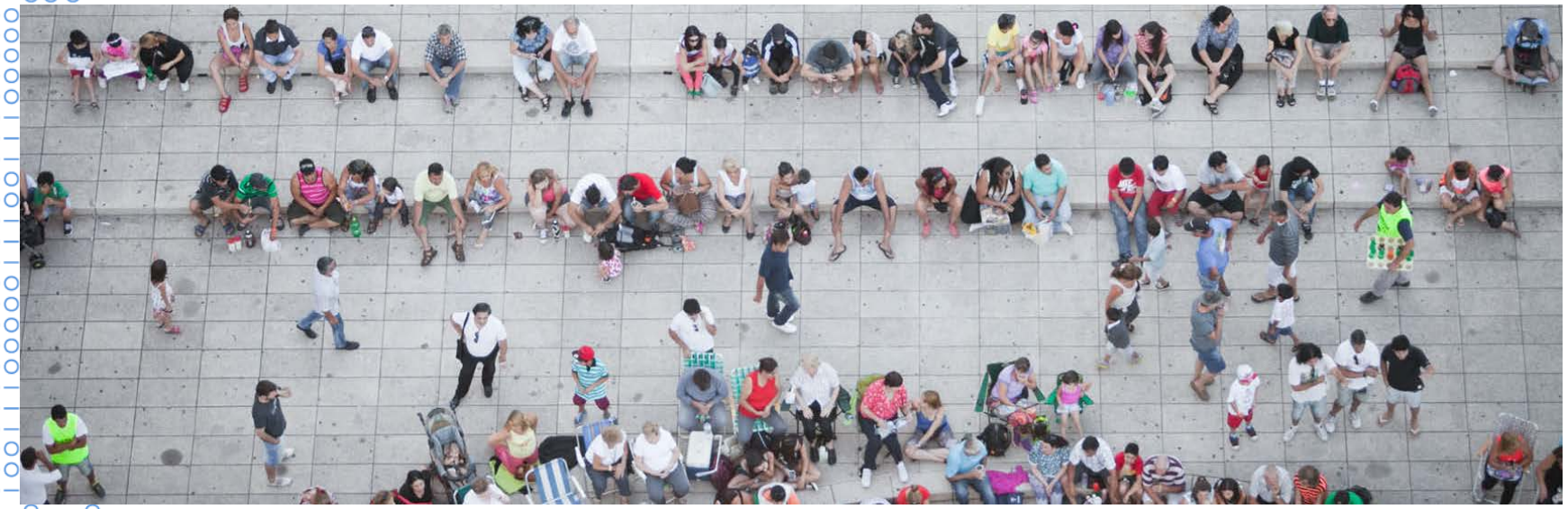

How do we make better graphs? Effective visual communication for the quantitative scientist

Mark Baillie

July 18th, 2019

Leuven, STRATOS symposia, ISCB 2019

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Table 11-4
Summary of best overall response as per investigator by treatment group
(Full analysis set)

	LDK 450mg + AUY 28 mg/m2 N=3 n (%)	LDK 450mg + AUY 40 mg/m2 N=5 n (%)	LDK 450mg + AUY 55 mg/m2 N=4 n (%)	LDK 600mg + AUY 28 mg/m2 N=6 n (%)	LDK 600mg + AUY 40 mg/m2 N=4 n (%)	All patients N=22 n (%)
Best overall response						
Complete response (CR)	2 (66.7)	0	1 (25.0)	0	0	3 (13.6)
Partial response (PR)	0	1 (20.0)	0	1 (16.7)	1 (25.0)	3 (13.6)
Stable disease (SD)	0	2 (40.0)	1 (25.0)	4 (66.7)	0	7 (31.8)
Progressive disease (PD)	0	2 (40.0)	2 (50.0)	1 (16.7)	2 (50.0)	7 (31.8)
Unknown	1 (33.3)	0	0	0	1 (25.0)	2 (9.1)
Overall response rate (ORR)	2 (66.7)	1 (20.0)	1 (25.0)	1 (16.7)	1 (25.0)	6 (27.3)
(CR or PR)						
95% CI	(9.4-99.2)	(0.5-71.6)	(0.6-80.6)	(0.4-64.1)	(0.6-80.6)	(10.7-50.2)
Disease control rate (DCR)	2 (66.7)	3 (60.0)	2 (50.0)	5 (83.3)	1 (25.0)	13 (59.1)
(CR or PR or SD)						
95% CI	(9.4-99.2)	(14.7-94.7)	(6.8-93.2)	(35.9-99.6)	(0.6-80.6)	(36.4-79.3)

Best overall response is based on investigator's assessment of disease status using RECIST 1.1.
Estimate (95%CI) for ORR and DCR were obtained using exact binomial 95% confidence interval test.

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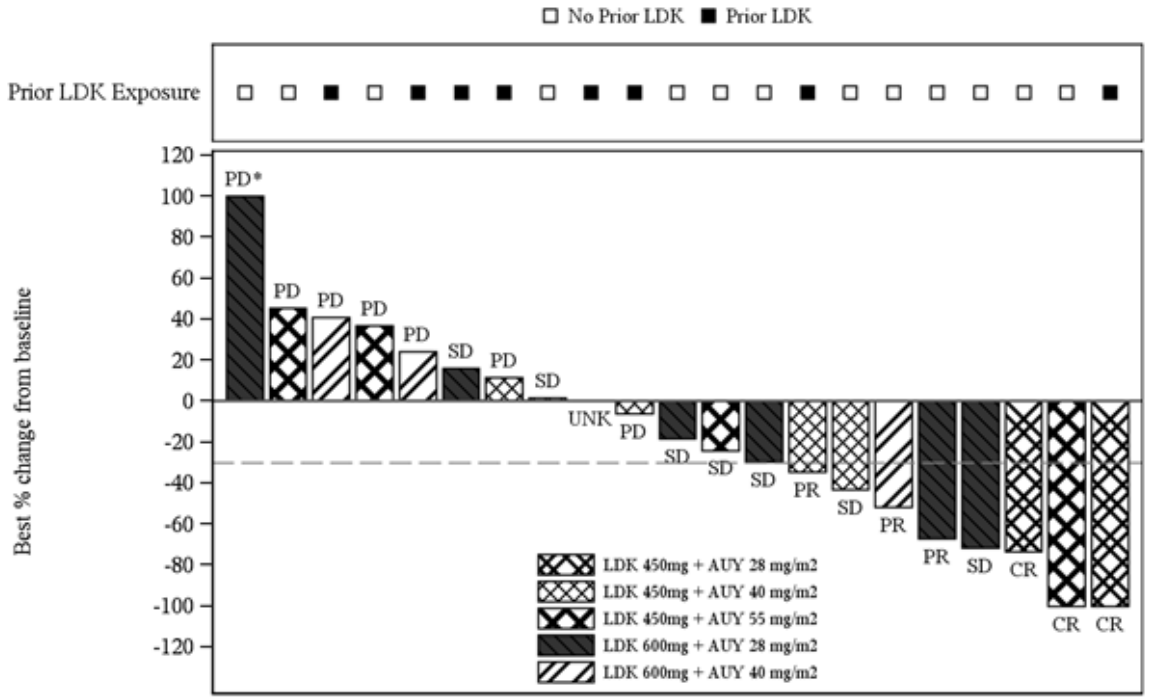
Figure 11-1 (Page 1 of 1)
Best percentage change from baseline in sum of longest diameters and best overall response as per investigator by prior LDK378 treatment
(Full analysis set)



- * Denotes the percentage change from baseline greater than 100.
Source: Table 11-4, Listing 14.2-1.2 and Listing 16.2.4-1.5

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Elements of a grapics initiative

Graphical principles and thinking

1. Graphics Principles Cheat Sheet
2. Newsletter

Easing the implementation

3. Graph Gallery
4. Analysis Results Datasets
5. Standardization of most common/important graphs

Graphics tomorrow ... or today?

6. Question-based visualizations and interactive graphics

... plus overarching stakeholder management and communication

https://graphicsprinciples.github.io/

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STRATOS Visualisation panel

“Visualization and the use of graphics can help at every stage of an analysis, from the planning and design of an experiment, the very first data explorations, through to the communication of conclusions and recommendations. Visualization is more than "plotting data"; it can lead to a deeper understanding and inform next steps.

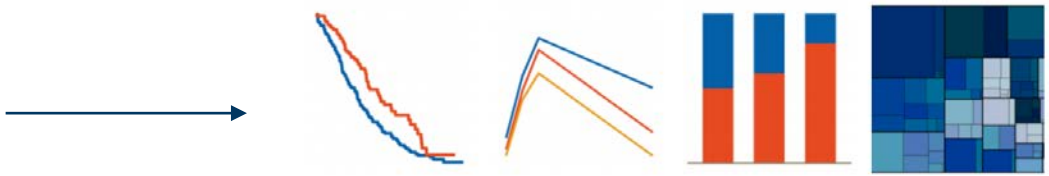
The role of the STRATOS visualization panel is to promote the use of good graphical principles for effective visual communication, providing guidance and recommendations covering all aspects from the design, implementation and review of statistical graphics.”

http://www.stratos-initiative.org

Effective visualisation is important throughout the workflow

Topic groups

1	Missing data
2	Selection of variables and functional forms in multivariable analysis
3	Initial data analysis
4	Measurement error and misclassification
5	Study design
6	Evaluating diagnostic tests and prediction models
7	Causal inference
8	Survival analysis
9	High-dimensional data



“Data Display is critical to data analysis. Graphs allow us to explore data to see overall patterns and to see detailed behavior; no other approach can compete in revealing the structure of data so thoroughly.

Graphs allow us to view complex mathematical models fitted to data, and they allow us to assess the validity of such models”

William Cleveland,
The Elements of Graphing Data (1985)

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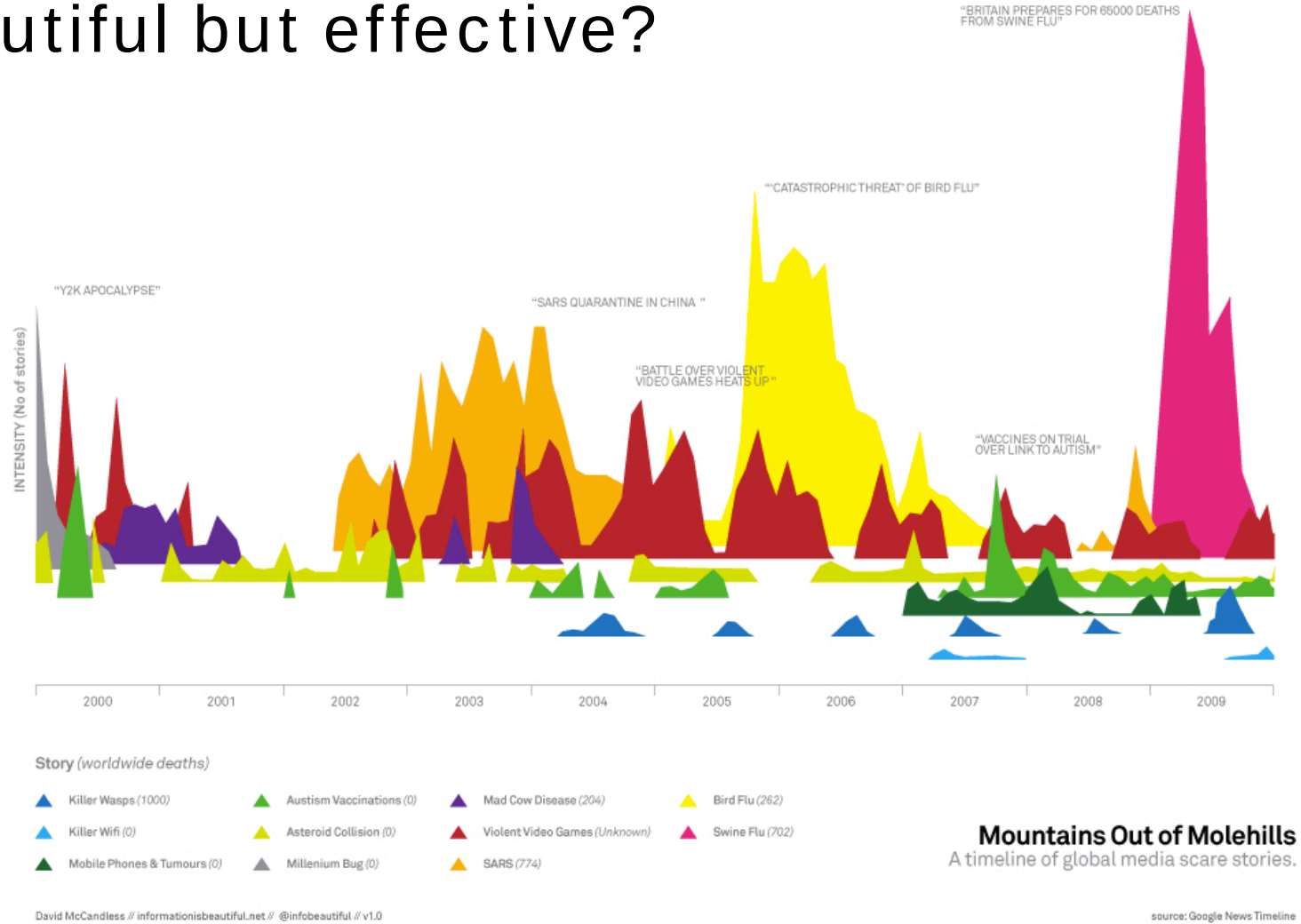
How do we get there?

- How do we tell a good graph from a bad one?
- How do we ensure we design a good graph that is fit for purpose?
- Recall goal: enhance understanding and use of **good graphical principles**

Effective data visualisation is effective visual communication

- Effective graphs...
  - are visually appealing, intuitive, legible
  - use the correct graph type and axis scales
  - use proximity & alignment to facilitate comparison
  - use labels and annotations to add clarity to the message
- Most importantly, effective use of visualisations
  - Enables clear and impactful communication
  - Elevates influence with stakeholders
  - Facilitates informed decision making

Beautiful but effective?



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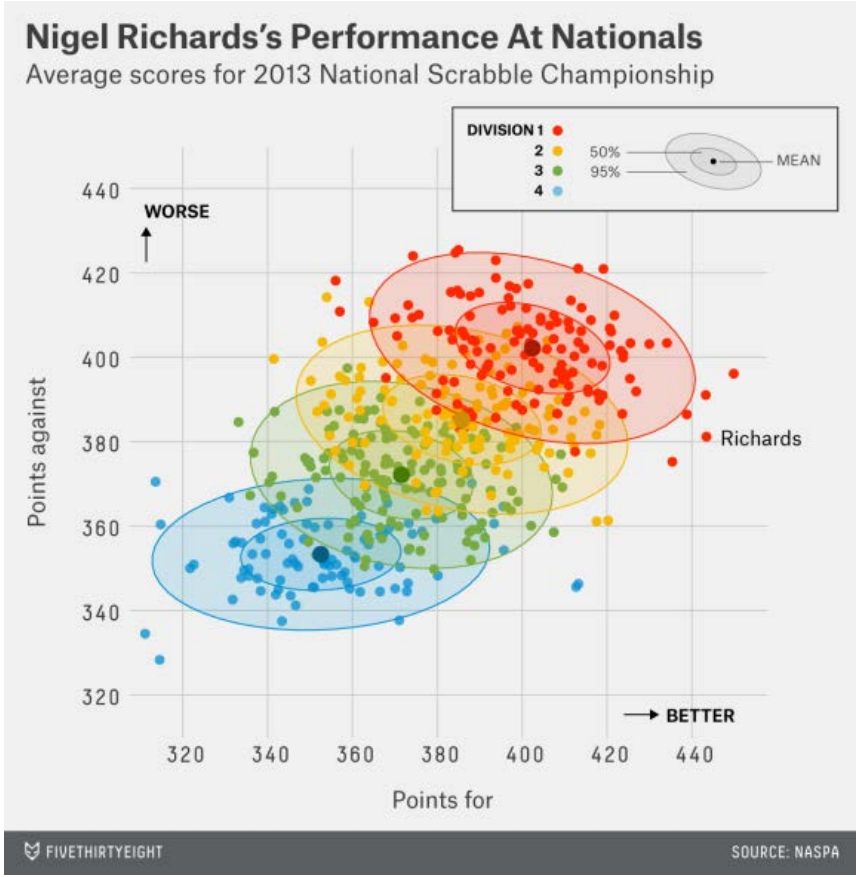

Principles for effective visual communication

Graphical Principles Cheat Sheet

Authors: Mark Baillie,[1] Alison Margolskee,[2] Baldur Magnusson,[1] Andrew Wright,[1] Ruquan You,[3] Ivan-Toma Vranesic,[1] Marc Vandemeulebroecke[1]
Affiliations: [1]Novartis Pharma AG, Basel, Switzerland; [2]Novartis Institutes for Biomedical Research, Cambridge, MA, United States; [3]Novartis Institutes for Biomedical Research, Shanghai, China

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.

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

Utilize the **Graph Gallery** (go/graphgallery). There are many effective base designs that can be adapted to your purpose.

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

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?
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Color for emphasis or distinction

- ❑ Are graphical elements displayed in a dark color on a light background?
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Resources

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

Use the cheat sheet for critical review

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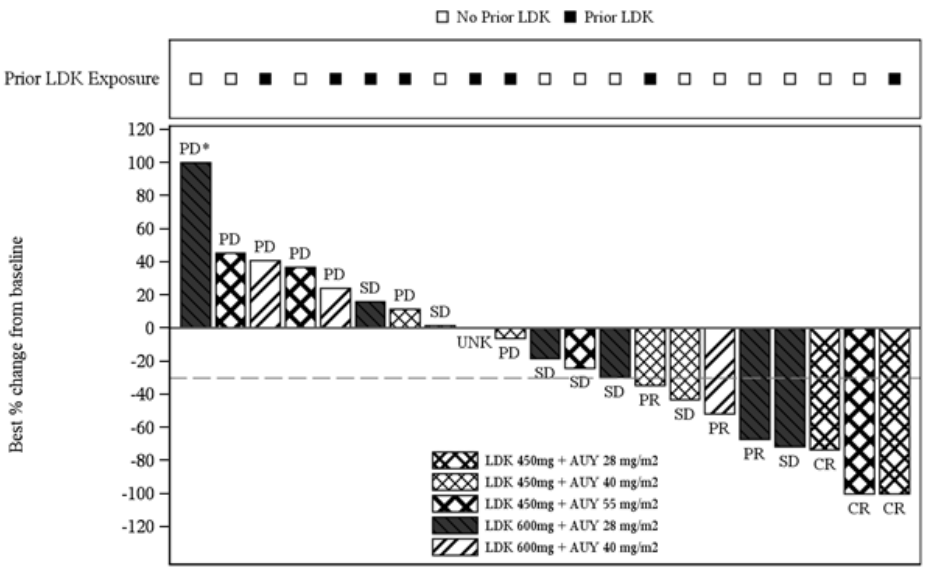
(Full analysis set)



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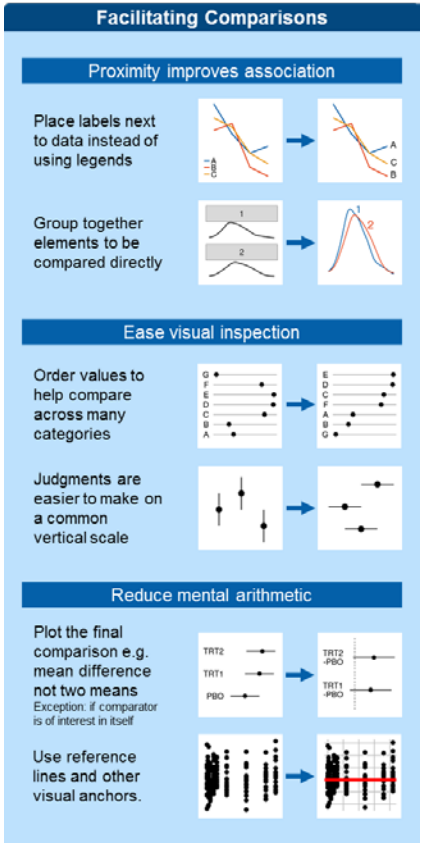

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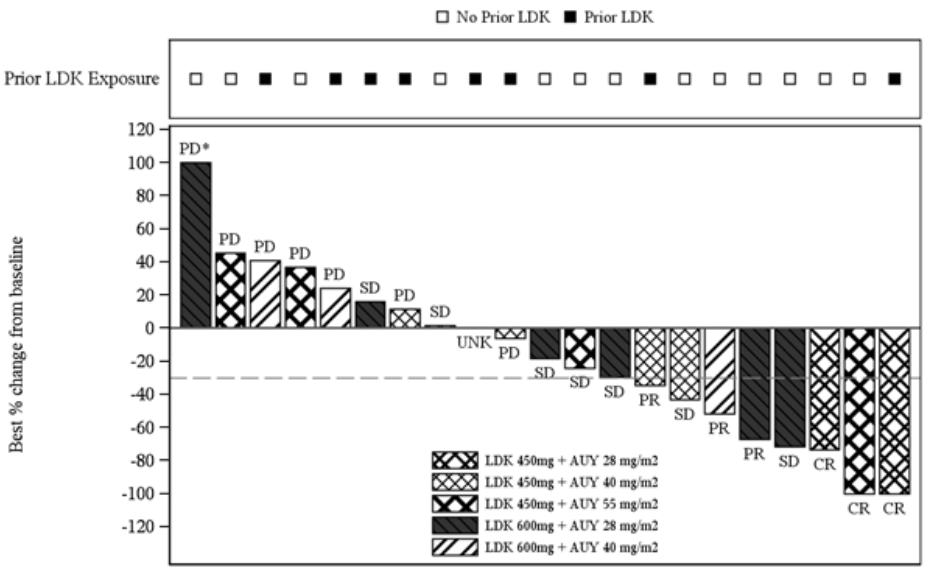

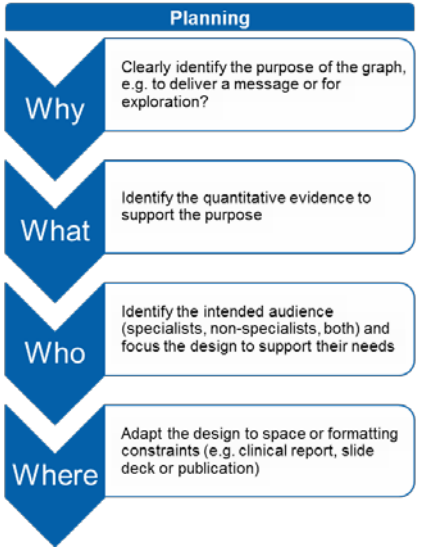

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Online resources:
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https://www.edwardtufte.com/tufte/ (E. Tufte)
http://flowingdata.com/ (N. Yau)
http://www.ai-process.be/ (J. Doumont)
http://andrewgelman.com/ (A. Gelman)
http://www.thefunctionalart.com/ (A. Cairo)
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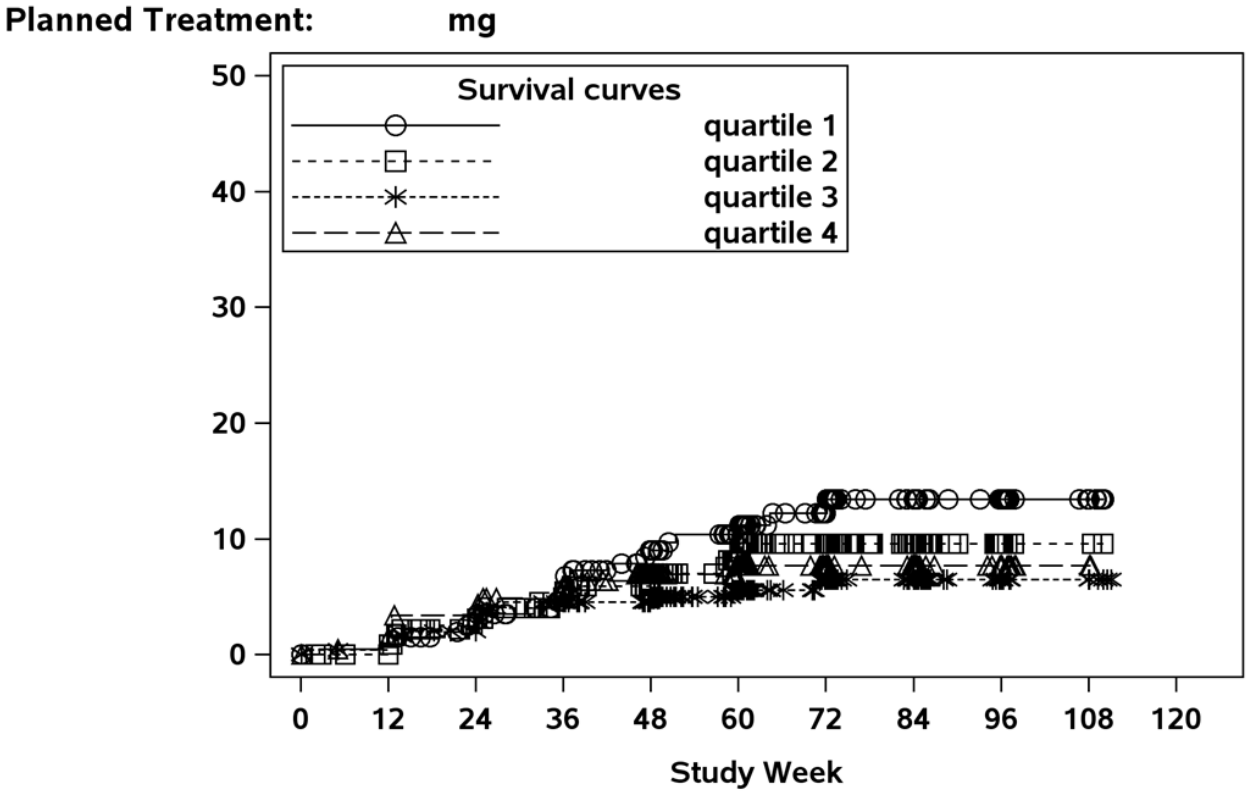
This is a continual process



Three laws for improving visual communication

Have a clear purpose

- Know the purpose of creating the graph
- Identify the quantitative evidence to support the purpose
- Identify the audience and focus the design to support their needs

Show the data clearly

- Choose the appropriate graph type to display your data
- Avoid misrepresentation (use appropriate scales)
- Maximize data to ink ratio (reduce distraction, less is more)

Make the message obvious

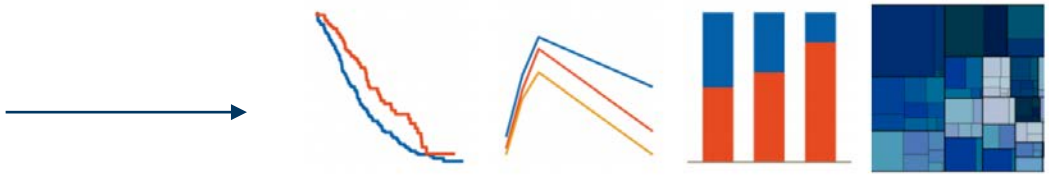
- Use proximity and alignment to aid in comparisons
- Minimize mental arithmetic (e.g. plot the difference)
- Use colors and annotations to highlight important details

https://arxiv.org/abs/1903.09512

Elements of a STRATOS VP initiative

Topic groups

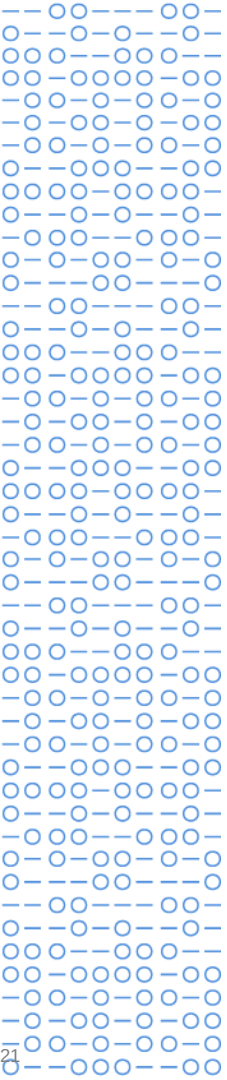
1	Missing data
2	Selection of variables and functional forms in multivariable analysis
3	Initial data analysis
4	Measurement error and misclassification
5	Study design
6	Evaluating diagnostic tests and prediction models
7	Causal inference
8	Survival analysis
9	High-dimensional data



STRATOS Visualisation panel

“Visualization and the use of graphics can help at every stage of an analysis, from the planning and design of an experiment, the very first data explorations, through to the communication of conclusions and recommendations. Visualization is more than "plotting data"; it can lead to a deeper understanding and inform next steps.

The role of the STRATOS visualization panel is to promote the use of good graphical principles for effective visual communication, providing guidance and recommendations covering all aspects from the design, implementation and review of statistical graphics.”



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