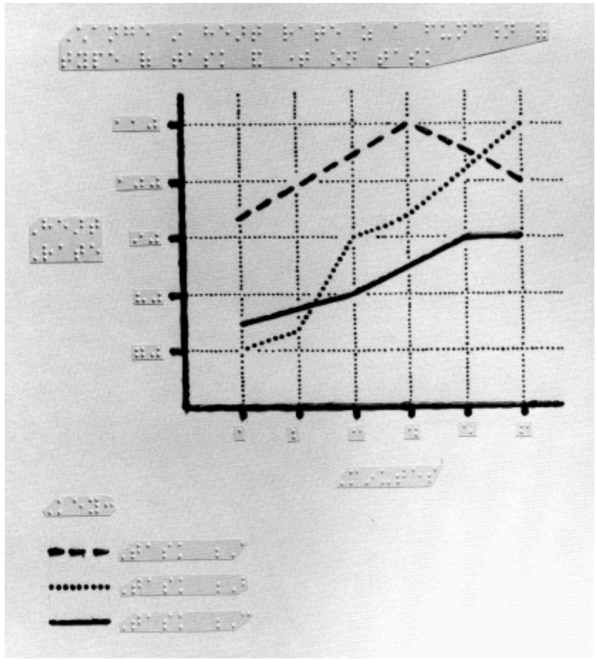


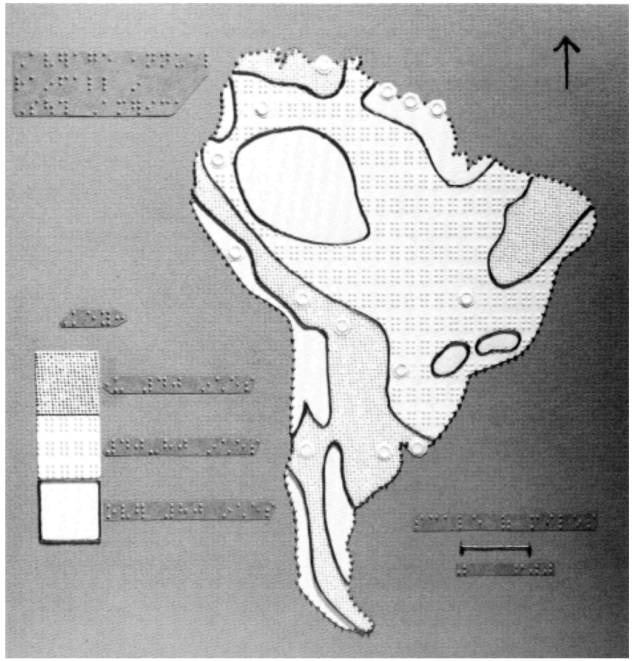


PHYSICALIZATIONS

Tactile Infographics

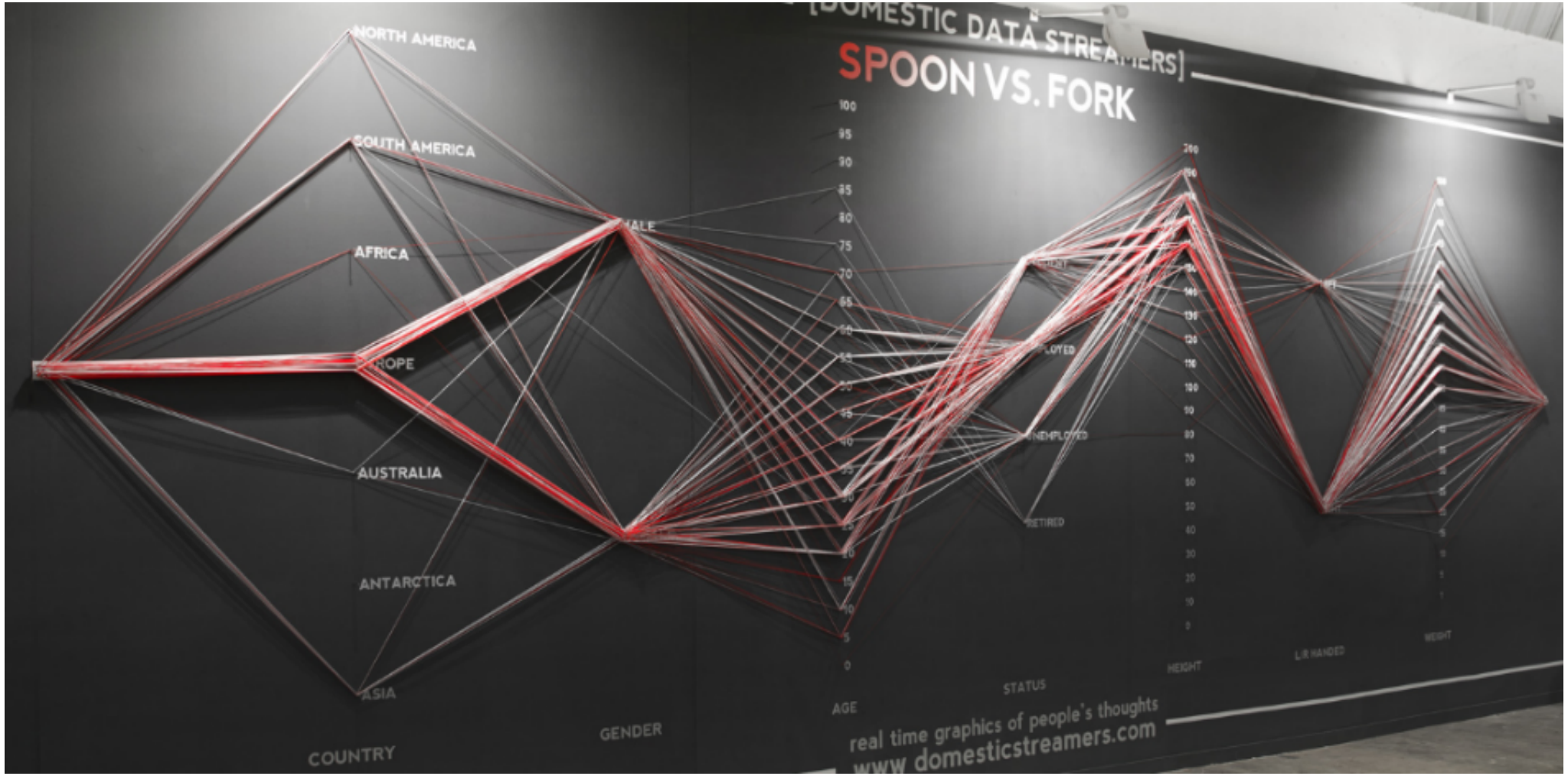
- **thermoform:** heated sheet of plastic sealed on a physical model
- **swell paper:** thermoform-lite
- **tactile map variables:** vibration, flutter, pressure, temperature, size, shape, texture, grain, orientation, and elevation.
- **audio tactile maps:** use software with audio files to convey information as the user's finger rolls over features or symbols





[domesticstreamers.com]

Spoon vs. Fork



Are there any issues with data collection? Where do you think this event took place? Is the spoon/fork question a red herring?