

# Intro to data visualization

by **Sofía Galván & Miranta Kouvari**

Palaeoverse hackathon

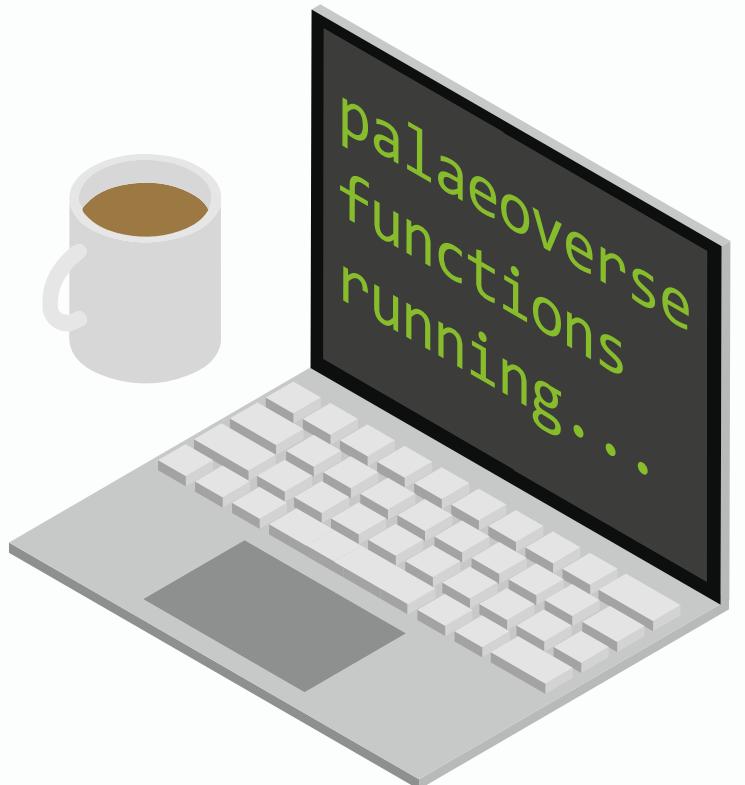
7<sup>th</sup> & 8<sup>th</sup> September 2023

UCL, London



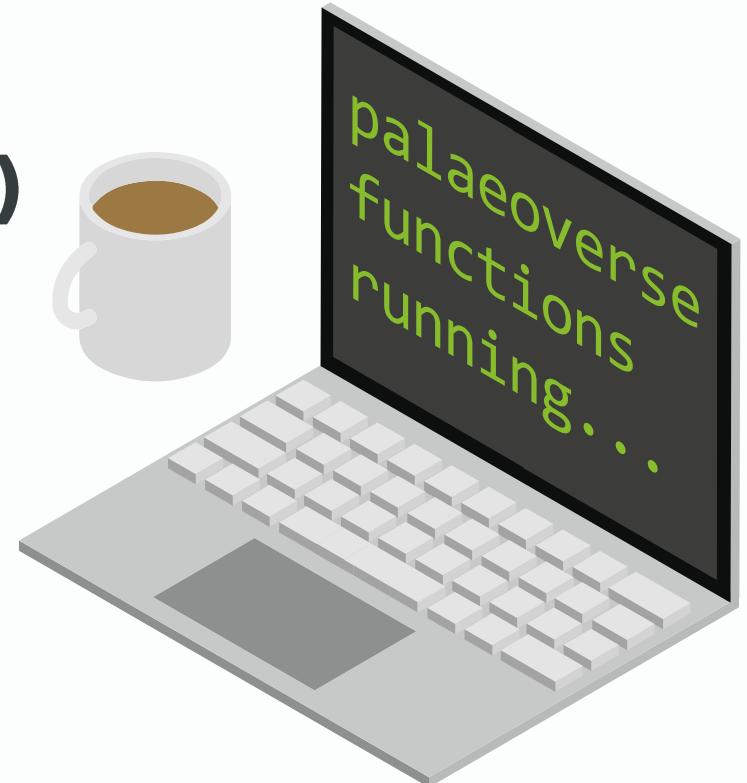
# Schedule

- 1. 10 mins theory**
- 2. 50 mins practical**



# Theory

- 1. What is data visualization**
- 2. Basic design principles (colour & type)**
- 3. What graph for what data**
- 4. Common mistakes**
- 5. File types**



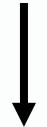
# What is data visualization

The representation of data  
through the use of **graphs**.

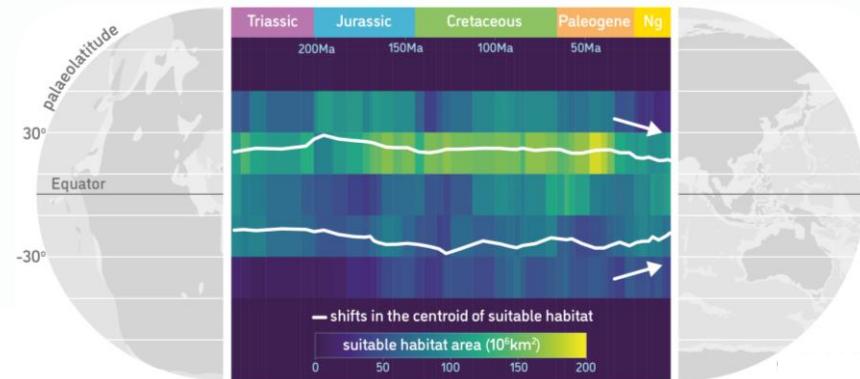
# What is data visualization



Figurative  
illustrations



figurative



Illustrated  
explanatory graphics



abstract



# Basic design principles

Colour

Type

Positioning (ggplot and R take care of that mostly)

# Basic design principles

# Colour

- Colours can be specified by an **RGB or HEX code**

#ffbee1 rgb(255, 238, 238)	#fce4ec rgb(252, 226, 236)	#3c5f5 rgb(23, 226, 246)	#ede76 rgb(231, 226, 246)	#e8eaf6 rgb(221, 242, 256)	#e32fd rgb(225, 246, 256)	#e1f5fe rgb(224, 241, 256)	#e07fa rgb(224, 241, 249)	#e0f2f1 rgb(224, 241, 233)	#e8f5e9 rgb(24, 241, 233)	#f1f8e9 rgb(24, 248, 233)	#ffbe7 rgb(24, 241, 233)	#ffde7 rgb(25, 254, 233)	#ff8e1 rgb(25, 245, 226)	#fff3e0 rgb(25, 243, 224)	#fbe9e7 rgb(25, 238, 228)	#efeb3 rgb(25, 238, 238)	#fafafa rgb(250, 250, 250)	#ecef11 rgb(255, 238, 246)	#fffff rgb(255, 255, 255)
#ffccdd2	#fbbcd0	#ebe7e7	#d4c4e9	#c5cae9	#b8defb	#b3e5fc	#b2ebf2	#b2dfdb	#c8e6c9	#dcdec8	#f0f4e3	#ff9c4	#ffecb3	#ffe0b2	#ffcacbc	#d7ccc8	#f5f5f5	#c1d8dc	#000000
#ef9a9a	#f48fb1	#ce93d8	#b39ddb	#9fa8da	#90caf9	#81d4fa	#80dee9	#80cbc4	#a5d6a7	#c5e15	#e6e09c	#ff159d	#ff0e82	#ffca80	#ffab91	#bcaa4	#eeeeee	#b0bec5	
#e57373	#f06292	#ba688	#9575cd	#7986cb	#64b5f6	#4fc3f7	#4dd0e1	#4db5ac	#81784	#e0581	#dce775	#ff176	#ff154f	#ffb74d	#ff8a65	#a1887f	#e0e0e0	#f9a5ae	
#ef5350	#ec407a	#fab470c	#7e57c2	#5c6bc0	#42a5f5	#29b6f6	#26c6da	#26a69a	#66bb6a	#9cc6b6	#d4e157	#fee59	#ffca28	#ffa726	#ff7043	#8d6663	#bdbdbd	#78909c	
#f44336	#e91e63	#9c27b0	#673ab7	#3f51b5	#2196f3	#03a9f4	#00bcd4	#009688	#4caf50	#8bc34a	#ffeb3b	#ffc107	#ff9800	#ff5722	#795548	#9e9e9e	#607d8b		
#e53935	#d81b60	#f824aa	#5e35b1	#3949ab	#1e88e5	#039be5	#00acc1	#00897b	#43a047	#7cb342	#f0ca33	#ffd835	#ff300	#fb8c00	#f4511e	#6d4c41	#757575	#546e7a	
#d32f2f	#c195b	#f7bf1a	#512da8	#3031f9	#1976d2	#0288d1	#0097a7	#00796b	#388e3c	#689f38	#fb42b	#fbc02d	#ff0000	#f57c00	#f64a19	#5d4037	#616161	#455a64	
#c62828	#ad1457	#6ab9a	#4527a0	#283593	#1565c0	#0277bd	#00838f	#00695c	#2e7d32	#55b2f	#f9e9d4	#f9a925	#ff8000	#ff5722	#4e342e	#424242	#37474f		
#b7fc1c	#880e4f	#4a148c	#311b92	#1a237e	#0d47a1	#01579b	#006064	#004d40	#1b5e20	#33691e	#f827717	#f57117	#ff6f00	#e65100	#b1360c	#3e2723	#212121	#263238	
#ff8a80	#ff80ab	#ea80fc	#b388ff	#8c9eff	#82b1ff	#80d8ff	#84ffff	#a7feb	#b9f6ca	#ccff90	#f4ff81	#ffffbd	#ffe57f	#ffd180	#ff9e80				
#ff5252	#ff4081	#e040fb	#7c4dff	#536dfe	#448aff	#40c4ff	#18ffff	#64ffda	#69f0ae	#b2ff59	#eef4f1	#ffff00	#ff7d40	#ffab40	#ff6e40				
#ff1744	#f50057	#d500f9	#651fff	#3d5afe	#2979ff	#00bfff	#00e5ff	#1de9b6	#00e676	#76f03	#c6ff00	#ffea00	#ffc400	#ff9100	#ff3d00				
#d50000	#51162	#aa00ff	#6200ea	#304ffe	#2962ff	#0091ea	#00b8d4	#00bf5	#00c853	#64dd17	#aeeea0	#ff6000	#ffab00	#ff6d00	#ff2d00				

#ff8a80	#ff80ab	#ea80fc	#b388ff	#8c9eff	#82b1ff	#80d8ff	#84ffff	#a7feb	#b9f6ca	#ccff90	#f4ff81	#ffffbd	#ffe57f	#ffd180	#ff9e80				
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#ff1744	#f50057	#d500f9	#651fff	#3d5afe	#2979ff	#00bfff	#00e5ff	#1de9b6	#00e676	#76f03	#c6ff00	#ffea00	#ffc400	#ff9100	#ff3d00				
#d50000	#51162	#aa00ff	#6200ea	#304ffe	#2962ff	#0091ea	#00b8d4	#00bf5	#00c853	#64dd17	#aeeea0	#ff6000	#ffab00	#ff6d00	#ff2d00				

#ffbee	#fce4ec	#f3e5f5	#ede7f6	#e8eaf6	#e3f2fd	#e1f5fe	#e0f7fa	#e0f2f1	#e8f5e9	#f1f8e9	#f9fbe7	#ffffde7	#fff8e1	#ff3e0	#fbe9e7	#febe9	#fafafa	#ceeff1	
rgb(255, 235, 238)	rgb(252, 228, 236)	rgb(243, 229, 245)	rgb(237, 231, 246)	rgb(232, 234, 246)	rgb(227, 242, 253)	rgb(226, 245, 254)	rgb(224, 247, 250)	rgb(224, 242, 241)	rgb(223, 245, 233)	rgb(249, 248, 233)	rgb(249, 251, 239)	rgb(255, 253, 239)	rgb(255, 248, 225)	rgb(255, 243, 224)	rgb(251, 233, 231)	rgb(239, 235, 233)	rgb(250, 250, 250)	rgb(236, 239, 249)	
#ffcd2	#f8bbd0	#e1bee7	#d1c4e9	#c5cae9	#bbdefb	#b3e5fc	#b2ebf2	#b2dfdb	#c8e6c9	#dcedc8	#f0f4c3	#fff9c4	#ffecb3	#ffe0b2	#ffccbc	#d7ccc8	#f5f5f5	#cf8dc	
rgb(255, 205, 210)	rgb(248, 187, 208)	rgb(225, 190, 231)	rgb(209, 196, 233)	rgb(197, 202, 233)	rgb(187, 222, 259)	rgb(179, 229, 252)	rgb(178, 235, 242)	rgb(178, 223, 219)	rgb(200, 230, 20)	rgb(220, 237, 200)	rgb(240, 244, 195)	rgb(255, 249, 196)	rgb(255, 236, 179)	rgb(255, 224, 178)	rgb(255, 204, 188)	rgb(251, 204, 200)	rgb(245, 245, 245)	rgb(207, 216, 220)	
#ef9a9a	#f48fb1	#ce93d8	#b39ddb	#9fa8da	#90caf9	#81d4fa	#80deea	#80cbc4	#a5d6a7	#c5e1a5	#e6ee9c	#fff59d	#ffe082	#ffcc80	#ffab91	#bcaaa4	#eeeeee	#b0bec5	
rgb(239, 154, 154)	rgb(244, 143, 177)	rgb(206, 147, 216)	rgb(179, 157, 219)	rgb(159, 168, 218)	rgb(144, 202, 249)	rgb(129, 212, 250)	rgb(128, 222, 234)	rgb(128, 203, 196)	rgb(165, 214, 167)	rgb(197, 225, 165)	rgb(230, 238, 156)	rgb(255, 245, 157)	rgb(255, 224, 130)	rgb(255, 204, 128)	rgb(255, 170, 145)	rgb(238, 238, 238)	rgb(216, 190, 197)	rgb(204, 245, 245)	rgb(176, 216, 220)
#e57373	#f06292	#ba68c8	#9575cd	#7986cb	#46b5f6	#4fc3f7	#4dd0e1	#4db6ac	#81c784	#aed581	#dce775	#fff176	#ffd54f	#ffb74d	#ff8a65	#a1887f	#e0e0e0	#90a4ae	
rgb(229, 115, 116)	rgb(240, 98, 146)	rgb(186, 104, 200)	rgb(149, 117, 209)	rgb(121, 134, 203)	rgb(100, 181, 246)	rgb(79, 195, 247)	rgb(77, 208, 225)	rgb(77, 182, 172)	rgb(129, 199, 152)	rgb(174, 213, 129)	rgb(220, 231, 117)	rgb(255, 241, 118)	rgb(255, 213, 79)	rgb(255, 183, 77)	rgb(216, 136, 127)	rgb(224, 224, 224)	rgb(144, 164, 174)	rgb(204, 238, 238)	rgb(176, 190, 197)
#e15350	#ec407a	#ab47bc	#7e57c2	#5c6bc0	#42a5f5	#29b6f6	#26c6da	#26a69a	#66bb6a	#9ccc65	#d4e157	#ffe58	#ffc28	#ffa726	#f7043	#8d6e63	#bdbdbd	#78909c	
rgb(239, 83, 80)	rgb(236, 64, 122)	rgb(171, 71, 188)	rgb(126, 87, 194)	rgb(92, 107, 192)	rgb(66, 165, 246)	rgb(41, 162, 246)	rgb(38, 198, 216)	rgb(28, 166, 154)	rgb(202, 187, 106)	rgb(156, 204, 129)	rgb(212, 225, 87)	rgb(255, 238, 88)	rgb(255, 202, 40)	rgb(255, 167, 36)	rgb(215, 162, 67)	rgb(241, 160, 99)	rgb(189, 189, 189)	rgb(202, 144, 159)	rgb(176, 216, 220)
#f44336	#e91e63	#9c27b0	#673ab7	#3f51b5	#2196f3	#03a9f4	#00bcd4	#009688	#4caf50	#8bc34a	#cdc39	#ffeb3b	#ffc107	#ff9800	#f5722	#9f5548	#9e9e9e	#607d8b	
rgb(244, 67, 54)	rgb(233, 30, 99)	rgb(156, 39, 176)	rgb(103, 58, 183)	rgb(63, 81, 189)	rgb(33, 150, 243)	rgb(169, 244)	rgb(166, 230)	rgb(160, 136)	rgb(76, 175, 80)	rgb(139, 195, 74)	rgb(205, 220, 57)	rgb(255, 235, 59)	rgb(255, 193, 7)	rgb(255, 152, 0)	rgb(255, 87, 34)	rgb(21, 85, 72)	rgb(158, 158, 158)	rgb(96, 125, 139)	rgb(176, 216, 220)
#e53935	#d81b60	#8e24aa	#5e35b1	#3949ab	#1e88e5	#039be5	#00acc1	#00897b	#43a047	#7cb342	#c0ca33	#ffdd835	#ffb300	#fb8c00	#f4511e	#6d4c41	#757575	#546e7a	
rgb(229, 57, 59)	rgb(216, 27, 96)	rgb(142, 36, 170)	rgb(94, 53, 177)	rgb(57, 73, 171)	rgb(10, 136, 229)	rgb(165, 226)	rgb(172, 183)	rgb(137, 123)	rgb(67, 160, 79)	rgb(124, 179, 66)	rgb(192, 202, 59)	rgb(253, 216, 53)	rgb(255, 178, 0)	rgb(251, 140, 0)	rgb(244, 81, 39)	rgb(109, 117, 117)	rgb(84, 110, 122)	rgb(161, 161, 161)	rgb(97, 97, 97)
#d32f2f	#c2185b	#7b1fa2	#512da8	#303f9f	#1976d2	#0288d1	#0097a7	#00796b	#388e3c	#689f38	#af4b2b	#fbc02d	#ffa000	#f57c00	#e64a19	#5d4037	#616161	#455a64	
rgb(211, 47, 47)	rgb(194, 24, 99)	rgb(123, 31, 162)	rgb(88, 45, 166)	rgb(48, 63, 159)	rgb(216, 188, 210)	rgb(136, 209)	rgb(151, 167)	rgb(121, 107)	rgb(65, 142, 60)	rgb(104, 155, 96)	rgb(175, 180, 49)	rgb(251, 192, 41)	rgb(255, 160, 0)	rgb(245, 124, 0)	rgb(230, 74, 25)	rgb(93, 64, 55)	rgb(97, 97, 97)	rgb(69, 90, 100)	rgb(176, 216, 220)
#c62828	#ad1457	#6a1b9a	#4527a0	#283593	#1565c0	#0277bd	#00838f	#00695c	#2e7d32	#558b2f	#9e9d24	#f9a825	#ff8f00	#ef6c00	#d84315	#4e342e	#424242	#37474f	
rgb(198, 40, 40)	rgb(173, 20, 87)	rgb(106, 27, 154)	rgb(106, 39, 160)	rgb(40, 53, 147)	rgb(21, 101, 192)	rgb(119, 189)	rgb(10, 131, 143)	rgb(10, 105, 92)	rgb(46, 125, 50)	rgb(85, 139, 47)	rgb(158, 187, 36)	rgb(249, 168, 37)	rgb(255, 143, 0)	rgb(239, 108, 0)	rgb(216, 67, 29)	rgb(6, 52, 49)	rgb(66, 66, 66)	rgb(55, 71, 79)	rgb(176, 216, 220)
#b71c1c	#880e4f	#4a148c	#311b92	#1a237e	#0d47a1	#01579b	#006064	#004d40	#1b5e20	#33691e	#827717	#f57f17	#ff6f00	#e65100	#bf360c	#3e2723	#212121	#263238	
rgb(183, 28, 28)	rgb(106, 14, 78)	rgb(74, 20, 140)	rgb(6, 27, 146)	rgb(16, 35, 126)	rgb(13, 71, 16)	rgb(1, 87, 156)	rgb(0, 96, 100)	rgb(0, 77, 64)	rgb(27, 94, 32)	rgb(51, 105, 30)	rgb(10, 119, 23)	rgb(245, 127, 21)	rgb(245, 111, 0)	rgb(255, 111, 0)	rgb(191, 54, 12)	rgb(52, 39, 35)	rgb(33, 33, 33)	rgb(38, 50, 56)	rgb(176, 216, 220)
#ff8a80	#ff80ab	#ea80fc	#b388ff	#8c9eff	#82b1ff	#80d8ff	#84ffff	#a7ffeb	#b9f6ca	#ccff90	#f4ff81	#ffff8d	#ffe57f	#ffd180	#ff9e80				
rgb(255, 138, 128)	rgb(255, 128, 17)	rgb(234, 128, 252)	rgb(179, 136, 255)	rgb(140, 158, 255)	rgb(130, 177, 255)	rgb(128, 216, 255)	rgb(132, 255, 255)	rgb(167, 246, 202)	rgb(185, 246, 202)	rgb(204, 255, 144)	rgb(244, 255, 129)	rgb(255, 255, 141)	rgb(255, 229, 127)	rgb(255, 209, 128)	rgb(255, 158, 128)				
#ff5252	#ff4081	#e040fb	#7c4dff	#536dfa	#448aff	#40c4ff	#18ffff	#64ffda	#69f0ae	#b2ff59	#e0ff41	#ffff00	#ffd740	#fab40	#ff6e40				
rgb(255, 82, 82)	rgb(255, 64, 129)	rgb(224, 64, 256)	rgb(124, 77, 255)	rgb(83, 109, 254)	rgb(88, 138, 255)	rgb(64, 196, 255)	rgb(6, 196, 255)	rgb(100, 255, 218)	rgb(105, 240, 174)	rgb(178, 255, 89)	rgb(238, 255, 65)	rgb(255, 255, 0)	rgb(255, 215, 64)	rgb(255, 171, 64)	rgb(255, 110, 64)				
#ff1744	#f50057	#d500f9	#651fff	#3d5afe	#2979ff	#00b0ff	#00e5ff	#1de9b6	#00e676	#76ff03	#c6ff00	#ffea00	#fc400	#ff9100	#ff3d00				
rgb(255, 23, 68)	rgb(245, 0, 67)	rgb(218, 0, 249)	rgb(101, 31, 253)	rgb(81, 93, 254)	rgb(41, 121, 255)	rgb(0, 196, 255)	rgb(0, 229, 255)	rgb(229, 233, 182)	rgb(230, 230, 188)	rgb(108, 255, 3)	rgb(178, 255, 0)	rgb(255, 234, 0)	rgb(255, 196, 0)	rgb(255, 140, 0)	rgb(255, 61, 0)				
#d50000	#c51162	#aa00ff	#6200ea	#304ffe	#2962ff	#0091ea	#00b8d4	#00bfa5	#00c853	#64dd17	#aeaee0	#ff6d00	#ffab00	#ff6d00					
rgb(213, 0, 0)	rgb(197, 17, 98)	rgb(170, 0, 255)	rgb(98, 0, 234)	rgb(48, 79, 254)	rgb(41, 98, 255)	rgb(0, 146, 234)	rgb(0, 184, 212)	rgb(0, 191, 165)	rgb(0, 200, 83)	rgb(74, 234, 0)	rgb(174, 234, 0)	rgb(255, 214, 0)	rgb(255, 171, 0)	rgb(255, 109, 0)	rgb(221, 44, 0)				
										#ffffff	rgb(255, 255, 255)								
										#000000	rgb(0, 0, 0)								

# Basic design principles Colour

You will use these HEX codes to **define colours in R and ggplot2.**

# Basic design principles Colour

You can **find HEX codes** for your preferred colours

- In software, e.g. PowerPoint (Colour>More Colours>Custom)
- Online, through websites (e.g. [HTML color codes](#), [coolors](#)) Or  
browser extensions (eg. [Color Picker](#))

# Basic design principles    Colour

You can pick your own **colour palettes**

or use already made ones e.g. [RColorBrewer](#), or [wesanderson](#) palettes.

But first, let's talk **colour accessibility**.



# Basic design principles Colour

## Accessibility

To have an accessible colour palette,  
colours must be **contrasting enough**.

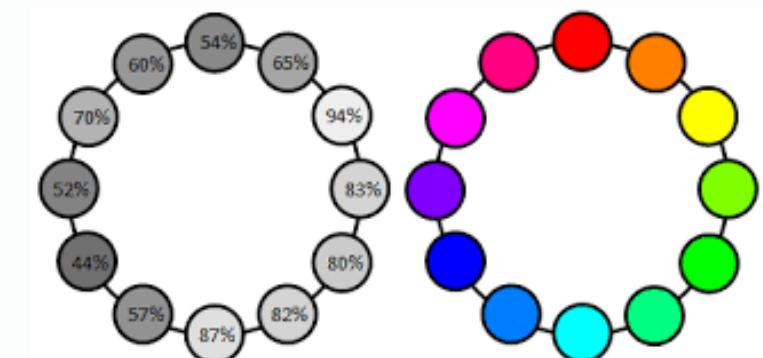
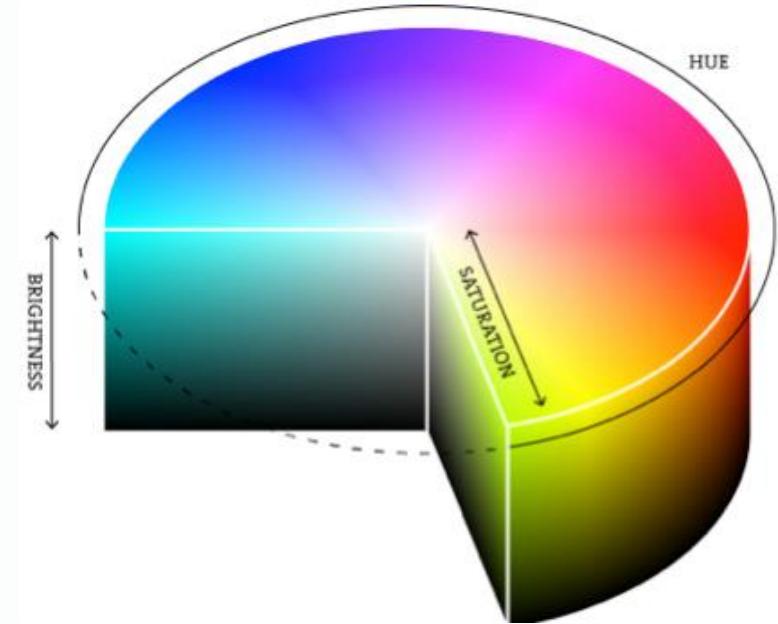


# Basic design principles Colour

## Accessibility

For this, we look at each colour's **relative luminance**, i.e. relative brightness or perceived brightness.

Insane functions and extensive info on that at [Web Content Accessibility Guidelines](#).



# Basic design principles Colour

## Accessibility

Then we compare these to each other.

**The larger the contrast ratio, the better.**

Contrast ratio	Verdict	
< 3:1	Fail	The colours are not contrasting enough
3-4.5:1	AA Large	Minimum contrast for large text
4.5-7:1	AA	Minimum contrast for normal text Enhanced contrast for large text
>7:1	AAA	Enhanced contrast

# Basic design principles    Colour

## Accessibility

- There are different ways to check if your chosen colours are contrasting enough (e.g. [ColourContrast](#) and [Colors Contrast Checker](#))
- or you can use **already made accessible colour palettes online** e.g. [venngage](#), or in R e.g. [RColorBrewer](#) and [viridis](#).

# Basic design principles    Colour

## Tips

- Colour is a powerful tool to guide the viewer's attention
- Too many colours can confuse
- Your graph **should be legible even in grayscale**, so use colours in combination with symbols etc.
- Avoid the combination of pure white and pure black

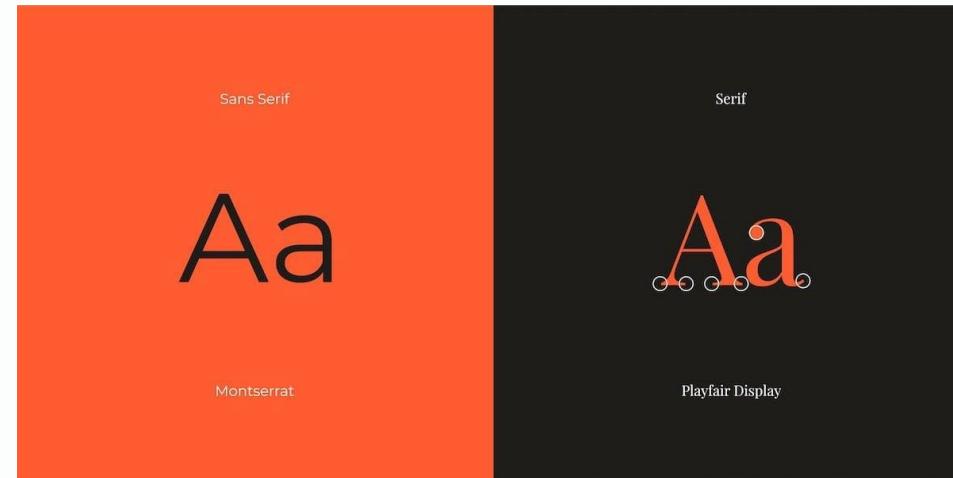
# Basic design principles

Type

There are two main group types:

**Sans Serif**

**Serif**



# Basic design principles

## Type

- You can access fonts for free at [Google Fonts](#)
- You can use these in any software, as well as R  
(using `sysfonts` and `font_add_google()`, tutorial [here](#))

# Basic design principles

## Type

We want easily readable fonts, like:

Tahoma

Calibri

Helvetica

Arial

Verdana

**Font size** is important in accessibility.

# Basic design principles

Type

## Tips

- One font is enough (max two)
- You can use **Bold** for emphasis, but *Italics* and Underline decrease accessibility
- Align text to the left (center and right-aligned is difficult to read)
- Use size as a tool to hierachise content (e.g. larger = titles)
- Use 1.5 line spacing for better readability and accessibility

# What graph for what data?

How many variables?

One variable

+1 variables

Class?

(continuous, quantitative, qualitative)

Histograms  
Density plots  
Barplots  
Boxplots

Scatterplots  
Correlation plots  
Boxplots  
Violin plots

# What graph for what data?

Most important: remember why you are plotting.

There is no golden rule. For example:

**Time**

line chart

**Distribution**

histogram, box and whiskers

**Geospatial**

map

**Relationship**

scatterplot

**Comparing categories**

barcharts

**Part of a whole**

stacked bars or piecharts

# Common mistakes

- Our brains cannot compare angles and volumes well, so best to avoid piecharts and 3D plots
- Never truncate your X/Y scales or zooming on one part of them without showing the overall pattern as well (to avoid risk of exaggerating results)
- Do not overcomplicate your graphs (sometimes two graphs are better than one combined)

Mistakes happen, even the Economist got it wrong.

# Common mistakes

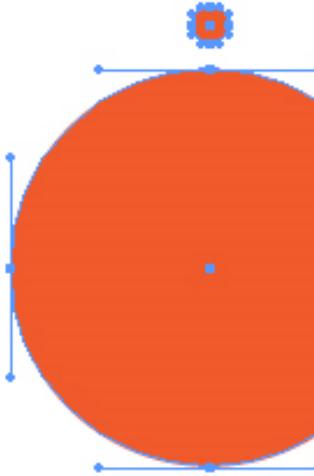
If in doubt, ask yourself:

**Is it clear what is the main point of the graph?**

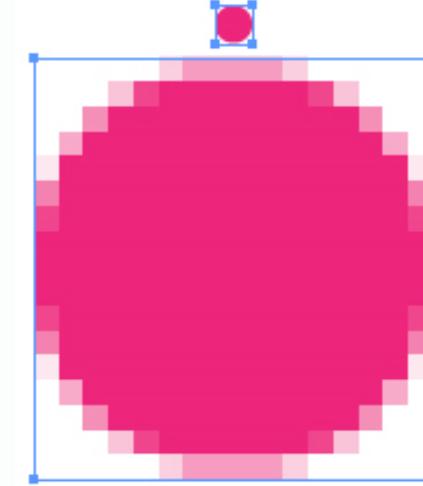
If not, rethink

1. The amount of data you chose to show
2. The type of graph
3. Your use of colour, symbols, text

# Vector images



# Pixel/Raster images



- Not scale-dependant
- Smaller size files
- Easily editable
- Usually have less details/textures etc.
- Can easily be converted to raster files

- Scale-dependant
- Large size files
- Not easily editable
- Can have lots of details/textures etc.
- Can't be converted easily to vector files

# File Types

You can **export your plots from R** in many file formats

e.g. using `ggsave()` and you can export in .png or .svg

File name	File type	
.jpg	Raster	Can't have transparent parts!
.png	Raster	Can also have transparent parts!
.svg	Vector	Vector image format – you can edit it in inkscape/illustrator!
.pdf	Vector	Not actually an image file type, but can be used

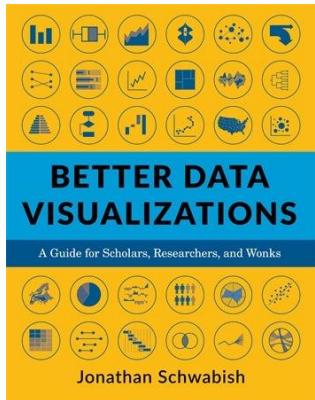
# Visualization resources in R

More?

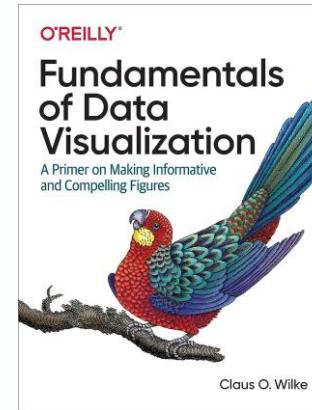
- {Lattice} package: emphasis on multivariate data.
  - {Scatterplot3d} package: 3D plots
  - {highcharter} package: R wrapper for Highcharts javascript library .
  - {plotly} package: contour plots, candlestick charts, 3D charts...
  - {rgl} package : 3D plots
- Spatial data
- Packages with specific object classes ({sp} - spatialobject, {sf} - sf, {raster} - raster, {terra} - rast).
  - Plotting: {graphics}, {ggplot3}, {sp}, {sf}, {raster}, {terra}, {utils}, {maps}, {tmap}, {maps}, {spatstat}, {rasterVis} packages...

- Base R (package *{graphics}*)
- Ggplot (package *{ggplot2}*)

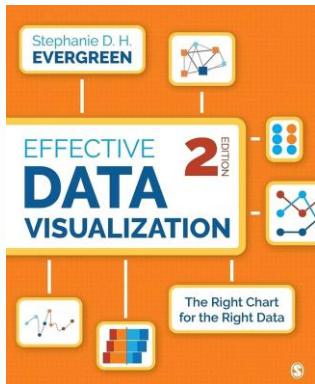
# Data Visualization books



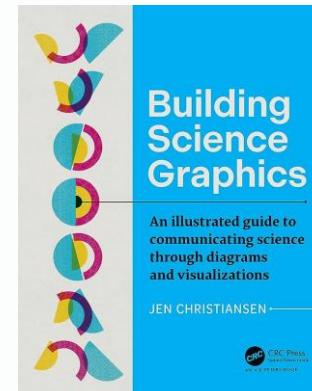
Better Data Visualizations  
by Jonathan Schwabish  
(Columbia University Press).



Fundamentals of Data  
Visualization by Claus O  
Wilke (O'Reilly Media Inc.).



Effective Data Visualization  
by Stephanie DH Evergreen  
(Sage Publishing).



(For science graphics)  
Building Science Graphics  
by Jen Christiansen  
(CRC Press).

# Practical

1. Data visualization  
using ggplot2

2. Data visualization  
of spatial data

