

Data Visualization

How to create informative and visually appealing figures

5th IZW PhD Symposium • Workshop by Cédric Scherer

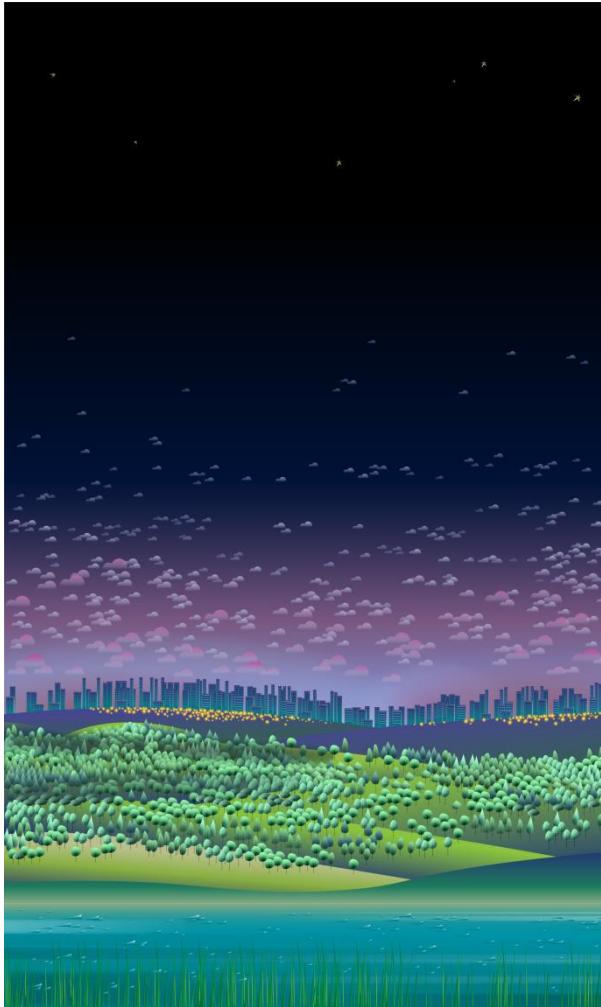


cedricscherer.netlify.com



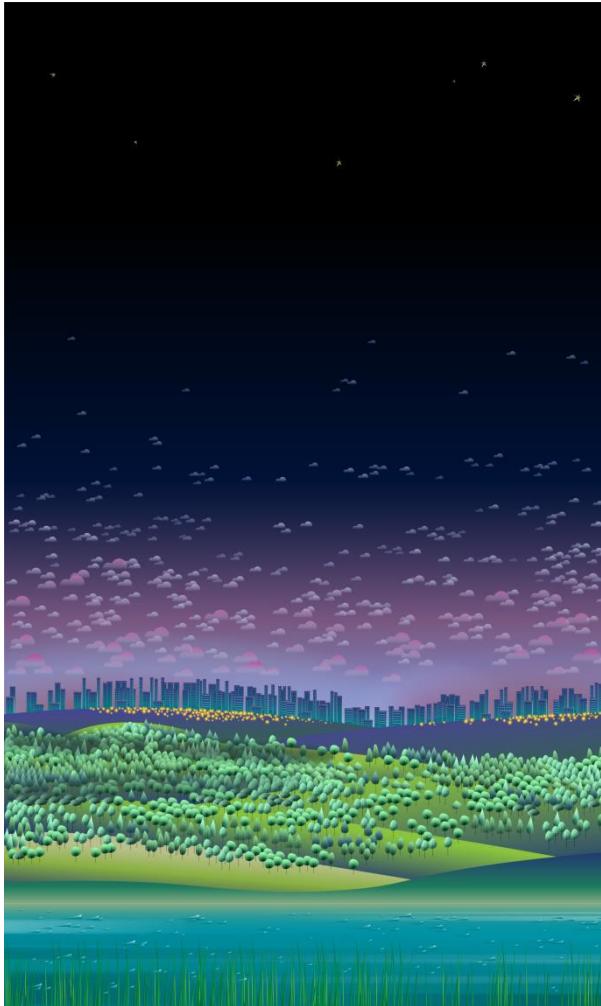
@CedScherer

You might be wondering
what you are viewing here.



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**Each element represents
a person who committed
suicide in the Netherlands
in the year 2017.**



You might be wondering what you are viewing here.

Each element represents a person who committed suicide in the Netherlands in the year 2017.



Each category/method of suicide is represented by a certain element:



hanging (strangulation)



taking drugs/alcohol/medicines



in front of train or metro



drowning



jumping from height



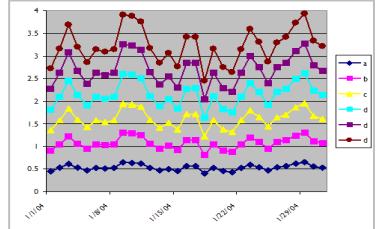
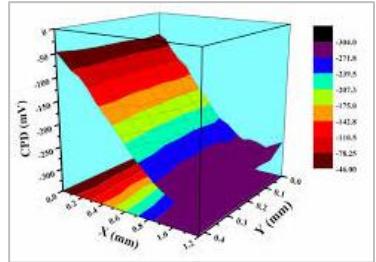
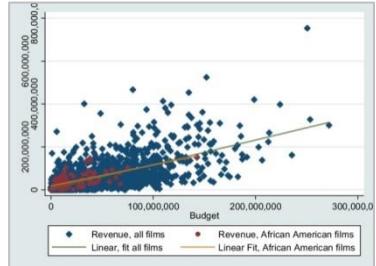
other method*



unknown method

Data visualization is any graphical representation of information and data

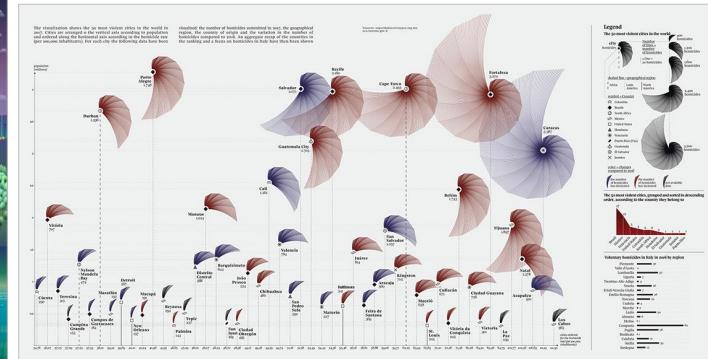
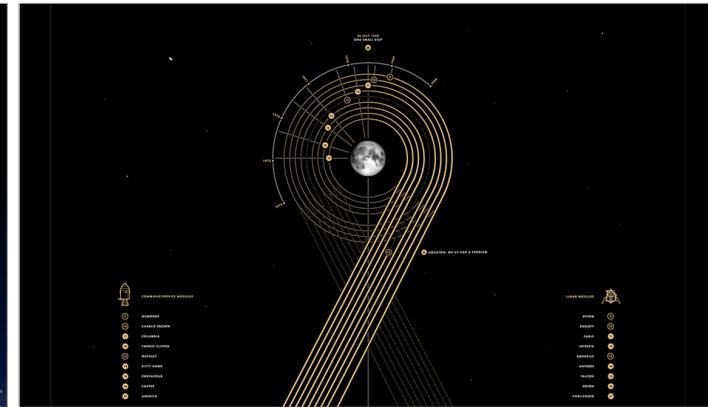
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Anonymous

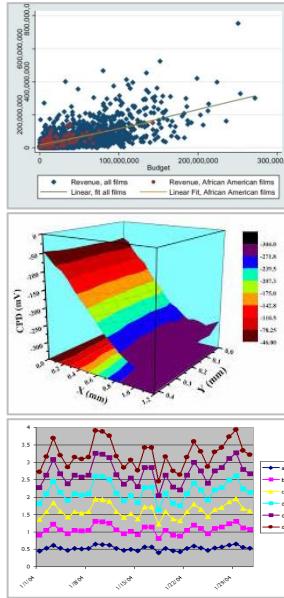


Sonia Kuijpers



Upper: Paul Button
Lower: Frederica Fragapane

Data visualization is any graphical representation of information and data



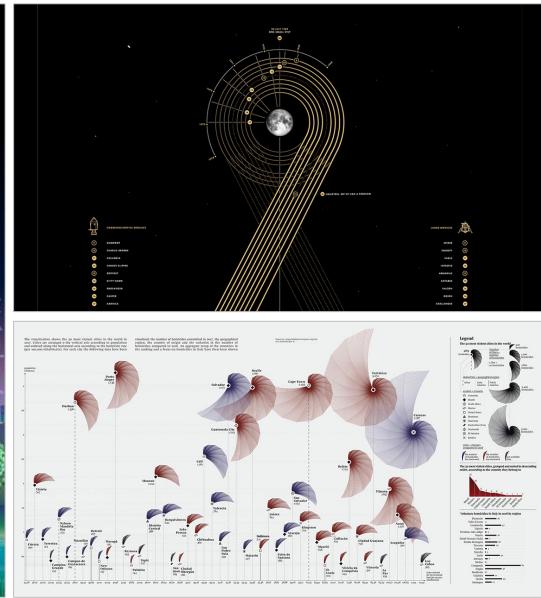
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We aim for DataViz that:

- is informative
- reduces complexity
- is easy to grasp
- is visually appealing
- draws attention



Sonia Kuijpers

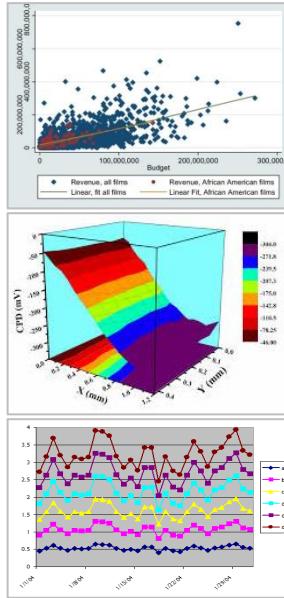


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Gradient from poorly designed & uninformative data visualization to data art



Data visualization is any graphical representation of information and data



Anonymous

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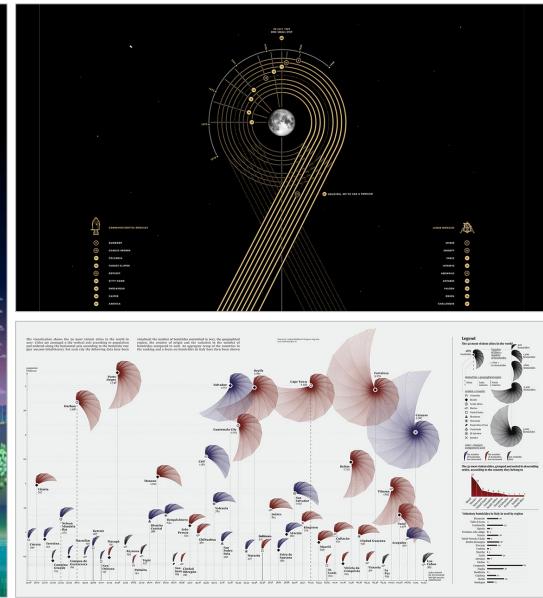
- is informative
- reduces complexity
- is easy to grasp
- is visually appealing
- draws attention

but:

- is not too abstract
- is not too “unusual”



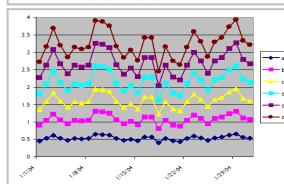
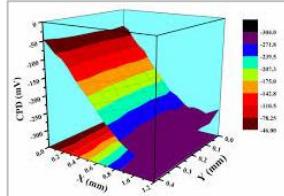
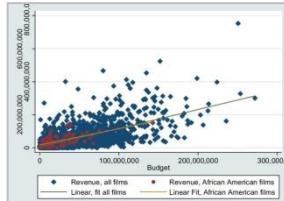
Sonia Kuijpers



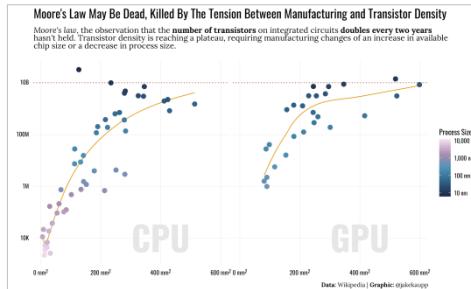
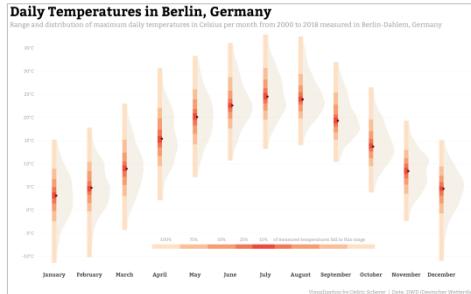
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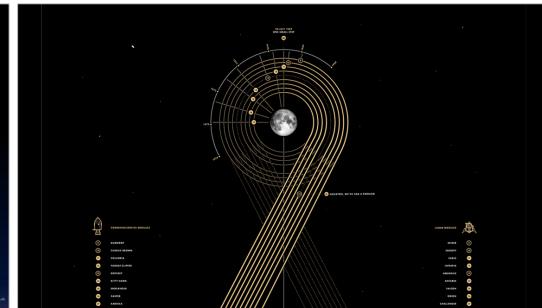
Anonymous



Upper: Cédric Scherer
Lower: Jake Kaupp



Sonia Kuijpers



Upper: Paul Button
Lower: Frederica Fragapane



Gradient from poorly designed & uninformative data visualization to data art

Know Your **Data Types**

Data Types

- **Quantitative (numerical)** versus **qualitative (categorical)** data
- **Continuous** versus **discrete** data
- **Ordered** versus **unordered** data

Data Types

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 - "female"?

Data Types

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 - 2019/09/26 "17:01:35"?

Data Types

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 - 1?

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Data Types

- Quantitative (numerical):

continuous or discrete, ordered variables

e.g. temperatures or concentrations (continuous),
age groups or species number (discrete)

- Qualitative (categorical):

discrete factors with different ordered or unordered levels (categories)

e.g. qualities or seasons (ordered),
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Data Types

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e.g. qualities or seasons (ordered),
species or sex (unordered)

- Plus special cases:

dates (discrete ordered) and **text** (discrete unordered)

Choice of the Color Palette

Color Terminology

- **Hue:** color, like blue or red
- **Chroma:** how pure a color is (saturation)
- **Value:** how light or dark a color is
- **Tint:** created by adding white to a hue
- **Tone:** created by adding grey to a hue
- **Shade:** created by adding black to a hue



visualcomposer.com/blog/ultimate-guide-to-colors-and-color-palettes

Color Palette Types

- Four main types of color palettes:

- **Categorical**



Color Palette Types

- Four main types of color palettes:

- **Categorical**



- **Sequential**



Color Palette Types

- Four main types of color palettes:

- **Categorical**



- **Sequential: Single-Hue**



- **Sequential: Multi-Hue**



Color Palette Types

- Four main types of color palettes:

- **Categorical**



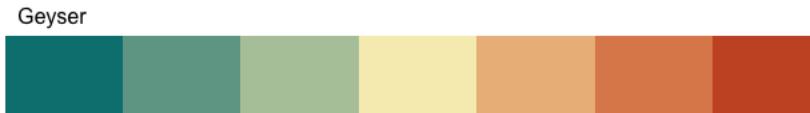
- **Sequential: Single-Hue**



- **Sequential: Multi-Hue**



- **Diverging**



Color Palette Types

- Four main types of color palettes:

- **Categorical**



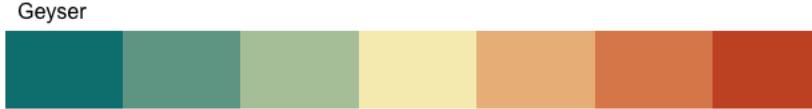
- **Sequential: Single-Hue**



- **Sequential: Multi-Hue**



- **Diverging**



- **Cyclical**



Choice of the Color Palette

Journals & Magazines > IEEE Computer Graphics and Ap... > Volume: 27 Issue: 2 [?](#)

Rainbow Color Map (Still) Considered Harmful

Publisher: IEEE

2 Author(s)

David Borland ; Russell M. Taylor II [View All Authors](#)

172
Paper Citations

3
Patent Citations

9091
Full
Text Views

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Medical Physics

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[Med Phys.](#) 2015 Jun; 42(6): 2942–2954.

Published online 2015 May 20. doi: [10.1118/1.4921125](https://doi.org/10.1118/1.4921125)

PMCID: PMC5148121

PMID: 26127048

Effect of color visualization and display hardware on the visual assessment of pseudocolor medical images

[Silvina Zabala-Travers](#), [Mina Choi](#), [Wei-Chung Cheng](#), and [Aldo Badano^a](#)

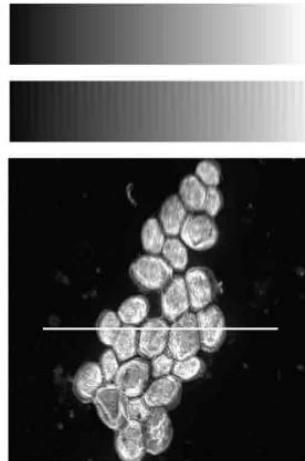
10 March 2017

Interpretation of the rainbow color scale for quantitative medical imaging: perceptually linear color calibration (CSDF) versus DICOM GSDF

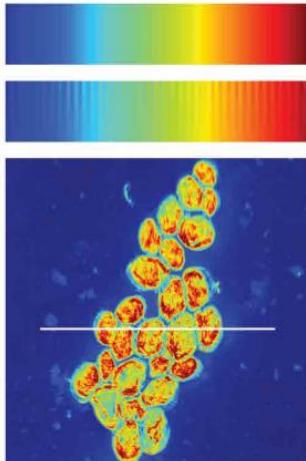
[Frédérique Chesterman](#); [Hannah Manssens](#); [Céline Morel](#); [Guillaume Serrell](#); [Bastian Piepers](#); [Tom Kimpe](#)

Choice of the Color Palette

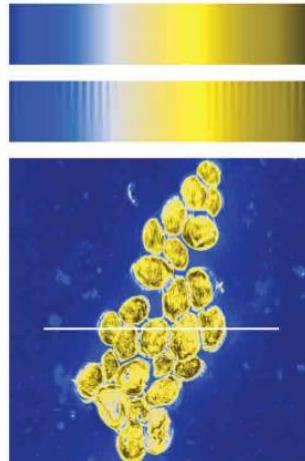
a) Grey



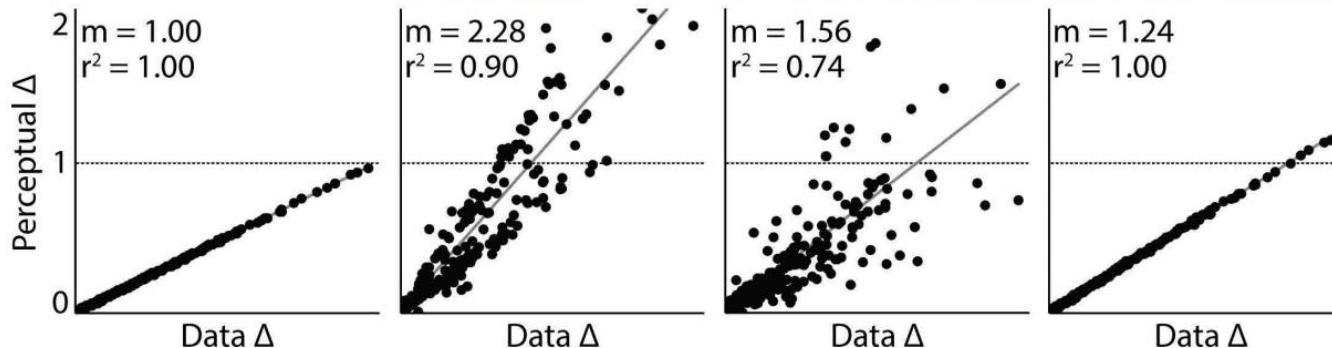
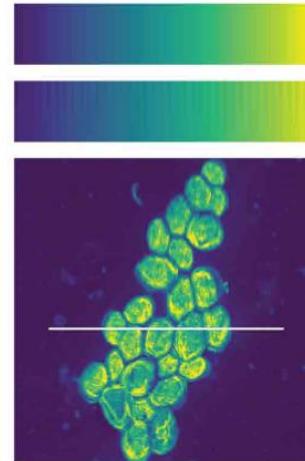
b) Jet



c) CVD-Jet



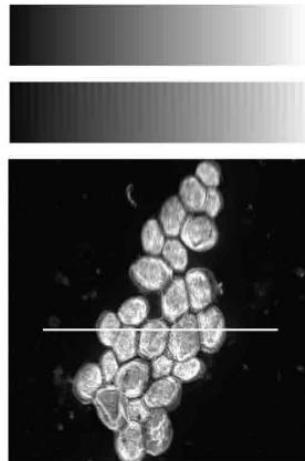
d) Viridis



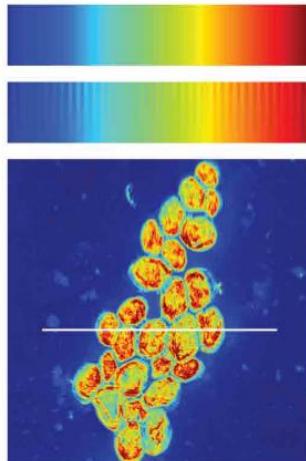
Nuñez, Anderton &
Renslow (2018) PLOSone

Choice of the Color Palette

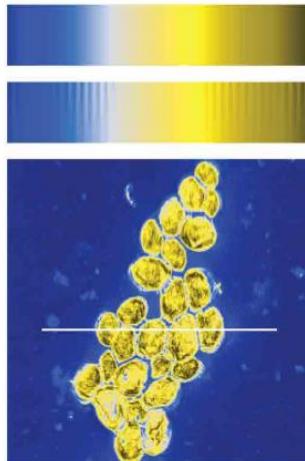
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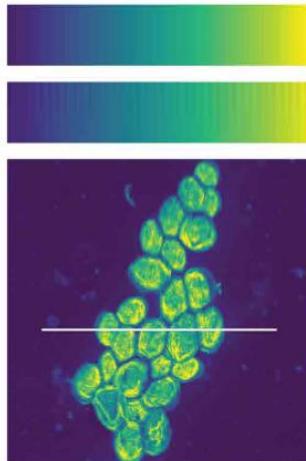
b) Jet



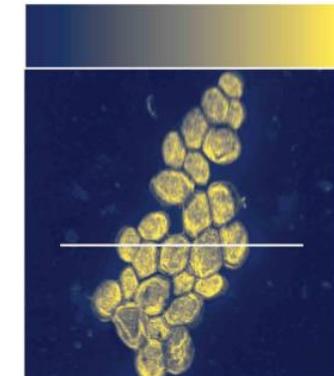
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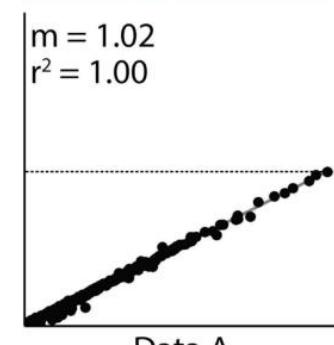
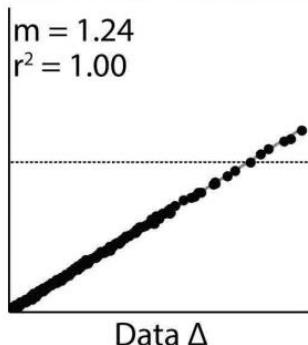
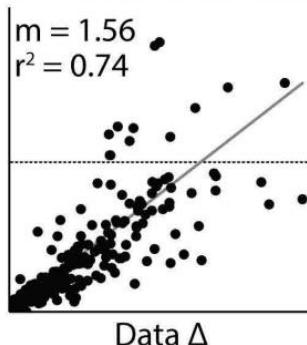
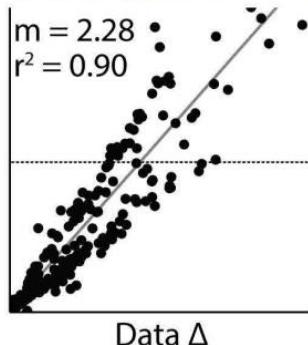
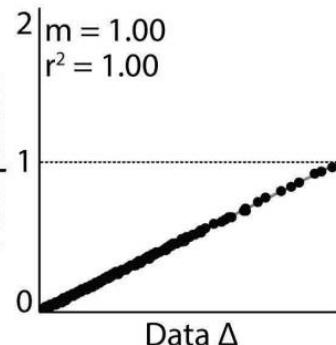
d) Viridis



e) Cividis



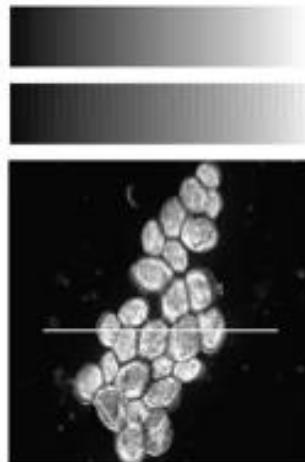
Perceptual Δ



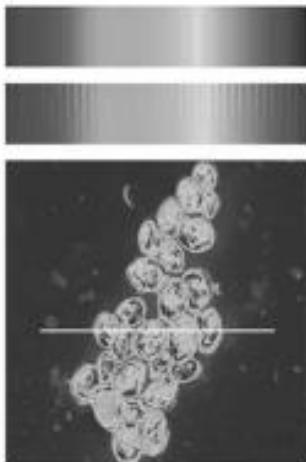
Nuñez, Anderton & Renslow (2018) PLOSone

Choice of the Color Palette

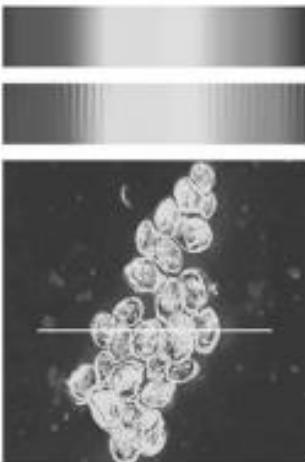
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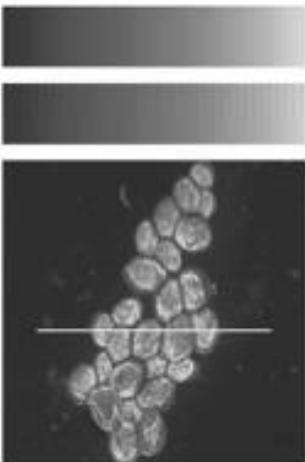
b) Jet



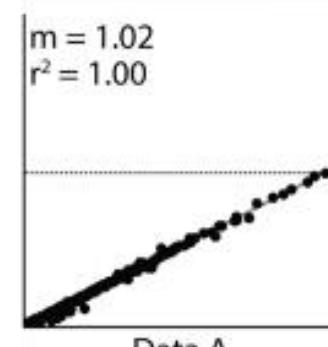
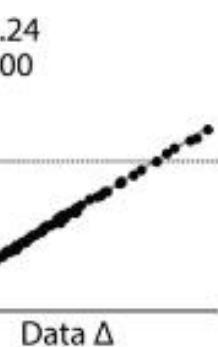
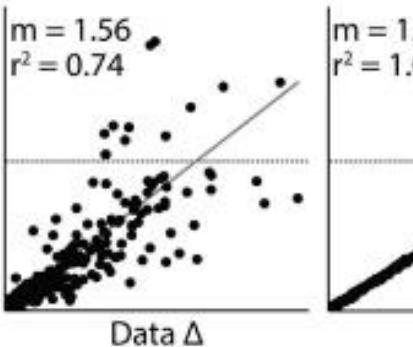
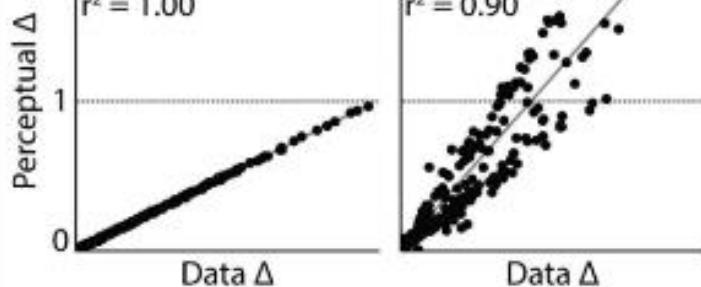
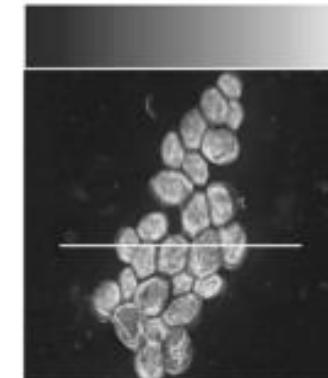
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Choice of the Color Palette

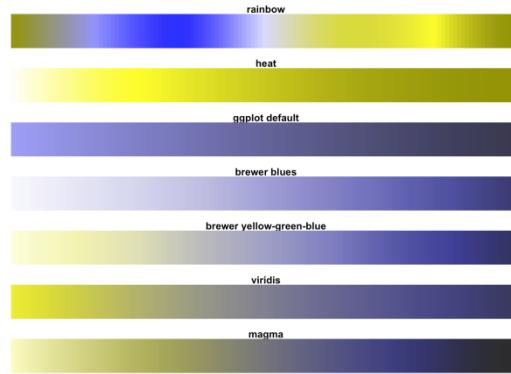


<https://cran.r-project.org/web/packages/viridis/vignettes/intro-to-viridis.html>

Color Blind Awareness



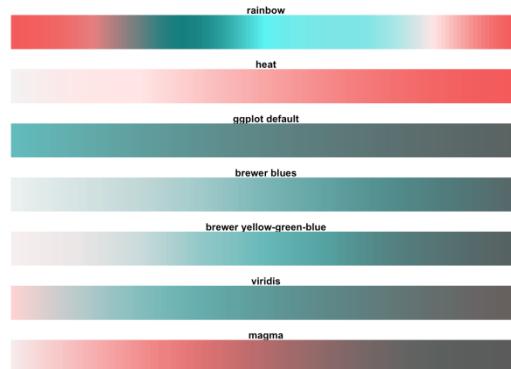
Deutanopia: present in 6% of males



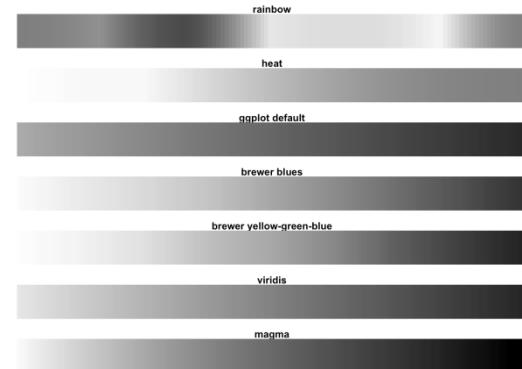
Protanopia: present in 1% of males



Tritanopia: present in 0.008% of humans



Monochromacy: present in 0.001% of humans



<https://cran.r-project.org/web/packages/viridis/vignettes/intro-to-viridis.html>

... and present in ~75% of university printers! ☺

Color Blind Awareness



**Make sure your plots
are readable for
color blind people and
when printed in grey scale!**

e.g. color-blindness.com/
coblis-color-blindness-simulator
projects.susielu.com/viz-palette

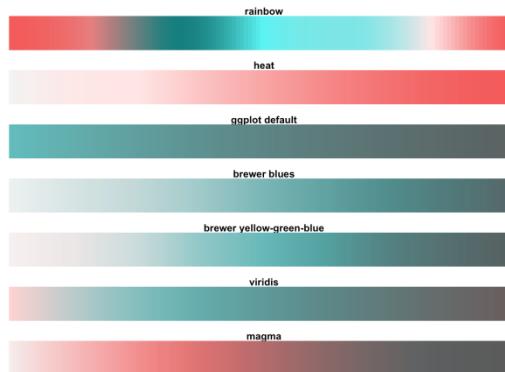
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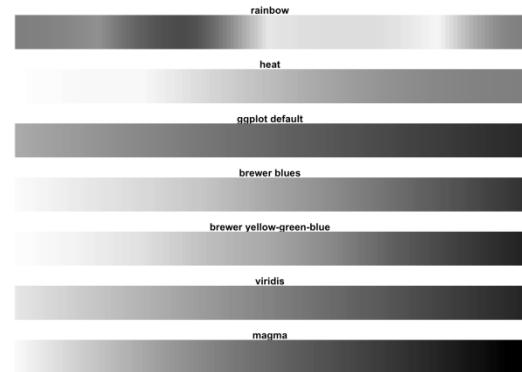
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Color Blind Awareness

VIZ PALETTE

By: Elijah Meeks & Susie Lu

PICK

Use Chroma.js

Use Colorgorical

Use ColorBrewer

EDIT

7 Colors

hex rgb hsl

1 ● ffd700
2 ● ffb14e
3 ● fa8775
4 ● ea5f94
5 ● cd34b5
6 ● 9d02d7
7 ● 0000ff

GET

String quotes Object with metadata

```
[ "ffd700", "ffb14e", "fa8775", "ea5f94", "cd34b5", "9d02d7", "#0000ff" ]
```

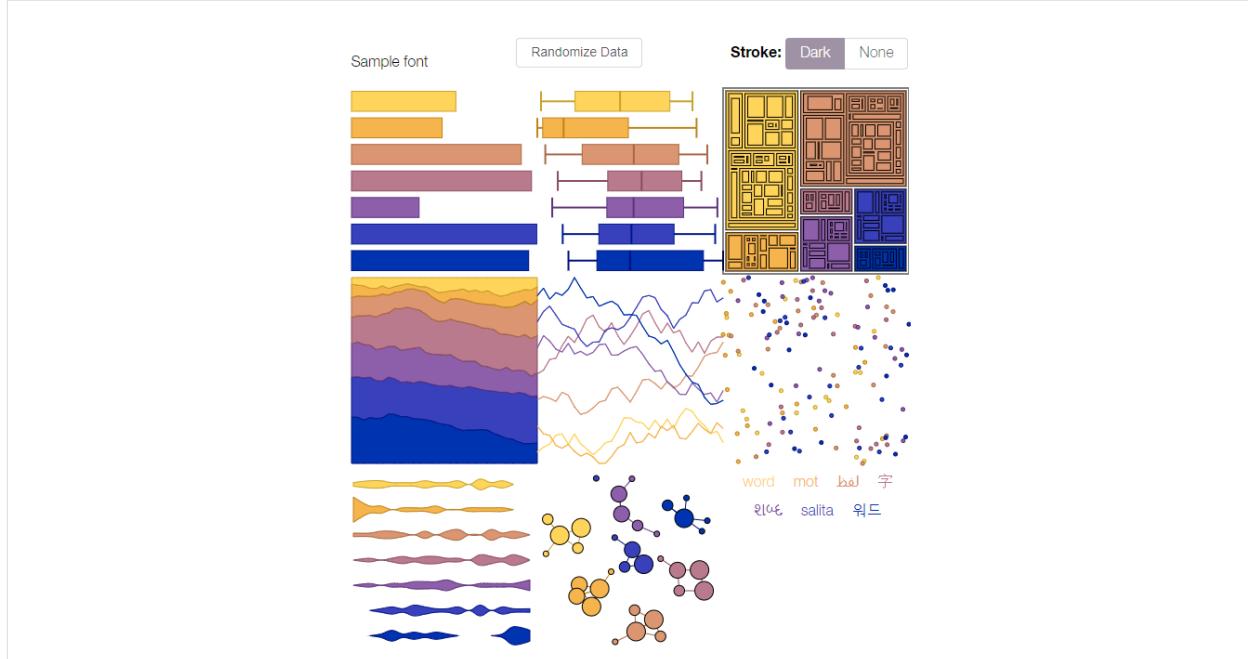
hex rgb hsl

COLORS IN ACTION

Color Population: No Color Deficiency - 96% Deuteranomaly - 2.7% Protanomaly - 0.66% Protanopia - 0.59% Deuteranopia - 0.56% Greyscale

Background color: #ffffff
Font color: ● #000000

Charts made with [Semitic](#)



projects.susielu.com/viz-palette

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VIZ PALETTE

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hex rgb
 hsl

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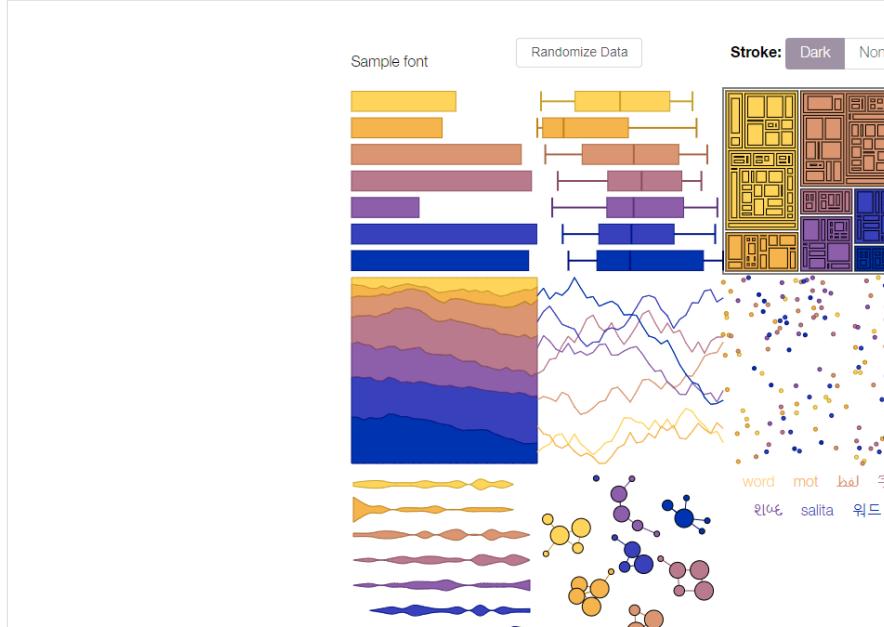
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Charts made with [Semitic](#)

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Sample font Stroke:



word mot bla 字
한국 salita 워드

projects.susielu.com/viz-palette

Choice of the Color Palette

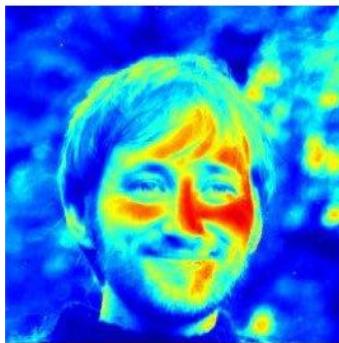
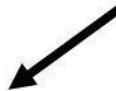


true-colour Phil

Choice of the Color Palette



true-colour Phil



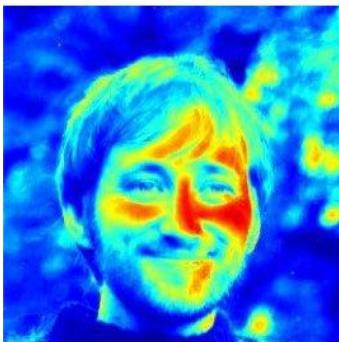
rainbow Phil
is distorted

fabiocramerich.netlify.com

Choice of the Color Palette



true-colour Phil



rainbow Phil
is distorted



batlow Phil
is flawless

Choice of the Color Palette

SANFORD AND SELNICK

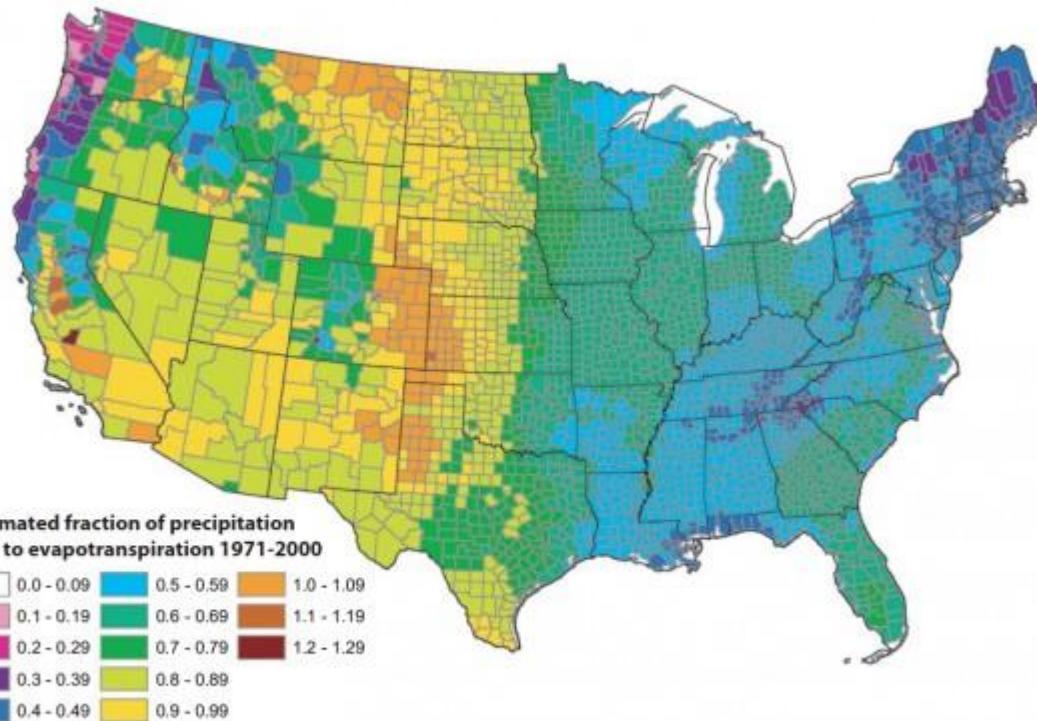


FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation (P) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of ET/P were made first at the 800-m resolution of the PRISM climate data. The mean values for the counties (shown) were then calculated by averaging the 800-m values within each county. Areas with fractions >1 are agricultural counties that either import surface water or mine deep groundwater.

[eagereyes.org/basics/
rainbow-color-map](http://eagereyes.org/basics/rainbow-color-map)

Choice of the Color Palette

SANFORD AND SELNICK

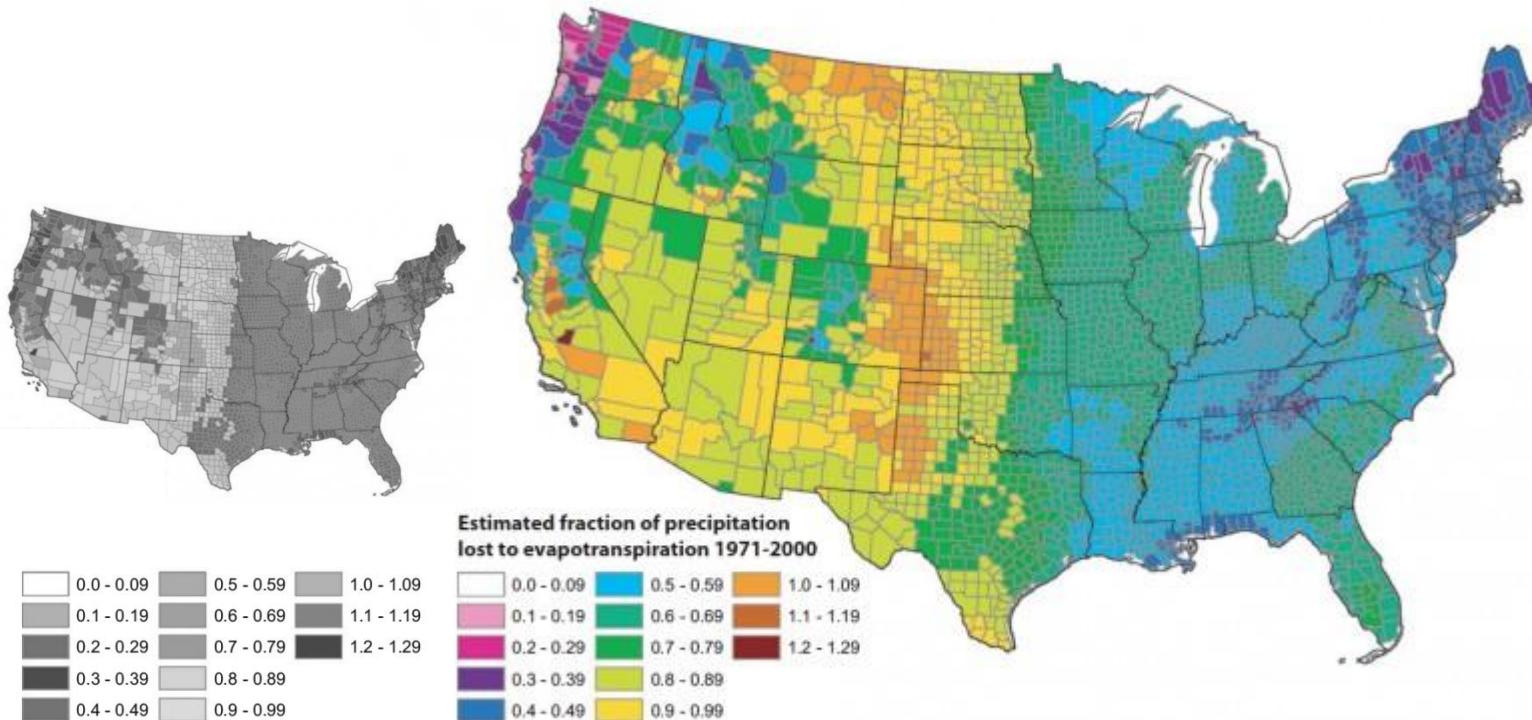


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[eagereyes.org/basics/
rainbow-color-map](http://eagereyes.org/basics/rainbow-color-map)

Choice of the Chart Type

Chart Types

Chart Suggestions—A Thought-Starter

www.ExtremePresentation.com
© 2009 A. Abela — a.vabела@gmail.com

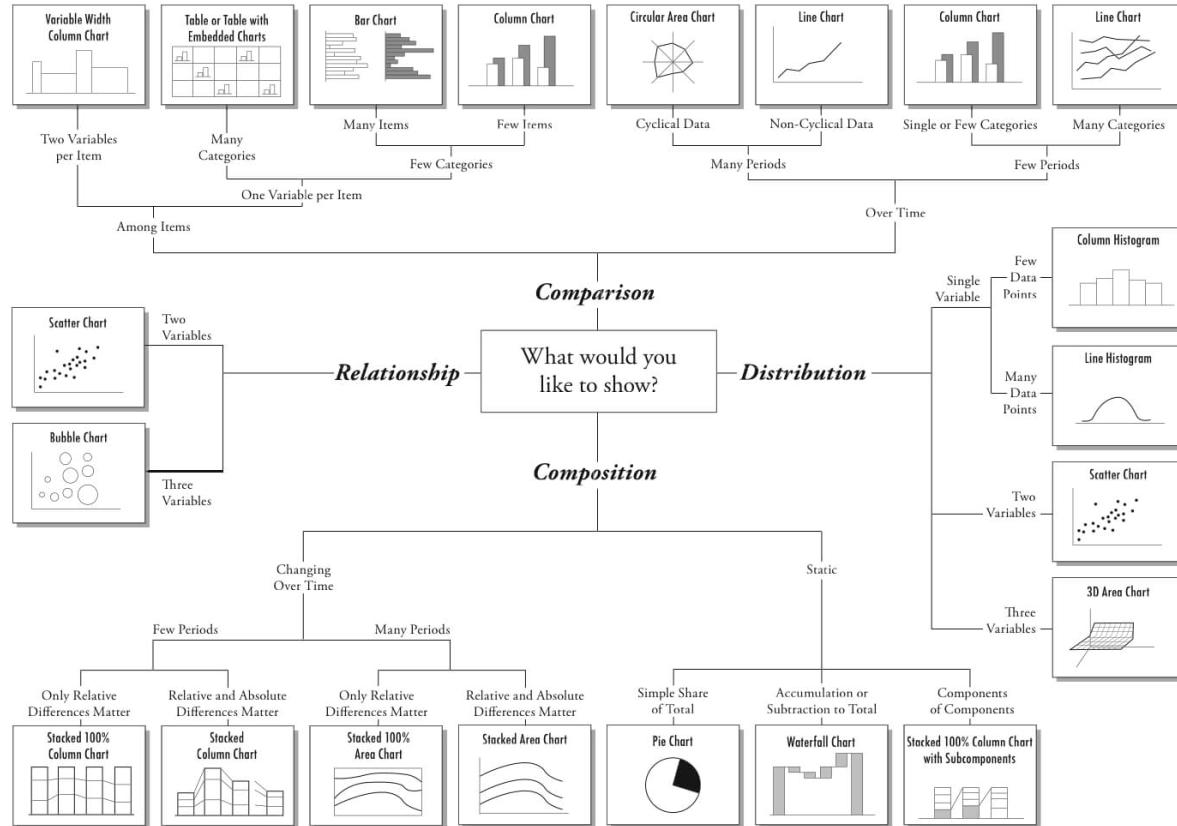
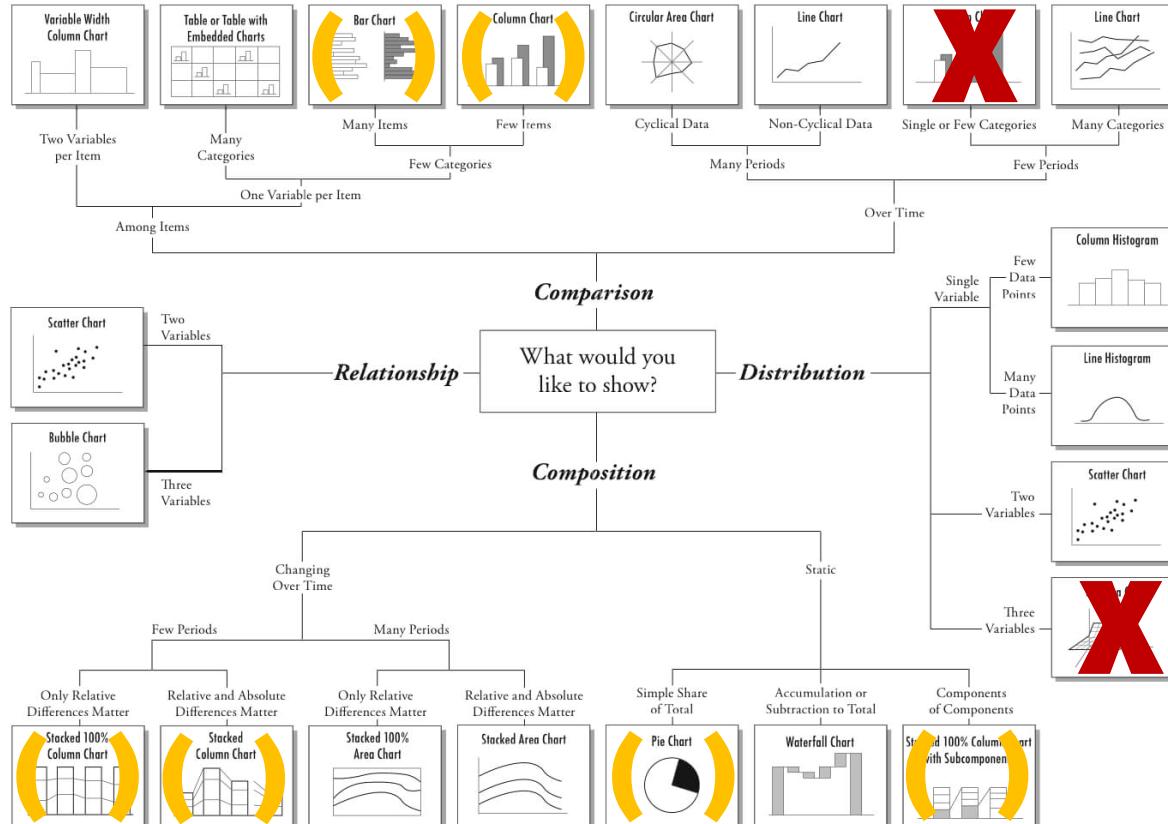


Chart Types

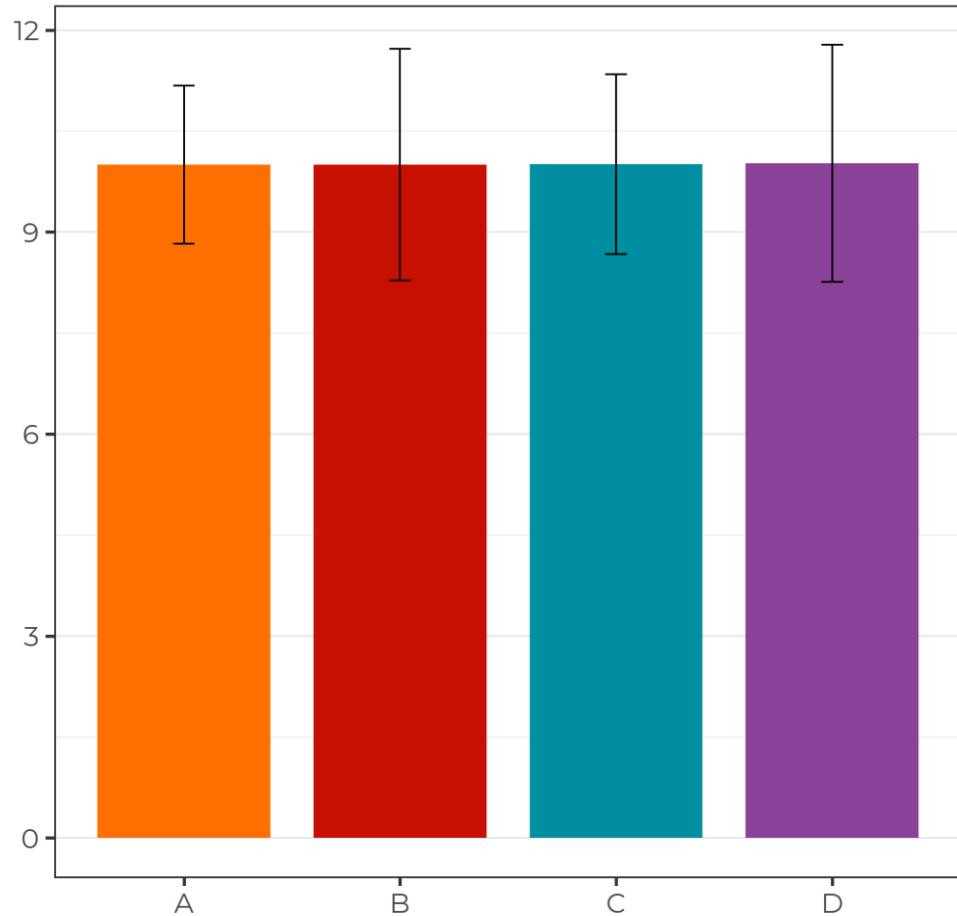
Chart Suggestions—A Thought-Starter

www.ExtremePresentation.com
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Barplot

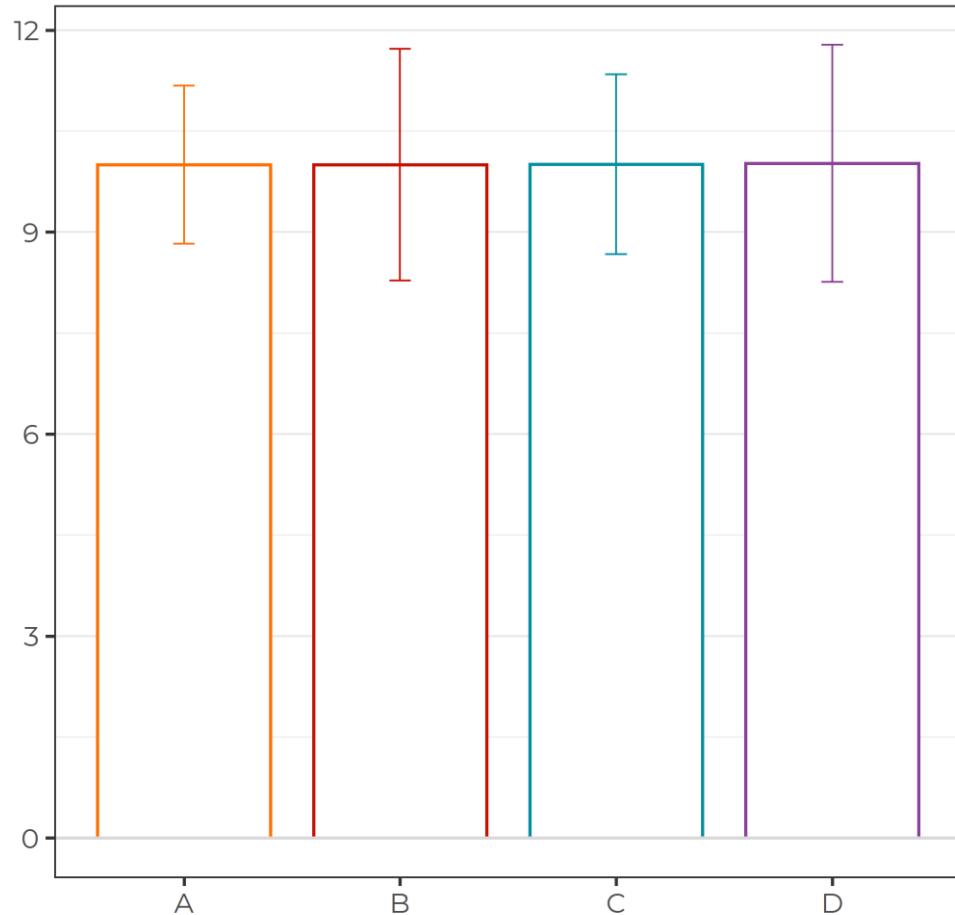
mean \pm SD



- Boring
- Not accurate
(only in case of amounts or proportion)
- Lots of useless space
(but never omit zero!)

Barplot

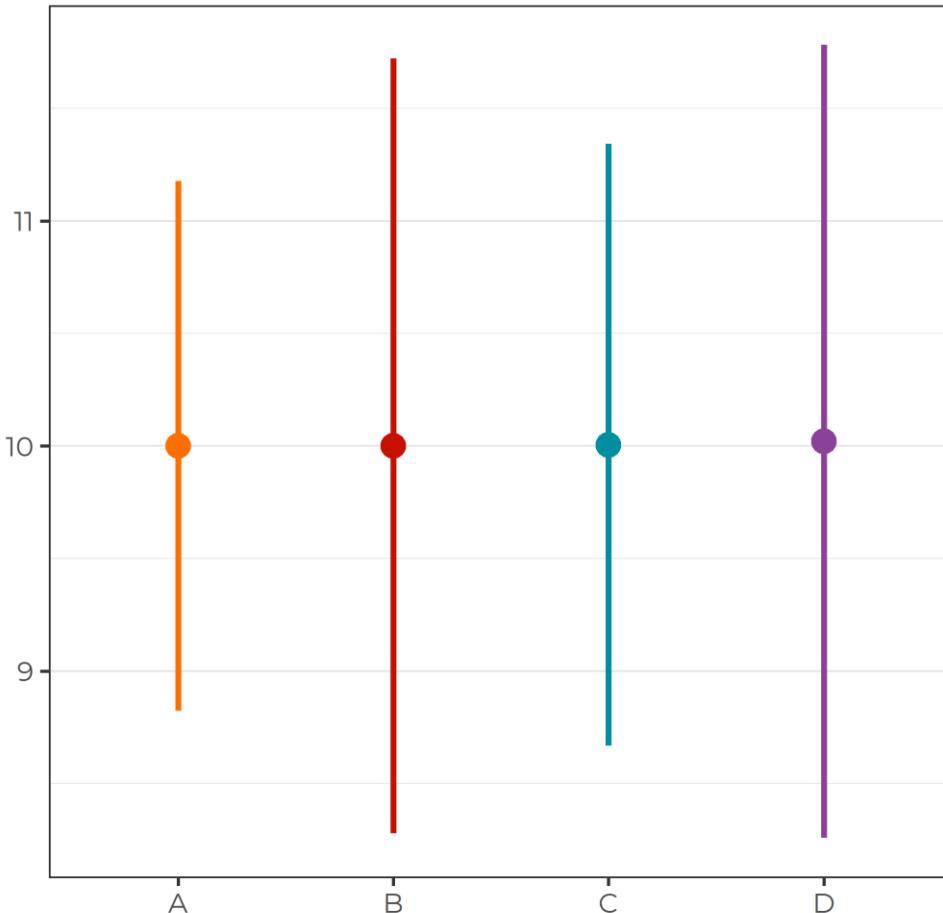
mean \pm SD



- Boring
- Not accurate
(only in case of amounts or proportion)
- Lots of useless space
(but never omit zero!)

Error Plot

mean \pm SD



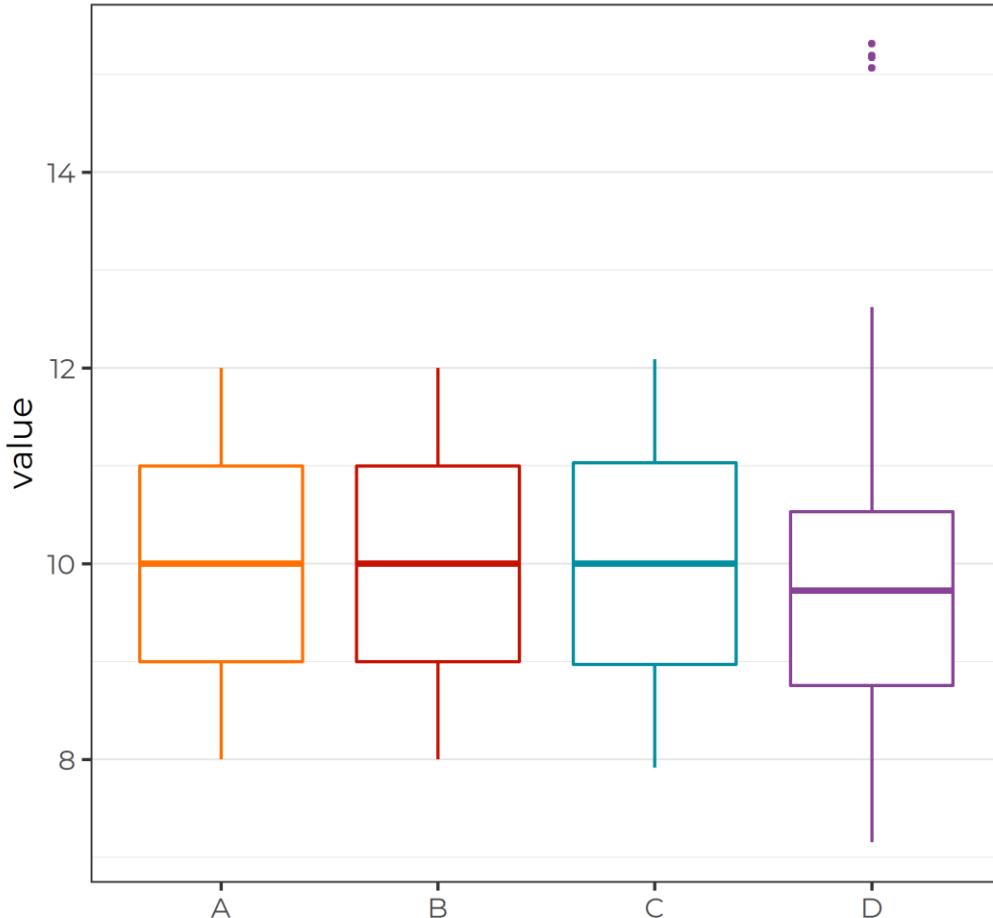
- More accurate than bar plot
- Better data-ink ratio

But:

- unclear what's shown

Box and Whiskers Plot

median, inter-quartile-range (IQR) and outliers



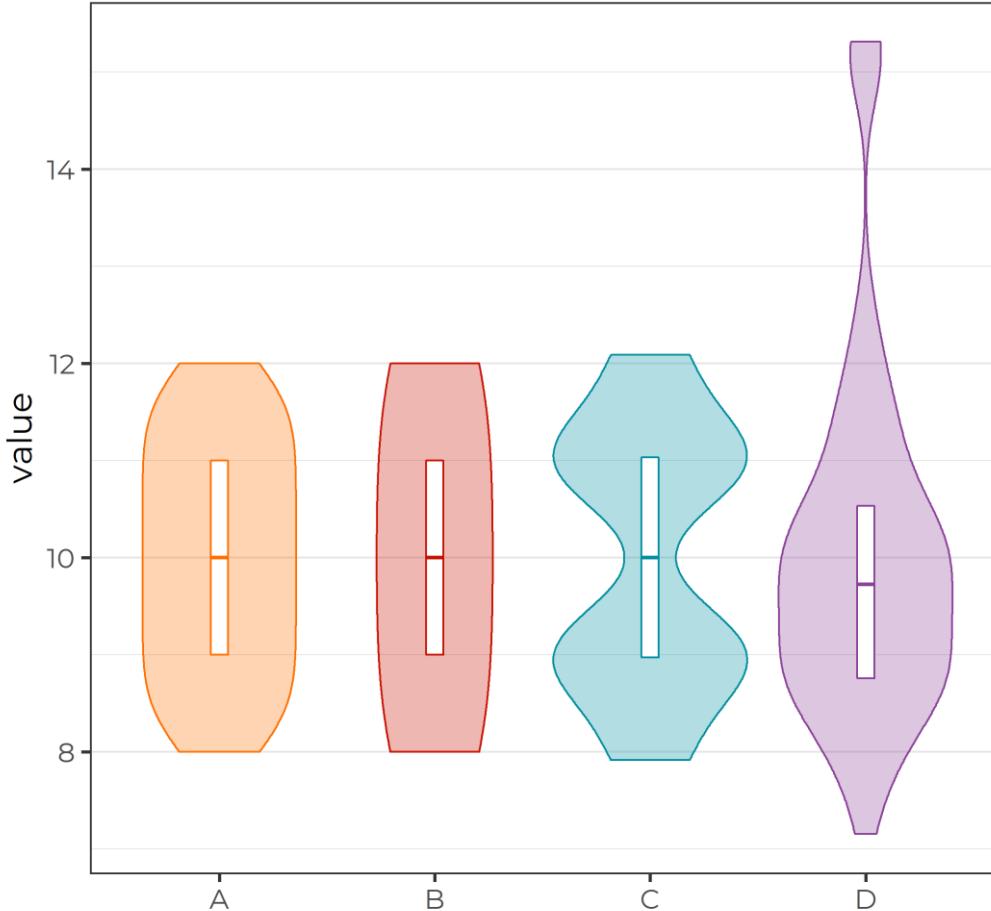
- Shows important summary stats
- Looks “scientifically”

But:

- No info about sample size
- Hard to grasp for broad audience

Violin Plot

distribution, median and IQR



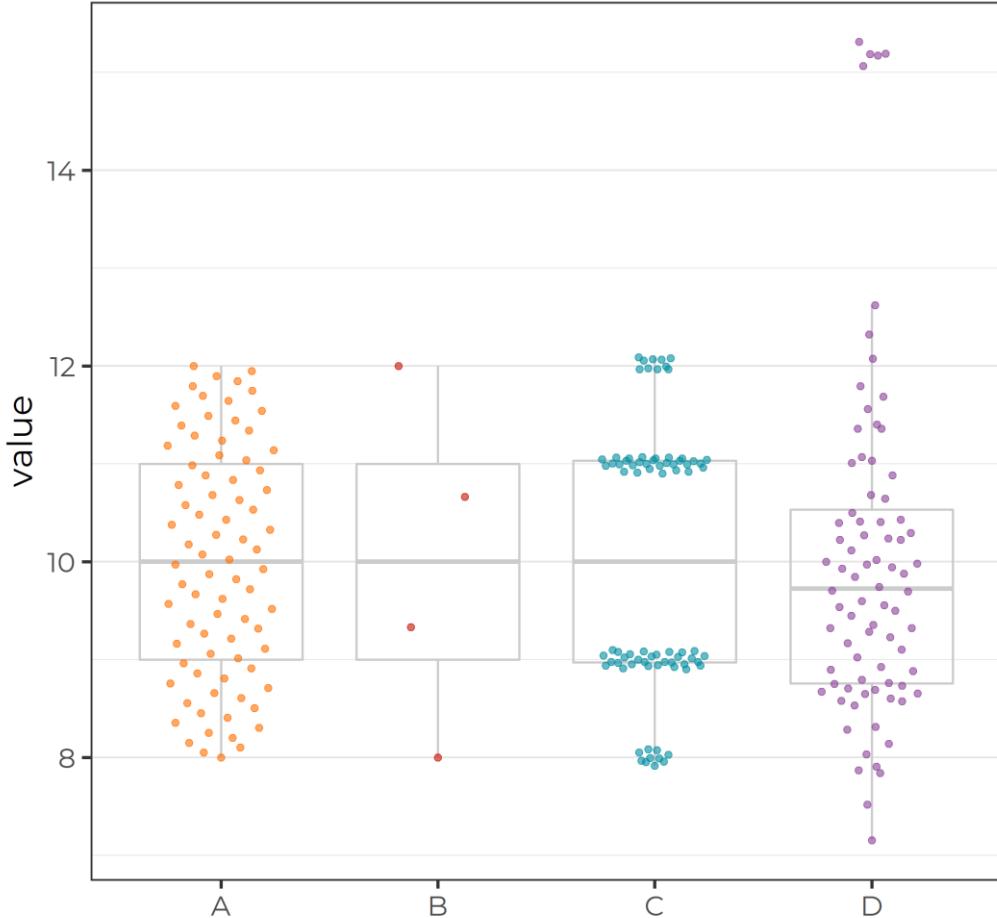
- Shows distribution and sample size
- Can be combined with summary stats

But:

- Sample size hard to estimate

Jitter or Sina Plot

raw data (jittered)



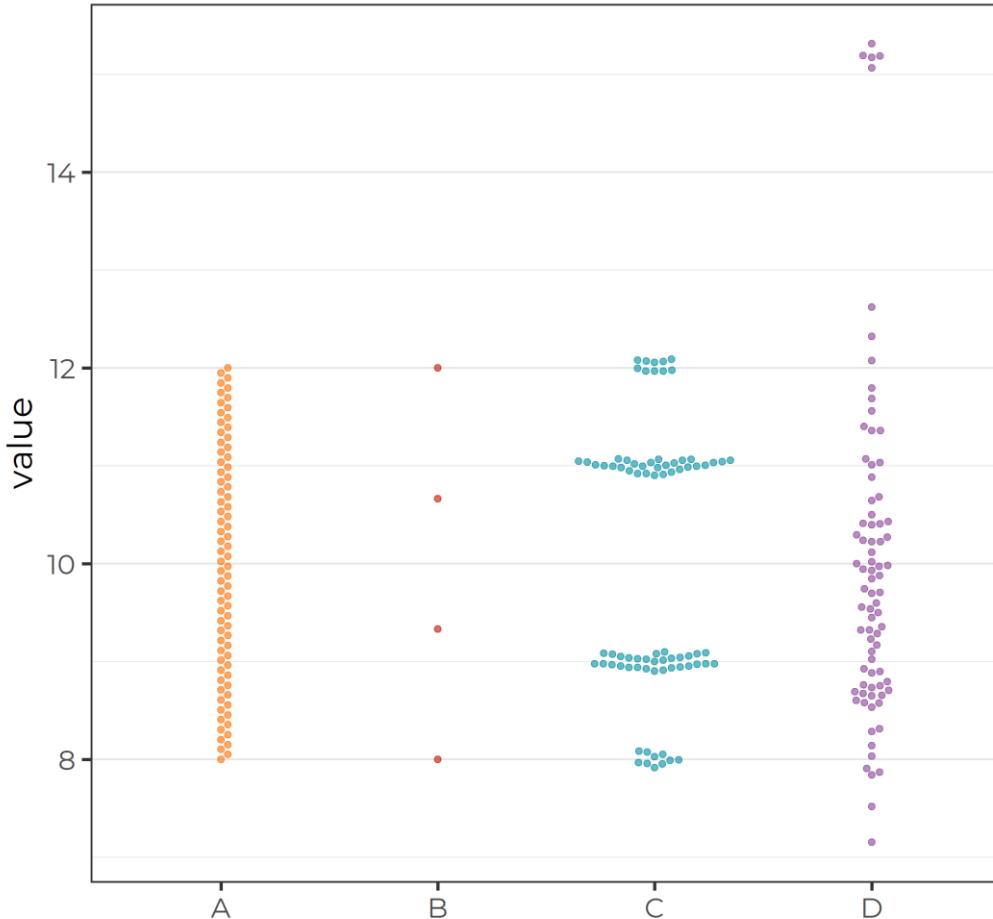
- Allows to estimate sample size and distribution
- Avoid overplotting by using transparency and/or jitter

But:

- Difficult in case of large sample size

Beeswarm Plot

raw data without overlap



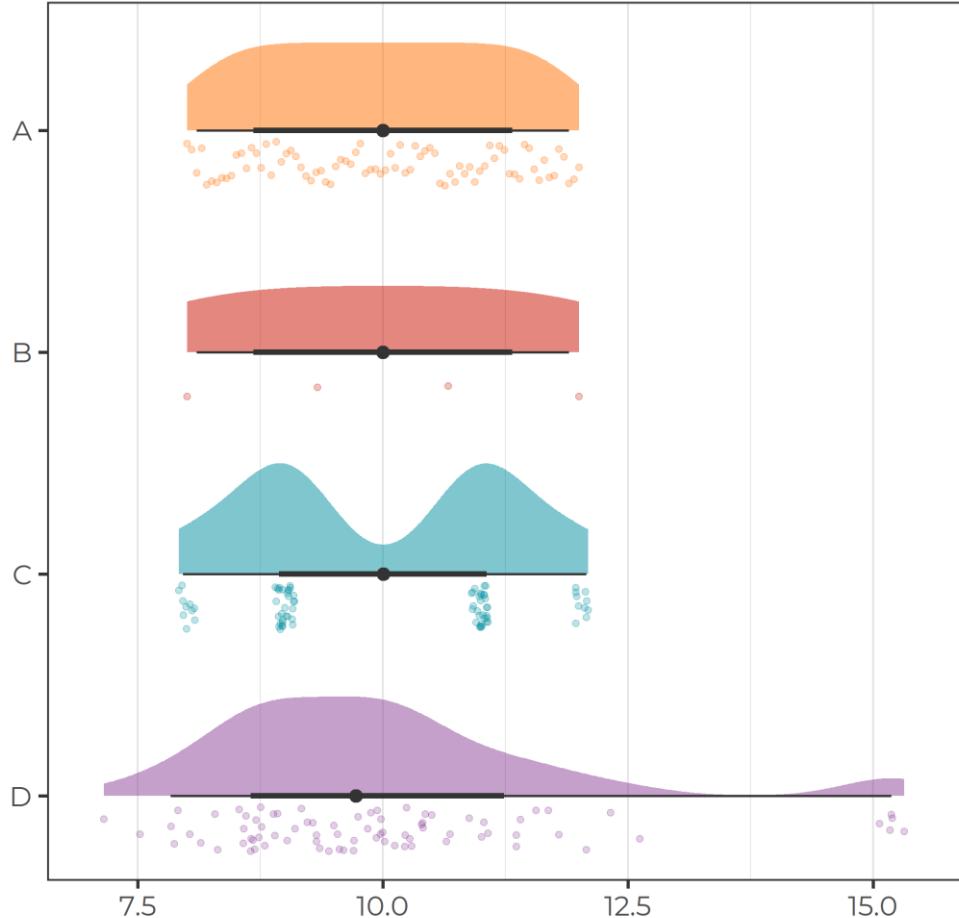
- Allows to estimate sample size and distribution
- Prevents overplotting

But:

- Difficult in case of large sample size

Raincloud Plot

distribution, median, density and raw data

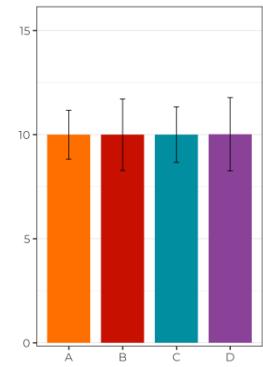


- Allows to estimate distribution, sample size and summary stats

Chart Type Choice

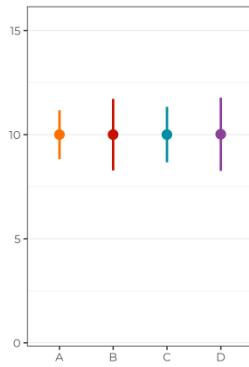
Barplot

mean \pm SD



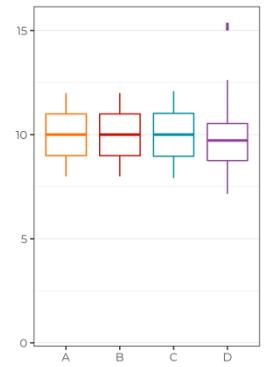
Error Plot

mean \pm SD



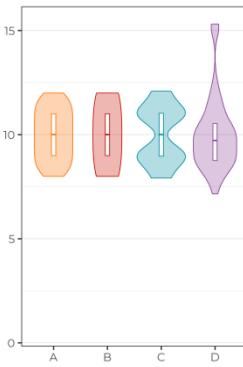
Box and Whiskers Plot

median, inter-quartile-range (IQR) and outliers



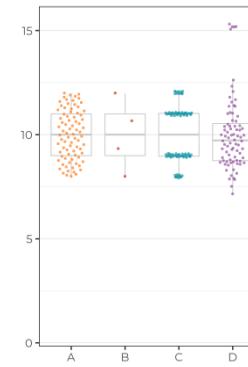
Violin Plot

distribution, median and IQR



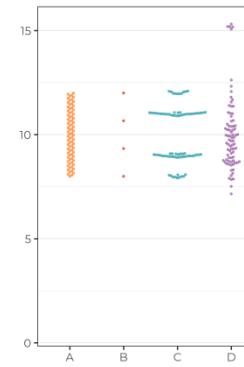
Jitter or Sina Plot

raw data (jittered)



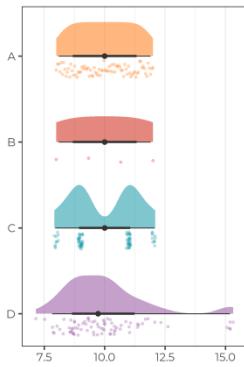
Beeswarm Plot

raw data without overlap



Raincloud Plot

distribution, median, density and raw data

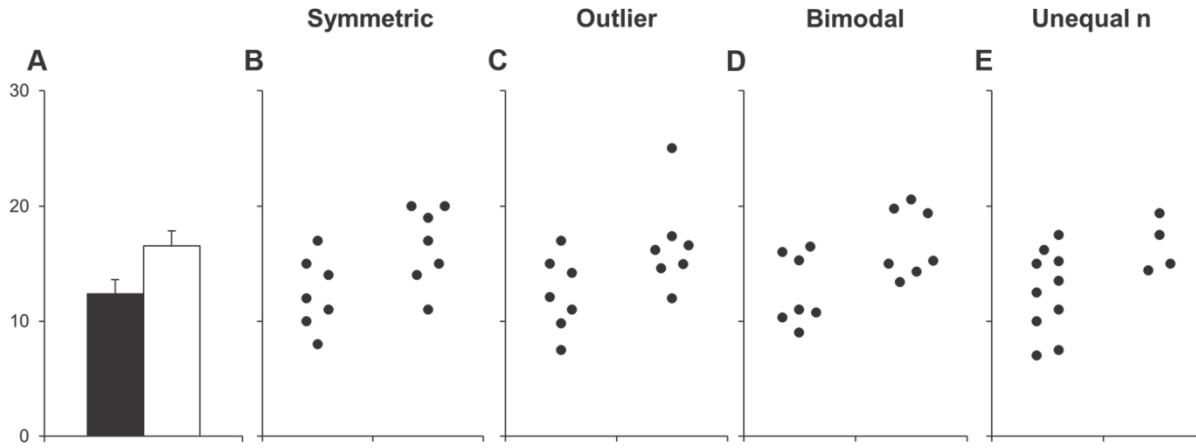


Visualization by Cédric Scherer

- Try several plot types and combinations
- Always check raw data and sample size
- Be as precise as possible
- Adjust chart type to audience

Beyond Bar and Line Graphs: Time for a New Data Presentation Paradigm

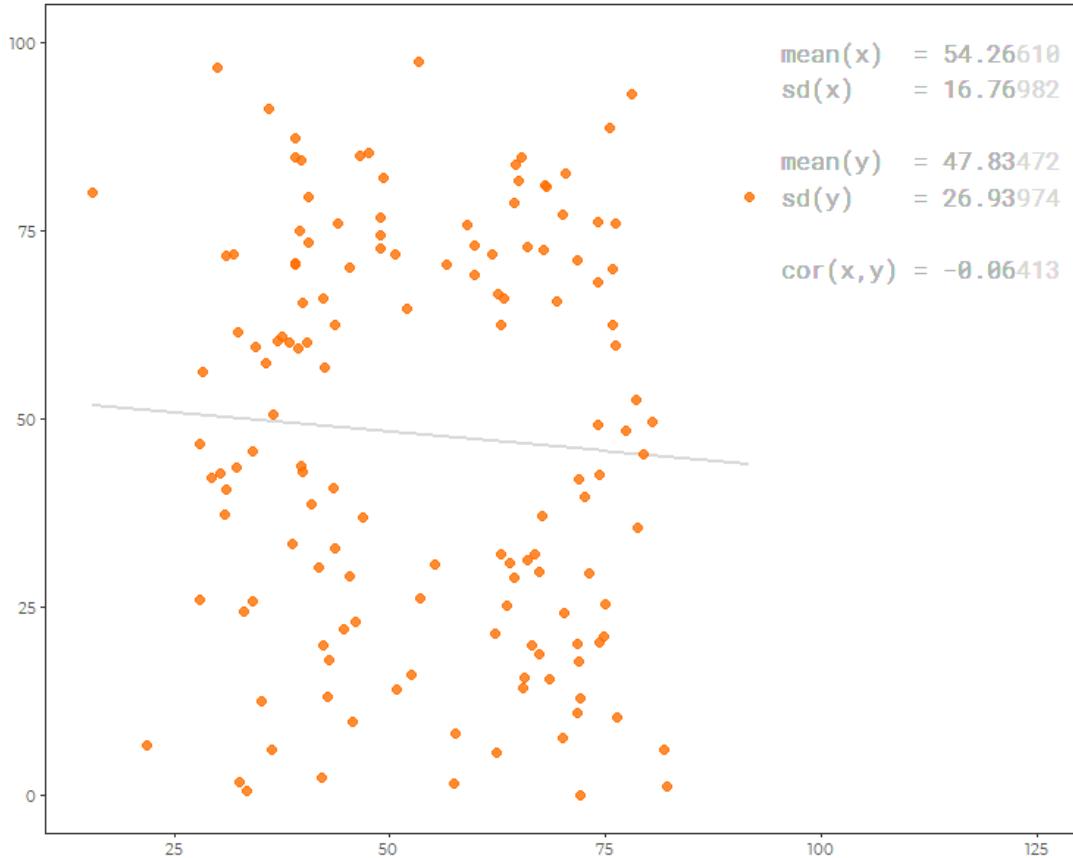
Tracey L. Weissgerber^{1*}, Natasha M. Milic^{1,2}, Stacey J. Winham³, Vesna D. Garovic¹



Test	p value			
T-test: Equal var.	0.035	0.050	0.026	0.063
T-test: Unequal var.	0.035	0.050	0.026	0.035
Wilcoxon	0.054	0.073	0.128	0.103

The Datasaurus Dozen

Different datasets – nigh-identical summary statistics

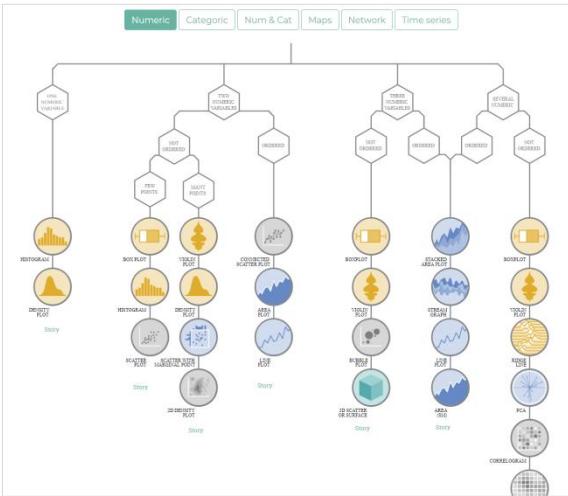


"The Datasaurus Dozen"

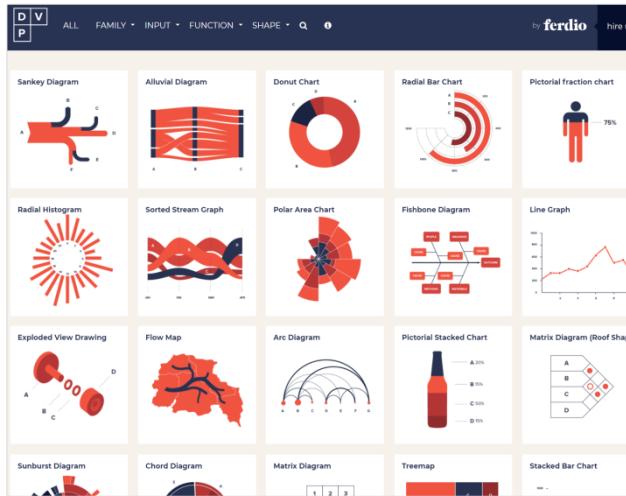
based on Anscombe's Quartet and Alberto

Idea by Alberto Cairo, Justin Matejka & George Fitzmaurice
Visualization by Tom Westlake & Cédric Scherer

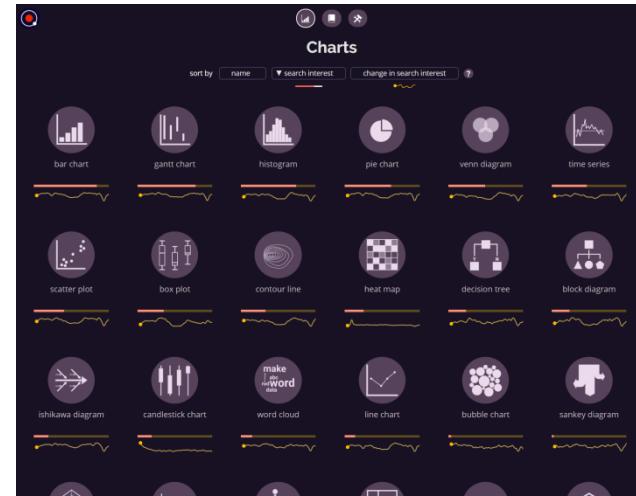
Chart Type Choice



data-to-viz.com



datavizproject.com



visualizationuniverse.com/charts



from Data
to Viz

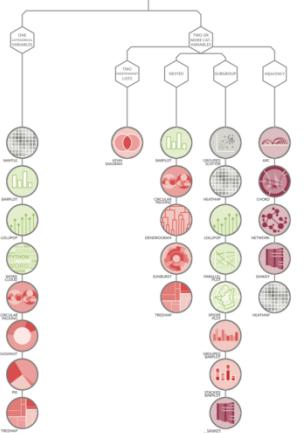
'From Data to Viz' is a classification of chart types based on input data format. It will help you find the perfect chart in three simple steps :

- 1 Identify what type of data you have.
 - 2 Go to the corresponding decision tree and follow it down to a set of possible charts.
 - 3 Choose the chart from the set that will suit your data and your needs best.

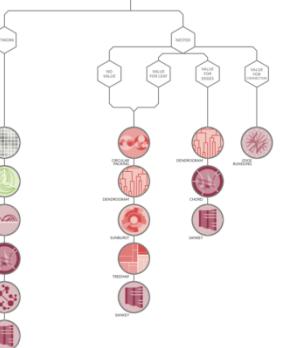
Dataviz is a world with endless possibilities and this project does not claim to be exhaustive. However it should provide you with a good starting point. For an interactive version and much more, visit:

data-to-viz.com

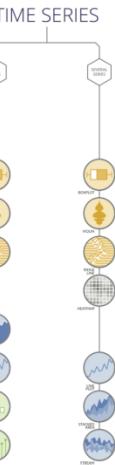
CATEGORIC



RELATIONAL

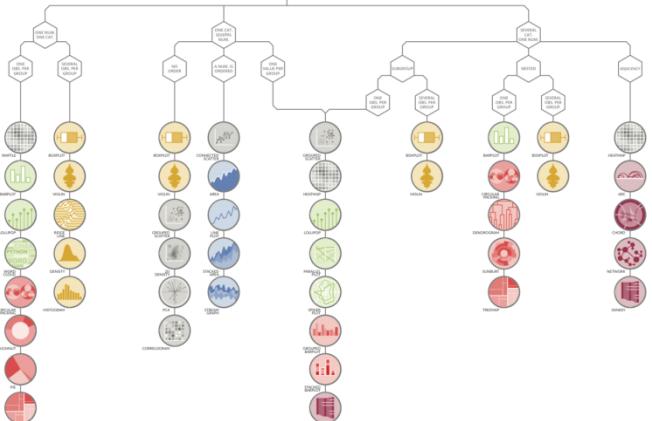


MAP

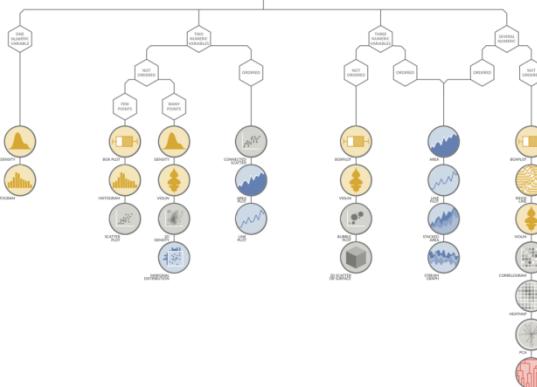


TIME SERIES

CATEGORIC AND NUMERIC



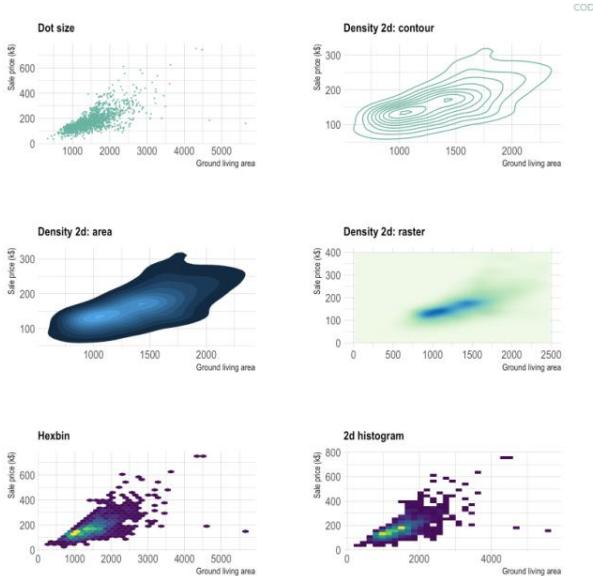
NUMERIC



https://github.com/holtzy/data_to_viz/blob/master/img/poster/poster_screenshot.png

Overplotting

The most common pitfall with scatterplot is overplotting: when the sample size gets big, dots are plotted on top of each other what makes the chart unreadable. There are several work around to avoid this issue as describe in this [specific post](#). Here is a summary of the different offered techniques:



Going further

You can learn more about each type of graphic presented in this story in the dedicated

POSSIBILITIES

presented in this website.

[Part of a whole](#) [Evolution](#) [Map](#) [Flow](#)

BOXPLOT
Summarize the distribution of numeric variables

About

A boxplot gives a nice summary of one or several numeric variables. The line that divides the box into 2 parts represents the median of the data. The end of the box shows the upper and lower quartiles. The extreme lines show the highest and lowest value excluding outliers.

Common Mistakes

- Boxplot hides the sample size of each group, [show it with annotation or box width](#).
- Boxplot hides the underlying distribution. Use jitter if low number of data points, or use violin with bigger data.
- Order your boxplot by median can make it more insightful.

Code

[R graph gallery](#) [Python gallery](#) [D3.js gallery](#) [Flourish](#)

Read More

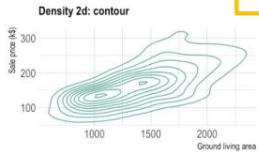
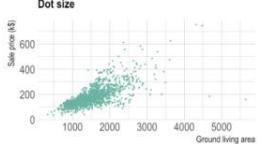
[See the dedicated page.](#)

Visualizations:

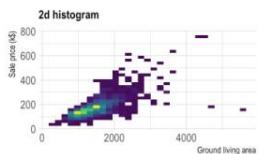
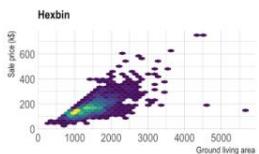
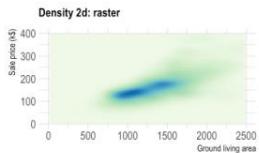
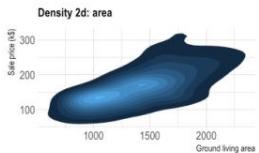
- Venn diagram
- Doughnut
- Pie chart
- Dendrogram
- Circular packing
- Sunburst

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Code

[R graph gallery](#) [Python gallery](#) [D3.js gallery](#) [Flourish](#)

[Read More](#)

See the dedicated page.

```
# code for all graphics:
p <- data %>
ggplot( aes(x=GroundArea, y=SalePrice/1000) +
  theme_ipsum() +
  theme(
    plot.title = element_text(size=12)
  ) +
  ylab('Sale price (k$)') +
  xlab('Ground living area')
)

# Reduce dot size
p1 <- p + geom_point(color="#69b3a2", alpha=0.8, size=0.2) + ggtitle("Dot size")

# Use density estimate
p2 <- p + stat_density2d(color="#69b3a2") + ggtitle("Density 2d: contour")

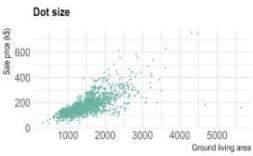
# Use density estimate (area)
p3 <- p + stat_density_2d(fill = ..level.., geom = "polygon") + ggtitle("Density 2d: area") + theme(legend.position="none")

# With raster
p4 <- p +
  stat_density_2d(fill = ..density.., geom = "raster", contour = FALSE) +
  scale_fill_distiller(palette=4, direction=1) +
  scale_x_continuous(expand = c(0, 0)) +
  scale_y_continuous(expand = c(0, 0)) +
  theme(
    legend.position="none"
  ) +
  ggtitle("Density 2d: raster") +
  xlim(0,2500) +
  ylim(0,400)

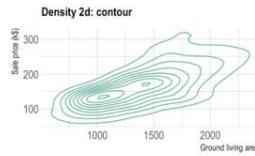
# Hexbin
p5 <- p + geom_hex() +
  scale_fill_viridis() +
  theme(legend.position="none") +
  ggtitle("Hexbin")

# 2d histogram
p6 <- p + geom_binned() +
  scale_fill_viridis() +
  theme(legend.position="none") +
  ggtitle("2d histogram")

p1 + p2 + p3 + p4 + p5 + p6 + plot_layout(ncol = 2)
```



Density 2d: area



Density 2d: raster

X

POSSIBILITIES

presented in this website.

[Part of a whole](#) [Evolution](#) [Map](#) [Flow](#)



BOXPLOT

Summarize the distribution of numeric variables



Ridgeline



Scatter



Connected scatter



Density 2d



Barplot



Lollipop



Circular Barplot



Treemap



Dendrogram



Circular packing



Sunburst

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Code

[R graph gallery](#)
[Python gallery](#)
[D3.js gallery](#)
[Flourish](#)

[Read More](#)

See the dedicated page.



Venn diagram



Doughnut



Pie chart





Cédric Scherer

 cedricscherer.netlify.com

 [@CedScherer](https://twitter.com/CedScherer)

Train Your Skills and Get Inspired!
Social DataViz Projects

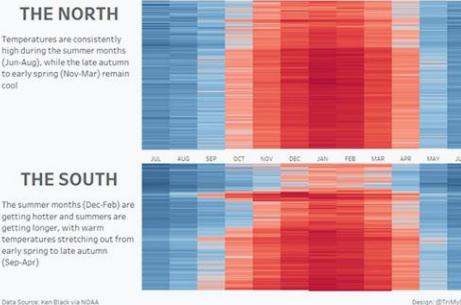
Social DataViz Projects

- **#MakeoverMonday** – weekly; any tool (but mainly contributions with Tableau)

"Join us every Monday to work with a given data set and create better, more effective visualizations and help us make information more accessible."

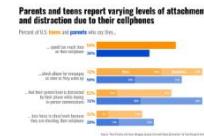
BATTLE OF THE HEMISPHERES

Which one is getting hotter - the Northern or the Southern Hemisphere

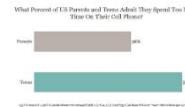


Data Source: Ken Black via NOAA

FAVORITES



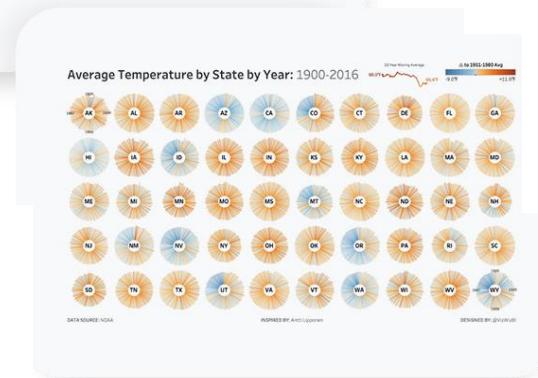
Author: Cédric Scherer
GGPlot



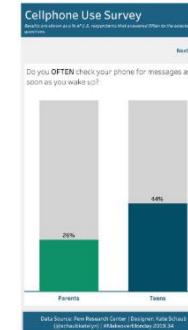
Author: Anna Foard
Link: Tableau Public



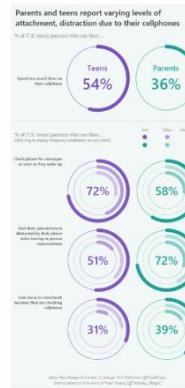
Author: Alex Avallon
Link: Tableau Public



Showcase at
makeovermonday.co.uk



Author: Kate Schaub
Link: Tableau Public



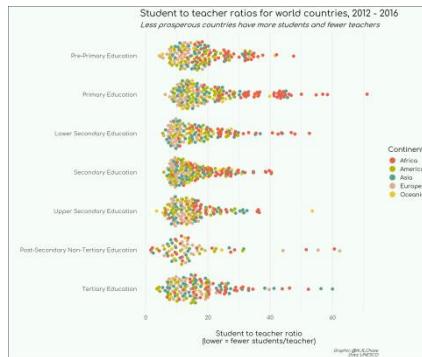
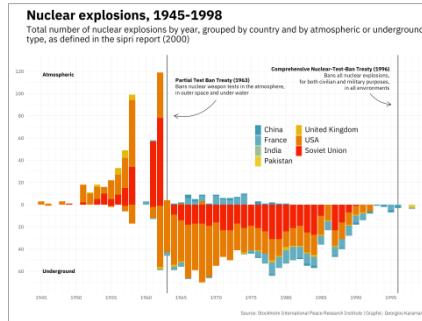
Author: Erik Rettman
Link: Tableau Public

Favorite Contributions to #MakeOverMonday 2019-40

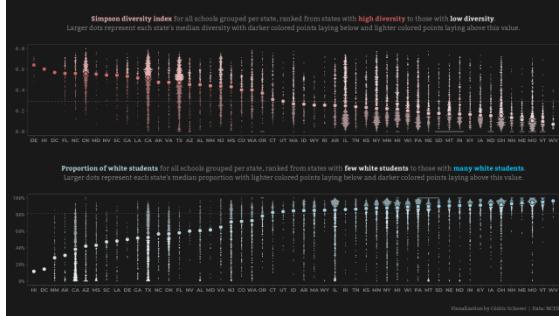
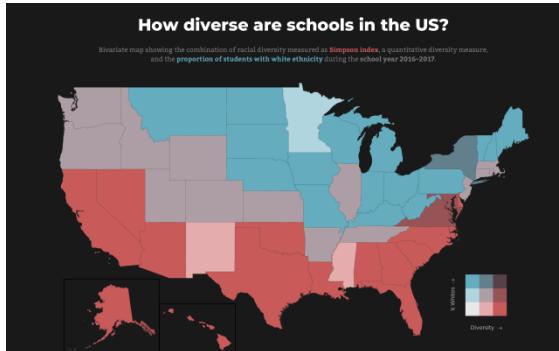
Social DataViz Projects

- **#TidyTuesday** – weekly; aimed at R and tidyverse/ggplot2 users

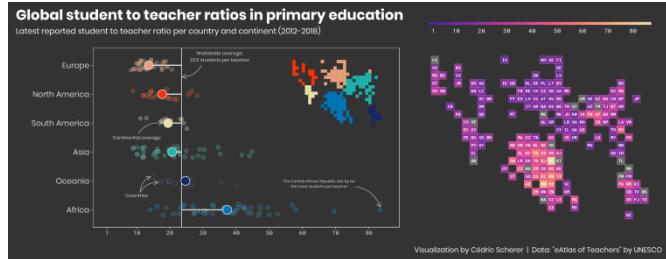
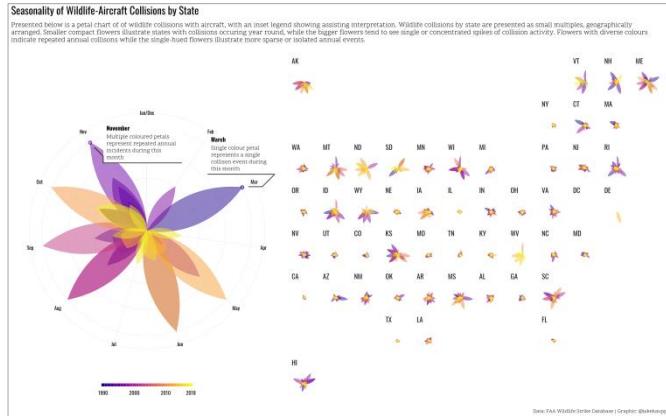
"A weekly data project aimed at the R ecosystem [with] an emphasis on understanding how to summarize and arrange data to make meaningful charts with ggplot2, tidyverse, dplyr, and other tools in the tidyverse ecosystem."



Upper: Georgios Karamanis
Lower: Will Chase



Cédric Scherer

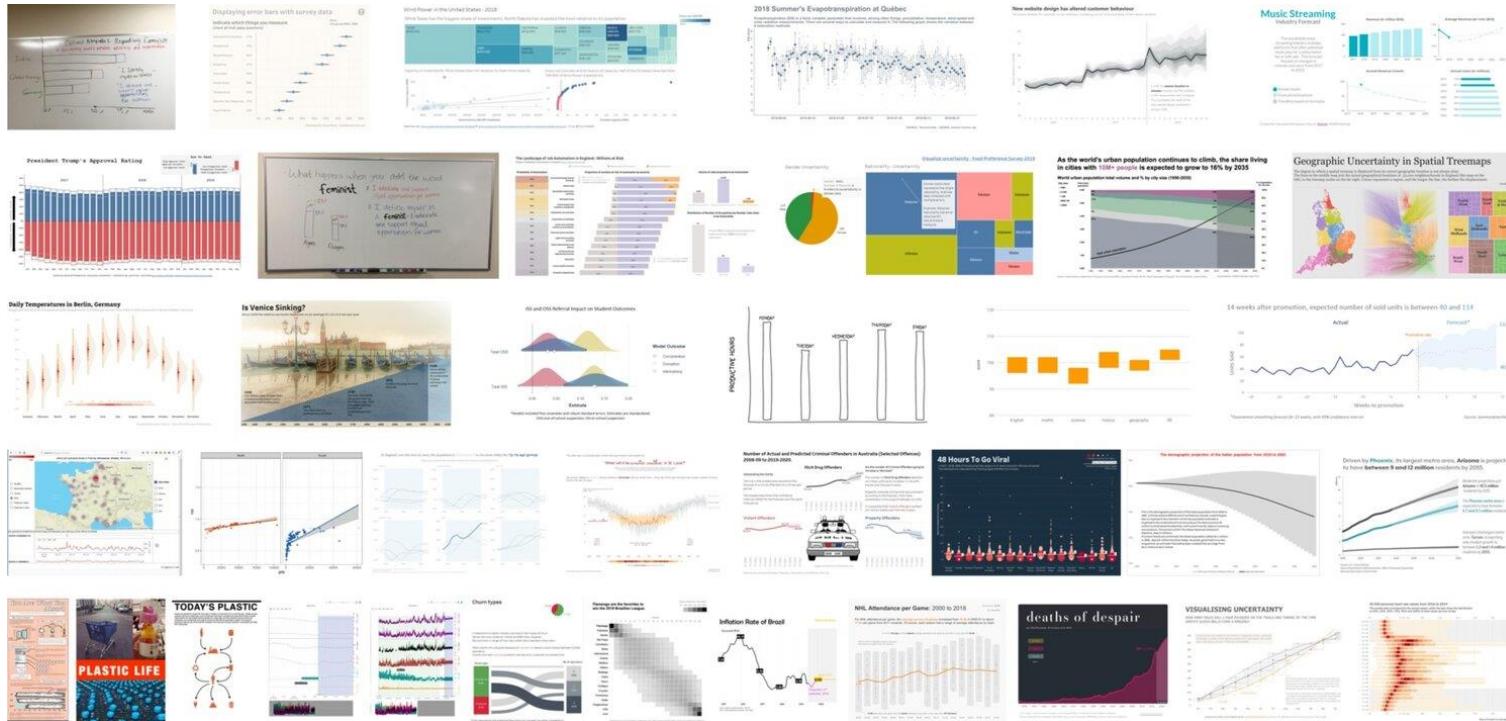


Upper: Jake Kaupp
Lower: Cédric Scherer

Social DataViz Projects

- **#SWDchallenge** – monthly; diverse set of tools and techniques

"The #SWDchallenge is a monthly challenge where you can practice and apply data visualization and storytelling skills. Think of this as a safe space to try something new: test out a new tool, technique, or approach."



Contributions to #SWDchallenge September 2019