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Improving scientific plots

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A good plot can elevate your scientific paper/poster/presentation and get you some extra points from your reader, reviewer and your supervisor. A bad plot will probably confuse your reader, and it might evenconfuse you. This is a short guide with some tips on how to improve your plots.

I propose to follow a **QUACK** rule: **Quality Annotations Uniform Color Knowledge**. Here is what falls into each category:

Quality
- high resolution, readable fonts, use of vector graphics, adapted to the venue format (*tip: always save in PDF*)

Annotations
- legend, plot label, axis labels, units marked, grid

Uniform
- use of the same font, same color palette, same style

Color
- colorblind-friendly, opacity

Knowledge
- check for the curse of knowledge, deliver an idea in a way that is simple to understand

A duck makes a QUACK. Photo by Christian Bowen on Unsplash

Checklist of a **good** plot (minimum):
- has clear X and Y labels with units
- has a concise legend
- the color scheme is colorblind friendly
- saved in pdf/svg/ai (aka "high-resolution")
- stick to only one type of font
- has a gray grid that does not overpower the image
- has a title

Checklist of a **great** plot:
- thoughtful use of color and opacity
- conveys a story
- is not "overloaded" with information
- is adapted to your target format

How does one create a good plot? Well, my number one tip: look at plots in papers that you read and make a mental note of what you like or not. You can create a gallery of plots that you find interesting — later on, it is easier to "transfer" a style than create a plot from scratch. For those looking for plot inspiration, I highly suggest a paper version of any of Edwards Tufte's books, https://pair.withgoogle.com/explorables/.

thoughtful use of color

- I recommend using colorblind-friendly palettes or presets. Some excellent examples of presets are https://www.nordtheme.com/, https://www.fabiocrameri.ch/colourmaps/, https://colorbrewer2.org/#type=sequential&scheme=PuRd&n=3

- If you already have one color that you are using, and you need to find "a pair" or a good match, you can use an awesome tool from Adobe https://color.adobe.com/create/color-wheel. You can play around with harmonies to find something that will work best for your case.

- Opacities are also a color! I cannot stress this point enough. Using opacities ("alpha" parameter in 99% of the matplotlib functions) helps to mute bold colors, emphasize without overwhelming the reader, and patch the whole plot together.

A black and white cat with yellow leaves. This cat shows a great use of contrast and a simple color palette. Photo by omid armin on Unsplash

conveys a story

- A good plot should have a descriptive, yet succinct title.
- Ask yourself "What do I want my reader to understand from looking at my plot?". Is it a comparison of two groups? Is it an overview of the method? Does my average reader knows what "MAE" abbreviation I used on the plot stands for?...

A cat in the box. Simple, yet an interesting story. Photo by Sahand Babali on Unsplash

is not "overloaded" with information

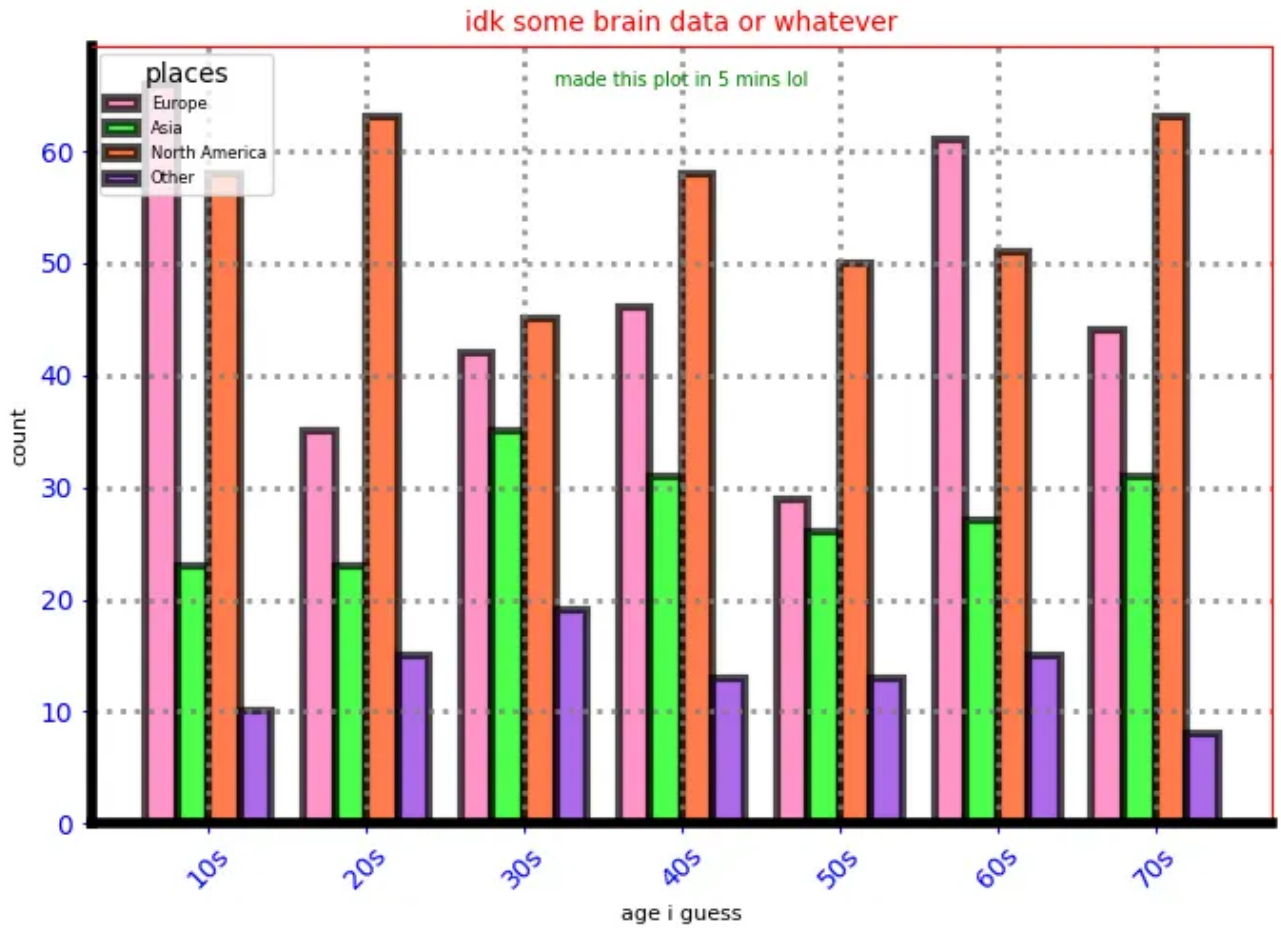
- Each extra label/number/color/figure adds to the processing time of the plot. Do not make your plots a riddle, make your plots a helpful visual clue to understanding your point.
- Make sure that **every** element/label/color/marker has a job in your plot, and remove redundant ones.

Simple cat on white backgroud. Just a white background, that's what you want in your plot! Photo by Cassidy James Blaede on Unsplash

example

Below, I'll walk you through some of the plots "before" and "after" to demonstrate the thought process that's happening.

Let's set a use case: you need to present a dataset by geography that you used for your new excellent paper. You don't have a lot of real estate in your plot, so the plot should take less space. Here is what you have:



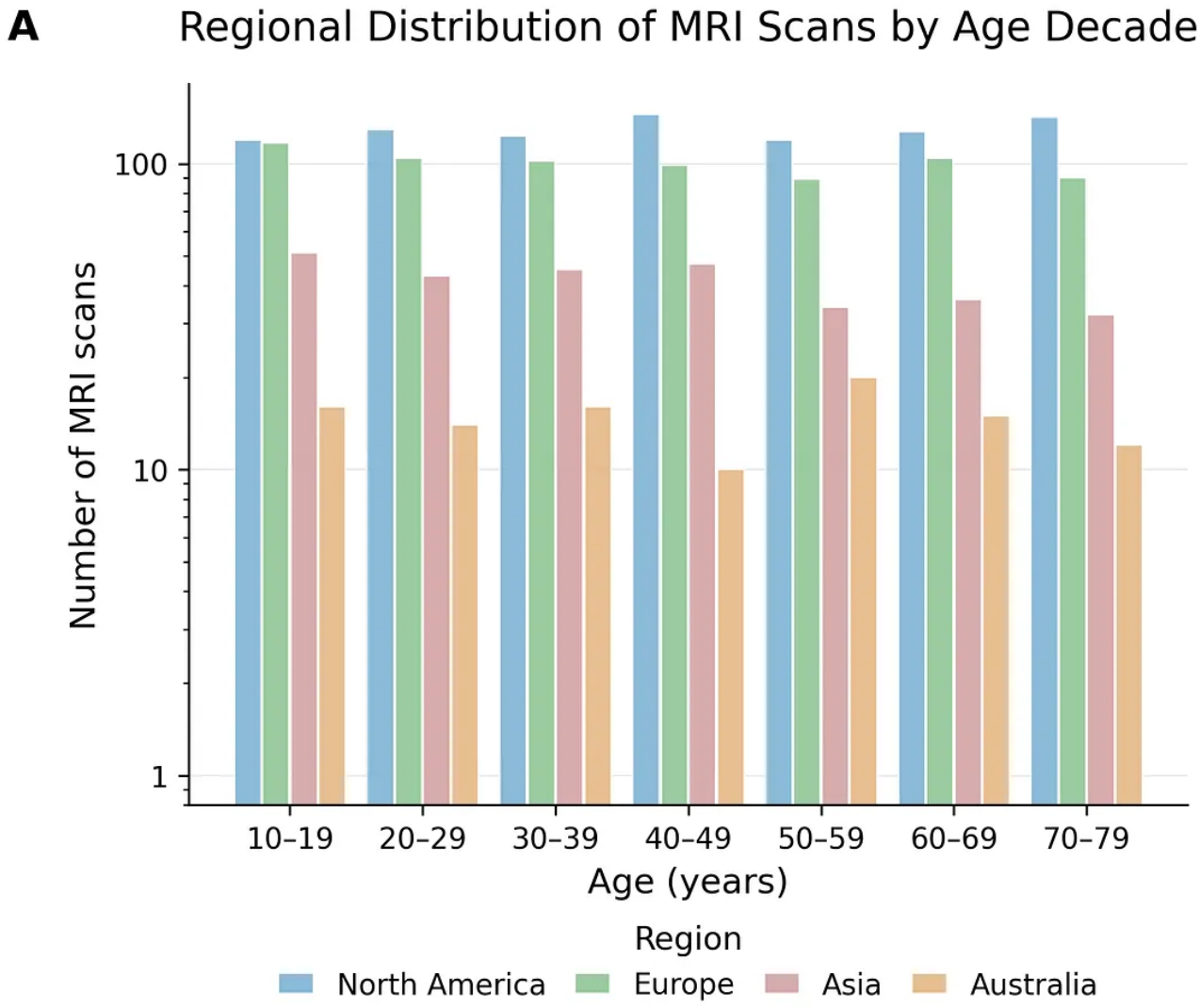
A really questionable plot.

Let's list some of the problems here:

- A clash of neon colors that hurts your eyes
- Unhelpful title and axis labels
- Legend crammed in the corner with microscopic text
- Unnecessary thick black borders on everything
- Random text annotation
- Lazy variable naming

- No proper formatting or care for readability

Here I offer you a slight improvement:



A little improvement!

Below, I link some of my all-time favorite resources for solid scientific plot reading:

- An overview of appropriate charts and when to use each https://github.com/Financial-Times/chart-doctor/blob/main/visual-vocabulary/FT4schools_RGS.pdf
- VERY good manual for the common mistakes https://github.com/cxli233/FriendsDontLetFriends
- Looking for unusual plot inspirations? Rent/or buy any book of Edward Tufte

- An excellent read on figures https://accessibility.huit.harvard.edu/data-viz-charts-graphs
- For a big upgrade in style, switch from plotting in **Python to R** -> much easier to customize and create aesthetic figures with ggplot2 then with matplotlib
- Using Claude/GPT/etc? Try adding something like "*make publication-ready high-quality plot*" to your prompt.

This cat is reading. And so should you check the reading materials! Photo by Madalyn Cox on Unsplash

Happy plotting! Let me know if you find this information helpful in the comments below :)

Science PhD Plot Data Visualization