Graphics Principles Cheat Sheet v1.1

Communication

Effective visualizations communicate complex statistical and quantitative information facilitating insight, understanding, and decision making.

But what is an effective graph?

This cheat sheet provides general guidance and points to consider.

Planning

Why – Clearly identify the purpose of the graph, e.g. to deliver a message or for exploration?

What – Identify the quantitative evidence to support the purpose

Who – Identify the intended audience (specialists, non-specialists, both) and focus the design to support their needs

Where – Adapt the design to space or formatting constraints (e.g. clinical report, slide deck or publication)

Principles of Effective Graphic Design

Proximity – group related elements together

Alignment – elements on the same vertical or horizontal plane are perceived as having similar properties

Simplicity – cut anything superfluous, only include elements that add value, limit to 2-3 colors or fonts

White space (empty space) – use white space to minimize distraction & provide clarity

Legibility – sans serif fonts are easier to read, use color for emphasis instead of a new typeface

Color – select colors that present enough contrast to make the graph legible. Choose monochromatic color schemes to prevent clashing. Use dark colors and accent colors to emphasize important information

Visual Hierarchy – use color, font, image size, typeface, alignment & placement to create a viewing order

Focal Points – primary area of interest that immediately attracts the eye, emphasize the most important concept and make it your focal point. Use contrasting colors to draw attention

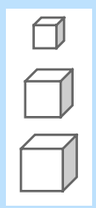
Repetition – repeating elements can be visually appealing, repeated shapes, labels, colors

Familiarity – using familiar styles, icons, navigation structure makes viewers feel confident

Consistency – be consistent with heading sizes, font choices, color scheme, and spacing. Use images with similar styles

Effectiveness Ranking

A graph is a representation of data that visually encodes numerical values into attributes such as lines, symbols and colors. The Cleveland-McGill scale can be used to select the most effective attribute(s) for your purpose.

Volume	Color hue	Depth: 3d position	Color intensity	Area	Slope or Angle	Length	Position on unaligned scale	Position on common scale
								
								

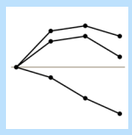
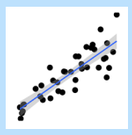
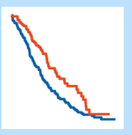
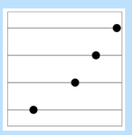
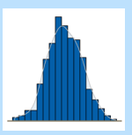
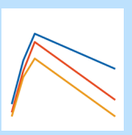
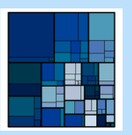
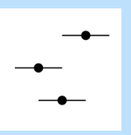
Least accurate → **Most accurate**

volume charts	poorly designed heat maps	multivariate density plots	heat maps	bubble charts, mosaic charts	line graphs, pie charts	stacked bar charts, waterfall chart	small multiple plots	dot plots, bar charts, parallel coordinate plots

Selecting the right base graph

Consider if a standard graph can be used by identifying suitable designs based on the:
(i) **purpose** (i.e. message to be conveyed or question to answer) and (ii) **data** (i.e. variables to display).

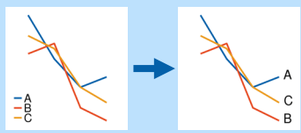
Example plots categorized by purpose

Deviation	Correlation	Ranking	Distribution	Evolution	Part-to-whole	Magnitude
Chg. from baseline	Scatter plot	Horizontal bar chart	Boxplot	Kaplan Meier	Stacked bar chart	Vertical bar chart
						
Waterfall	**Heat map**	**Dotplot**	**Histogram**	**Line plot**	**Tree map**	**Forest plot**
						

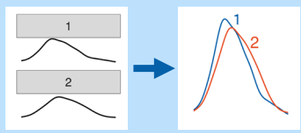
Facilitating Comparisons

Proximity improves association

Place labels next to data instead of using legends

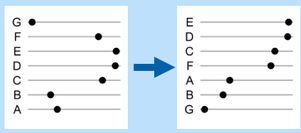


Group together elements to be compared directly

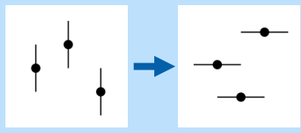


Ease visual inspection

Order values to help compare across many categories

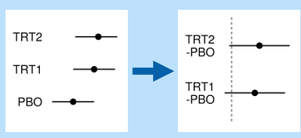


Judgments are easier to make on a common vertical scale

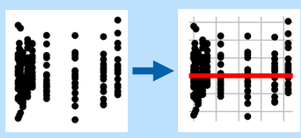


Reduce mental arithmetic

Plot the final comparison e.g. mean difference not two means
Exception: if comparator is of interest in itself



Use reference lines and other visual anchors.



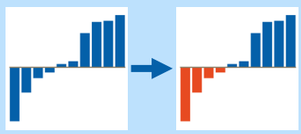
Color for emphasis or distinction

Restrained use of color is highly effective in organizing a narrative and calling attention to certain elements.

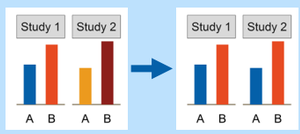
Think carefully before introducing additional color. Do you really need it?

Do not use color to differentiate between categories of the same variable

Use colors or shades to represent meaningful differences such as positive/negative values, treatments or doses



Be consistent, use the same color to mean the same thing in a series of graphs (e.g. treatment, dose)



Use a bold, saturated or contrasting color to emphasize important details.

Emphasize the data by minimizing unnecessary ink, e.g. soften gridlines with a light color

Utilize existing resources for selection of appropriate palettes such as
Color brewer
or Munsell

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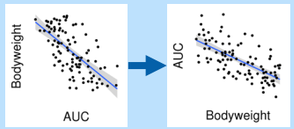
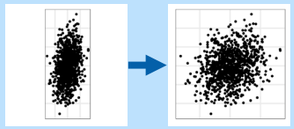
Implementation Considerations

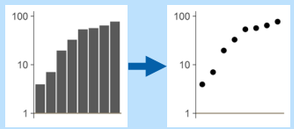
Plot cause on the x-axis and effect on the y-axis. Use this standard convention in order to avoid misinterpretation.



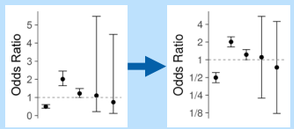
Aspect ratio can influence interpretation. Aim for a 45 degree angle of change to avoid over-interpretation of slope.



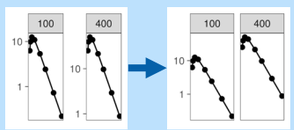
Use position for comparisons rather than length (i.e. dots instead of bars), especially for non-linear scales (e.g. log scale or % change).



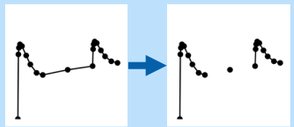
Do not plot log-normally distributed variables on a linear scale (e.g. hazard ratio, AUC, CL)



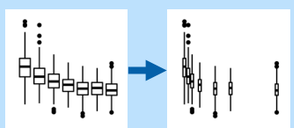
When displaying data measured on the same scale, also plot them on the same scale for easy comparison.



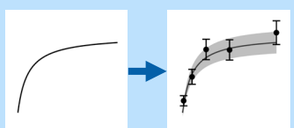
Connected data imply continuity. Do not connect data across a disconnected or uneven time scale.



Visits displayed close together are perceived to be closer in time. Space the visits proportional to the time between each in order to avoid confusion.
Exception: baseline or pre-dose



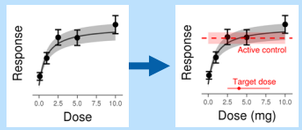
Plot data and inferences to support stories about models.



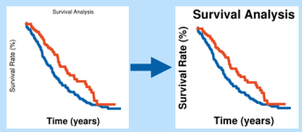
Legibility and Clarity

Effective graphs stand alone. They use titles, annotations, labels, shapes, colors, and textures to deliver important information.

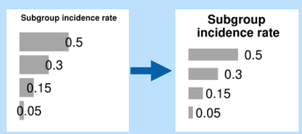
Label axes with clear measurement units and provide annotations that support the message.



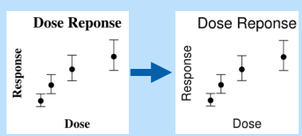
Use font size to create hierarchy (e.g. set titles 2pt larger than all other labels to make them more prominent).



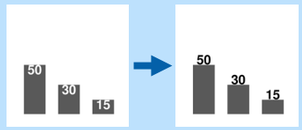
Do not type too small or too condensed. Break long titles into two lines. Shift or adjust size of labels that overlap.



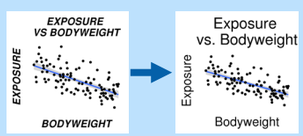
Keep the font style simple – sans serif is easier to read.



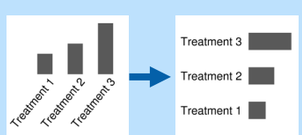
Display text with enough contrast to be visible. Favor the use of dark on light instead of light on dark whenever possible.



Bold or italics should only be used for layering or emphasis. Emphasizing everything means nothing gets emphasized.

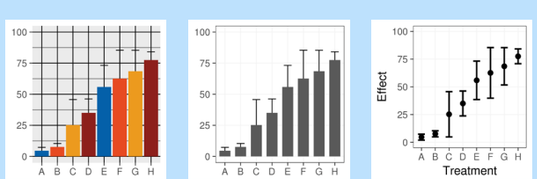


Try not to set text at an angle, as this decreases readability. Think of alternative solutions such as transposing the graph.



Putting it all together – Remove the clutter & emphasize the message

Creating a graph is an iterative process: produce, review and refine.



Colors, backgrounds, and borders can be removed and gridlines reduced.

It is easier to see differences in position over a difference in length, i.e. a dot over a bar.

Using too many colors can be distracting. Use white background and try using other methods to distinguish different curves.

One solution could be repeating the data in different panels, highlighting individual curves in a darker color.

Good graph checklist

Clear Communication

- ❑ Is the message of the graph as clear as possible?
- ❑ Is it easy for someone unfamiliar with the data to interpret the graph?
- ❑ Are the patterns/relationships easily identified?
- ❑ Is the graph tailored to its primary purpose and audience?
- ❑ Is the correct graph type used?

Facilitating Comparisons

- ❑ Are elements to be compared grouped together?
- ❑ Are labels placed next to data instead of in legends?
- ❑ Have categories been ordered for easy comparison?
- ❑ Can the plot be read without doing mental calculations?
- ❑ Are the estimates of interest plotted (e.g. mean differences with confidence intervals)?

Color for emphasis or distinction

- ❑ Are graphical elements displayed in a dark color on a light background?
- ❑ Are grid lines drawn with a thin line and a light color such as grey?
- ❑ Are colors used sparingly (e.g. max 3)?
- ❑ Do all elements in the graph have a purpose (e.g. colors, textures, grid lines)?
- ❑ Are the same colors used to mean the same thing in a series of graphs?

Implementation Considerations

- ❑ Are multiple panels plotted on the same scale?
- ❑ Are lognormally distributed variables plotted on a log scale?
- ❑ Are common baselines used wherever possible?
- ❑ Does the orientation of the axes aid interpretation?
- ❑ Does the aspect ratio allow the reader to see variations in the data?
- ❑ Are data across a disconnected time scale kept disconnected?
- ❑ Are data spaced proportionally to the actual time interval (instead of according to visit number)?
- ❑ Are data and inferences plotted to support stories about models?
- ❑ Are number of patients by group reported if this adds context?

Legibility and Clarity

- ❑ Can all graphical elements be seen?
- ❑ Does the graph have a clear title, axis labels, annotations and data units?
- ❑ Can the font be read without eye strain or effort?
- ❑ Are sans-serif fonts used?
- ❑ Do text sizes have correct hierarchy (big to small, main text to subtext)?
- ❑ Are the elements of the graph clearly labeled (e.g. points, error bars, lines, shaded regions)?
- ❑ Are labels oriented horizontally where possible?

Resources

Books:

E. R. Tufte, The visual display of quantitative information, Connecticut, Graphics. Press, 2001.

Cleveland, W.S. and McGill, Robert, Graphical perception: theory, experimentation and application to the development of graphical methods, JASA, Vol. 79, No. 387, pp. 531 – 554, 1984.

S. Few, Show Me The Numbers - Designing Tables and Graphs to Enlighten (2nd. Edition), Burlingame, CA: Analytics Press, 2012.

D. M. Wong, The Wall Street Journal Guide to Information Graphics: The Dos and Don'ts of Presenting Data, Facts, and Figures. December 16, 2013.

J. Doumont, Trees, maps, and theorems: Effective communication for rational minds. PRINCIPIAE.

N. B. Robbins, Creating More Effective Graphs. Chart House.

Online resources:

https://www.perceptualedge.com/ (S. Few)
https://www.edwardtufte.com/tufte/ (E. Tufte)
http://flowingdata.com/ (N. Yau)
http://www.principiae.be/ (J. Doumont)
http://andrewgelman.com/ (A. Gelman)
http://www.thefunctionalart.com/ (A. Cairo)
http://www.nbr-graphs.com/ (N. Robbins)

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