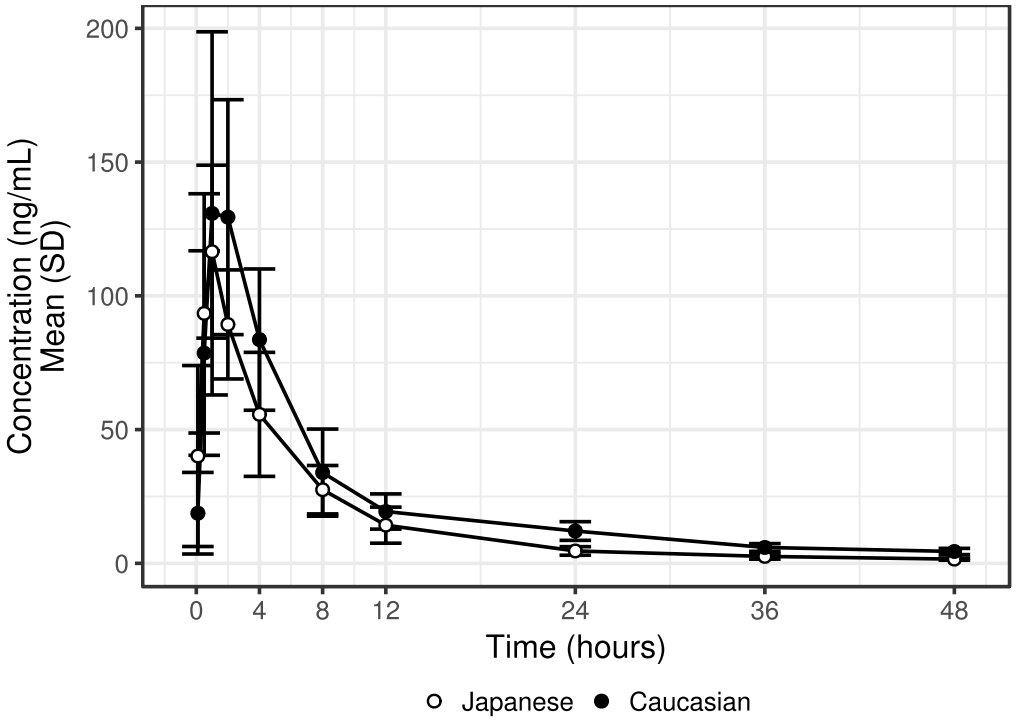
Effective Visual Communication (EVC) for Quantitative Scientists

Mark Baillie & Marc Vandemeulebroecke

International Biometric Conference (IBC), Riga, 11th July 2022

https://graphicsprinciples.github.io/

Science?



 https://github.com/GraphicsPrinciples/IBC2022

Art?

Effective Visual Communication (EVC) !

 https://github.com/GraphicsPrinciples/IBC2022

https://youtu.be/pfxulpF9XOw

Welcome and few tips before starting

- Do you have
  - A copy of the cheat sheet
  - The “purpose worksheet” word document
  - An example of a visualization you will work on (printed or not)
  - Paper (A4 pages to draw on), pen, pencils, color...
- **If not... Its’ time to get this now**

https://github.com/GraphicsPrinciples/IBC2022

Agenda – part 1

Timing	Agenda Item	Presenter
5 min	**Welcome** and housekeeping	Marc
15 min	**Introduction** and Learning Outcomes	Mark
25 min	**The 3 EVC Principles**	Marc
10 min	**Purpose Worksheet** and **Graphics Principles Cheat sheet**	Mark / Marc
15 min	**EVC in practice:** Example walk-through	Mark
45 min	**Your turn**: Work on your own example • Backup option: take a graph from us	Mark / all
5 min	**Wrap up** part 1	Mark

 https://github.com/GraphicsPrinciples/IBC2022

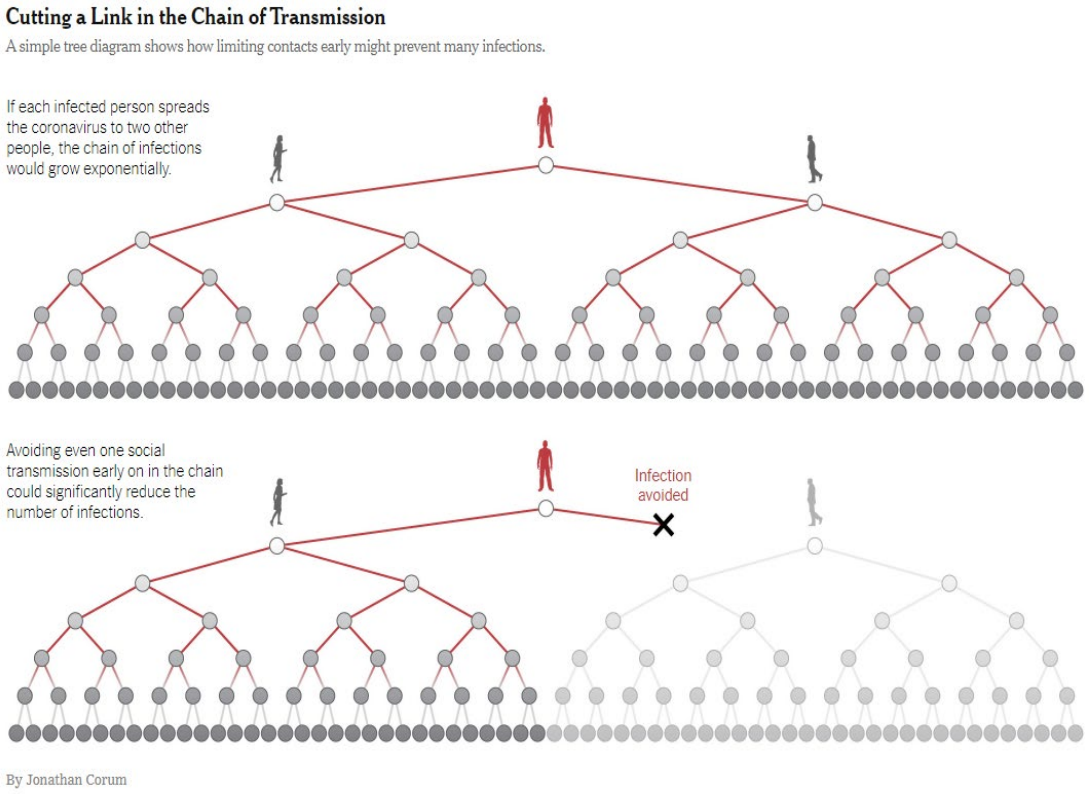
Agenda – part 2

Timing	Agenda Item	Presenter
5 min	Welcome back / housekeeping	Marc
5 min	Recap of part 1	Marc
45 min	**Feedback** and **group discussion** on your work	All
15 min	Reflections, resources & close	Mark

Introduction and Learning Outcomes

Mark

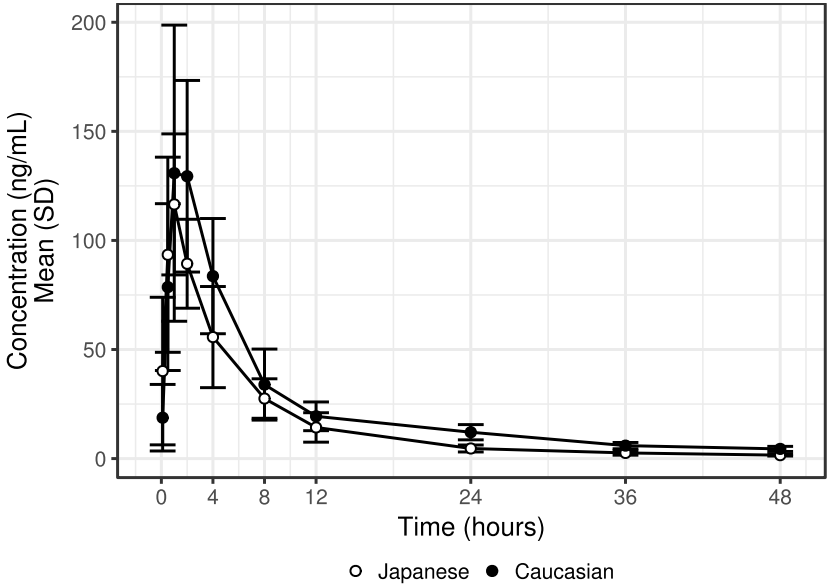
Effective visualisation is important



https://github.com/GraphicsPrinciples/IBC2022

https://www.nytimes.com/2020/03/19/health/coronavirus-distancing-transmission.html

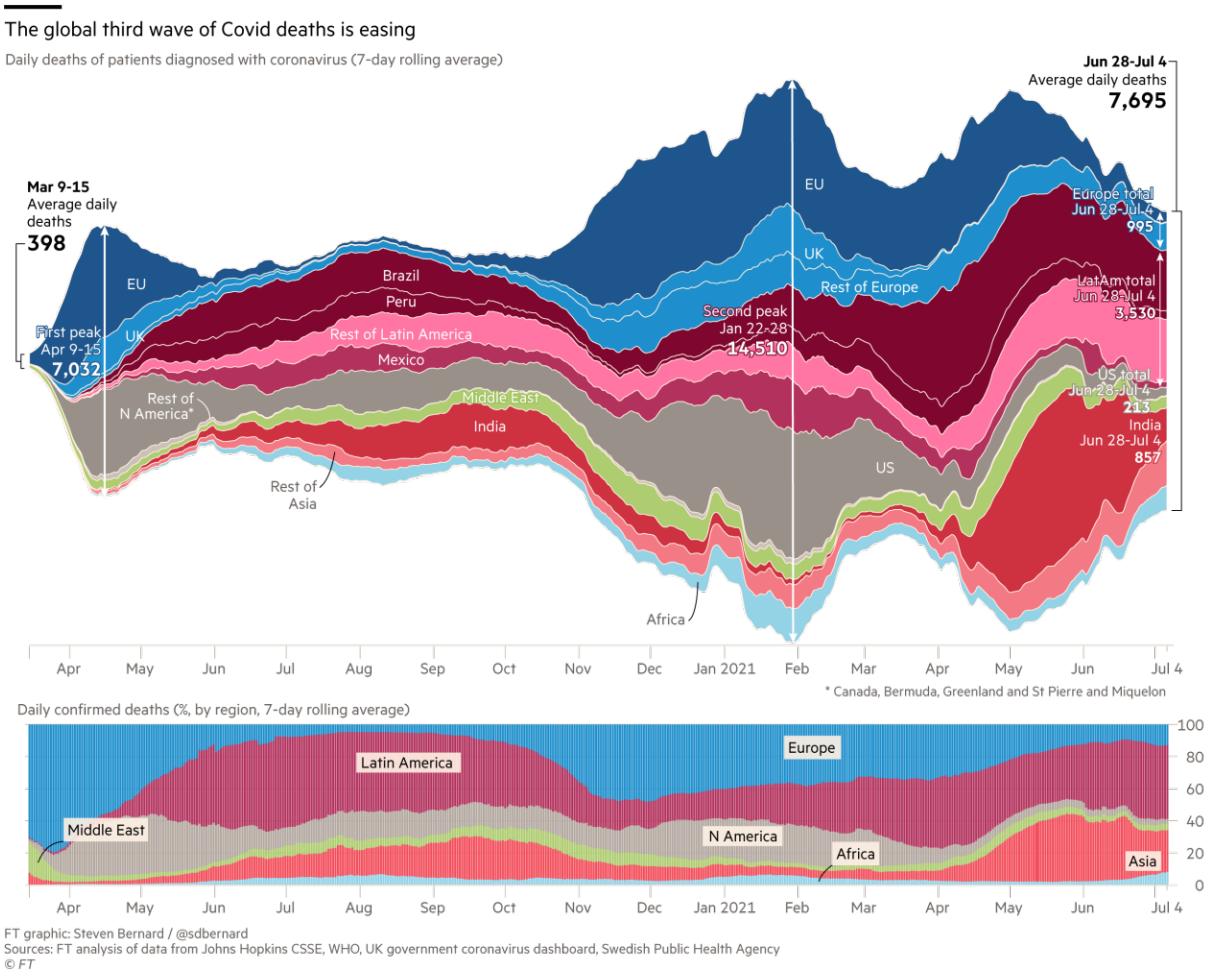
We are not always good at it



- Is exposure different?
- How?
- What are we supposed to conclude?

 https://github.com/GraphicsPrinciples/IBC2022

Beautiful – but effective?



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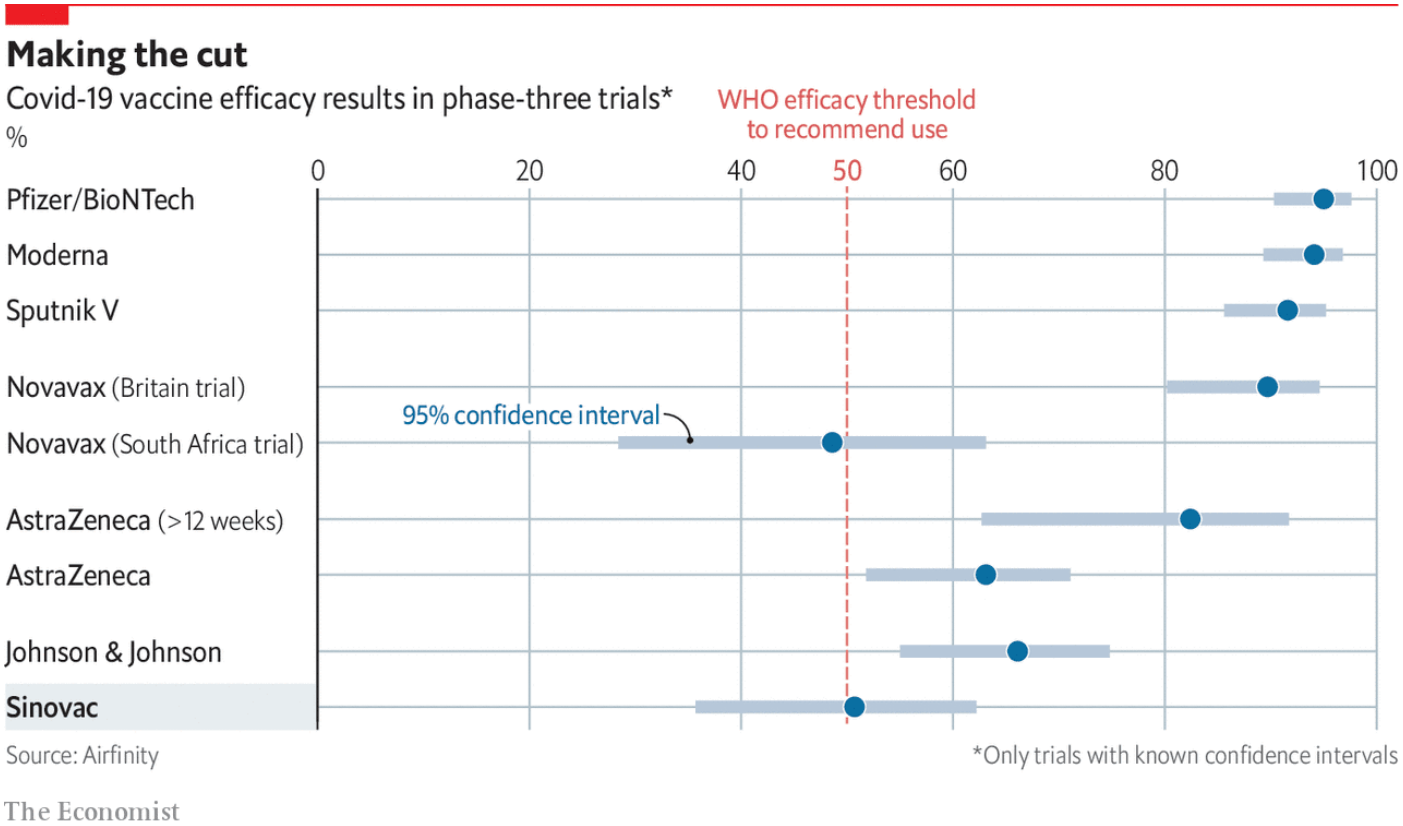
Beautiful and effective?



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https://www.economist.com/graphic-detail/2021/04/15/in-clinical-and-real-world-trials-chinas-sinovac-underperforms

Why does it matter?

- Effective Visual Communication (EVC) is essential in every step of a quantitative workflow, from scoping to execution through to communicating results and conclusions
- Within the quantitative sciences, traditional university and professional training curricula have not focused on EVC
- One hears regularly “I don’t understand this graph”
- A visual representation can be very powerful if it is clear and aligned with the intended purpose

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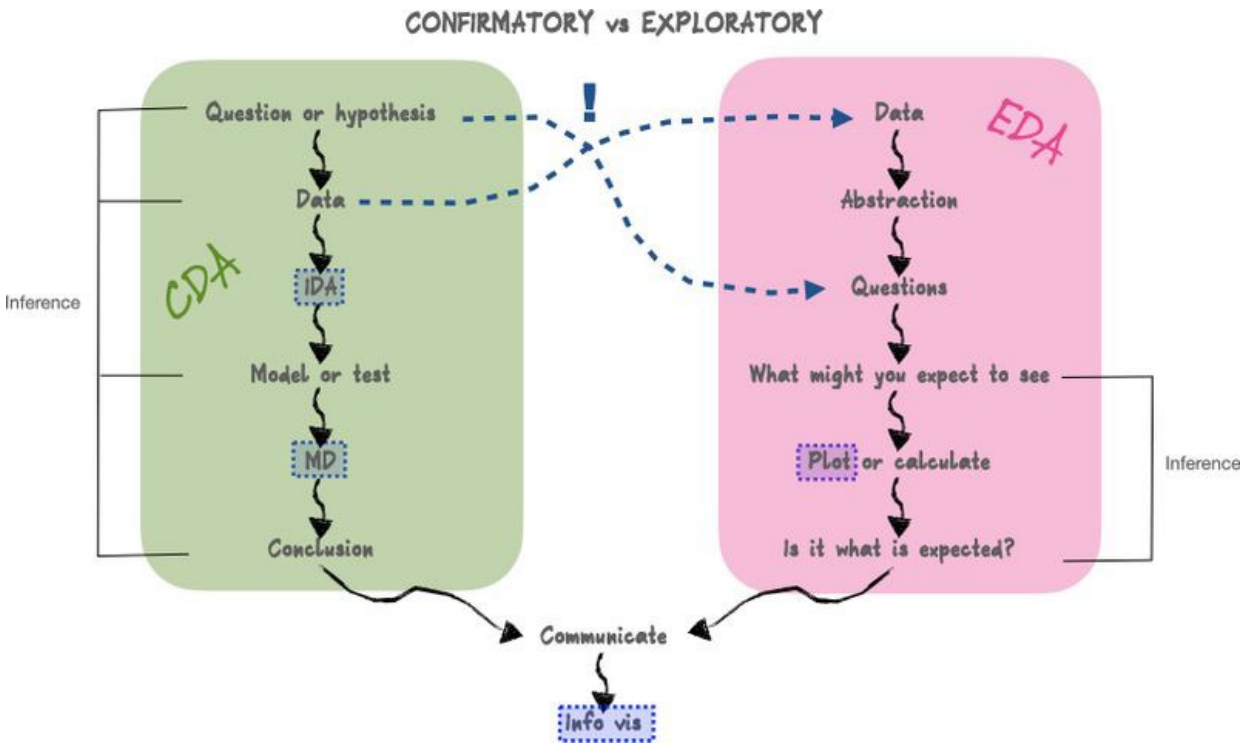
Learning outcomes for today's workshop

- Appreciate why Effective Visual Communication (EVC) is a key competency for the quantitative scientist.
- Explain the three principles of EVC (purpose, clarity and message).
- Design a visualization based on a specific purpose.
- Redesign a visualization to show data clearly.
- Enhance the message of a visualization.
- Recognize where to apply the three EVC principles in your daily work.

 https://github.com/GraphicsPrinciples/IBC2022

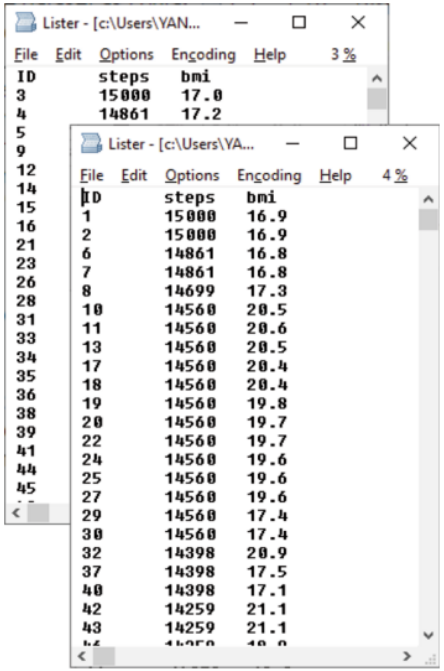
Where am I on the data analysis workflow

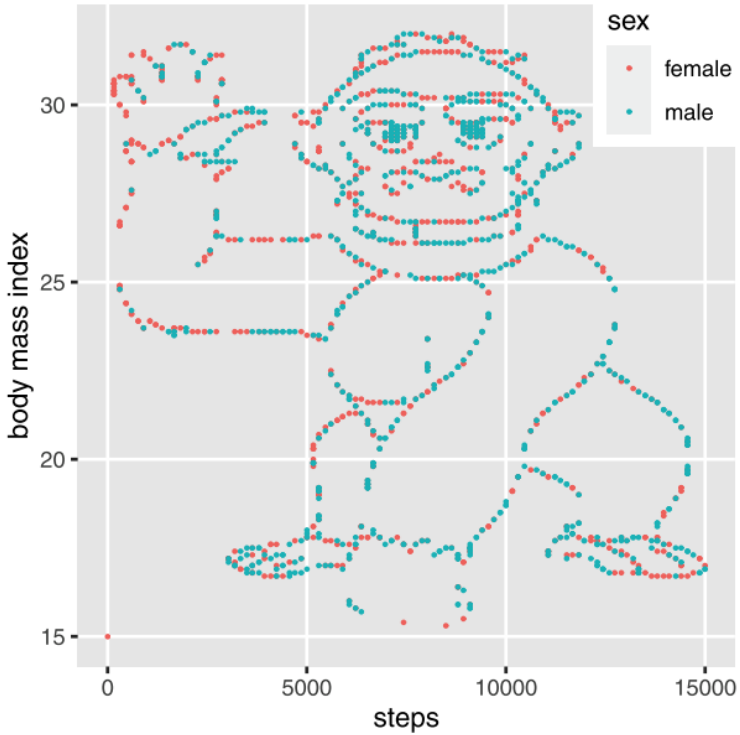


 https://github.com/GraphicsPrinciples/IBC2022

https://hdsr.mitpress.mit.edu/pub/mpdasaqt/release/2

Plot your data to see patterns





 https://github.com/GraphicsPrinciples/IBC2022

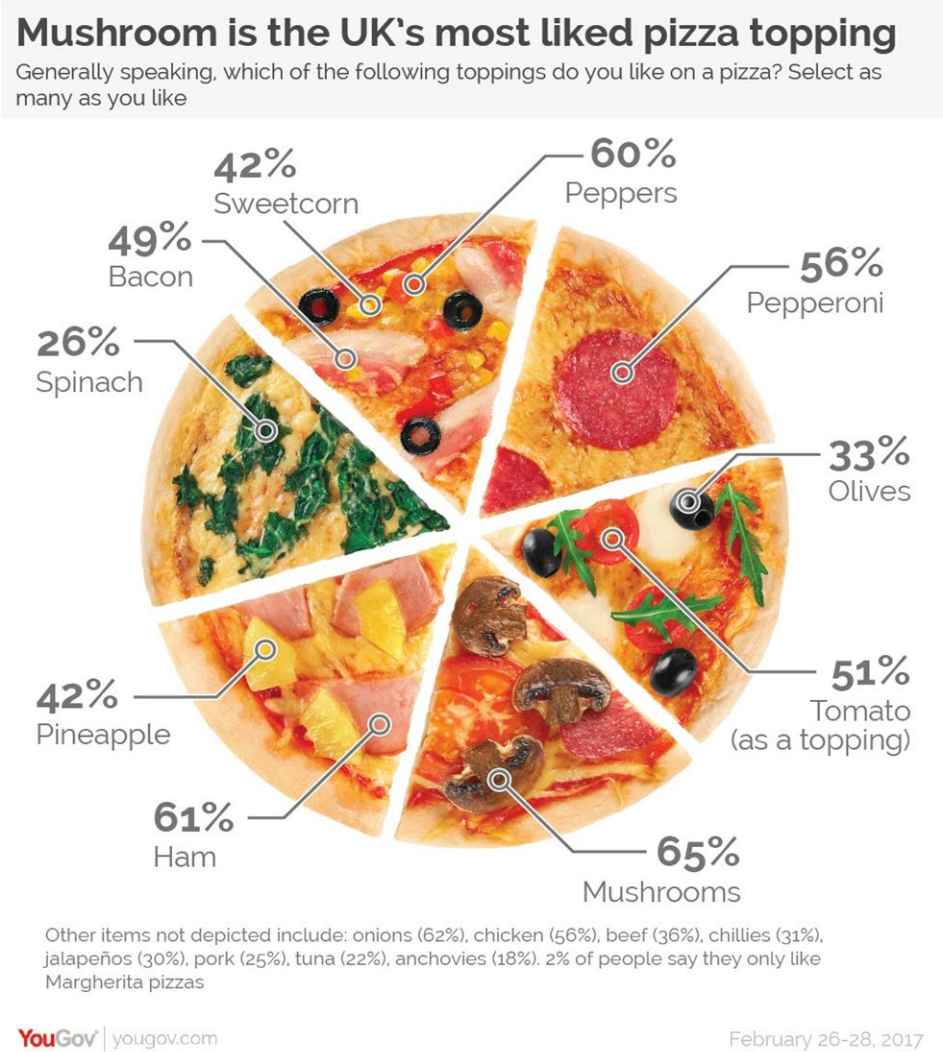
https://genomebiology.biomedcentral.com/articles/10.1186/s13059-020-02133-w

Don't mislead

 https://github.com/GraphicsPrinciples/IBC2022

https://www.theguardian.com/world/2019/sep/04/trump-hurricane-dorian-alabama-sharpie-map

Don't confuse



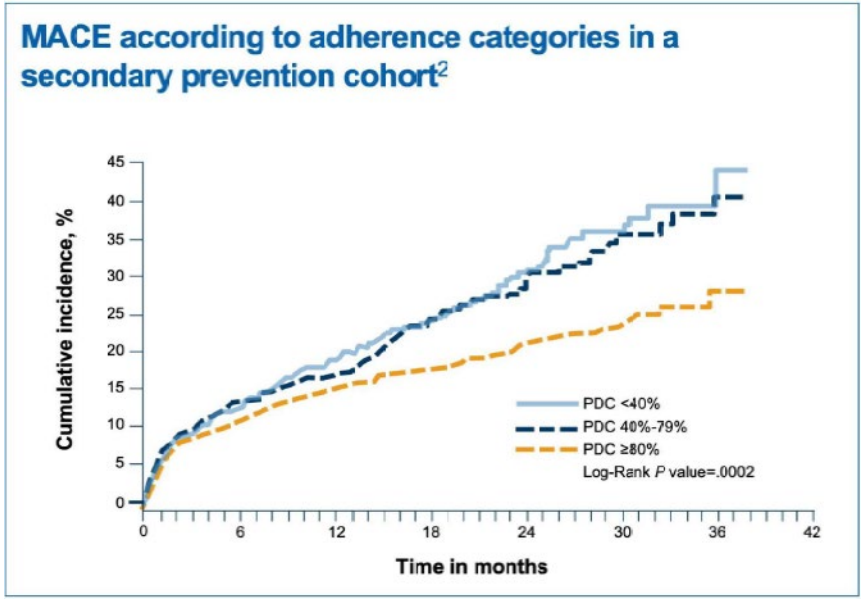
 https://github.com/GraphicsPrinciples/IBC2022

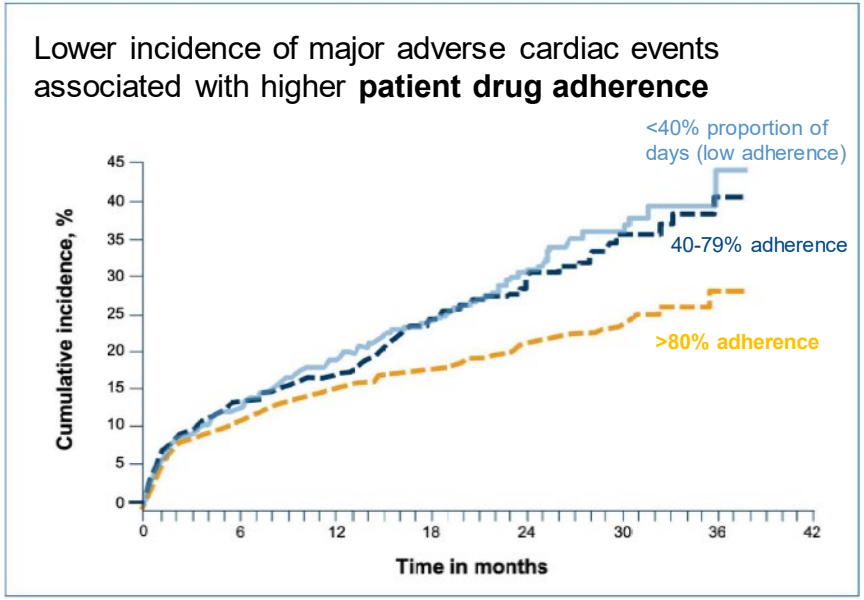
Don't worry

https://twitter.com/YouGov/status/838750115796041728

 https://github.com/GraphicsPrinciples/IBC2022

Act as a guide





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The 3 EVC Principles

Marc

1st principle
Have a clear purpose

Have a clear purpose

- What is the question?
- Who wants to know?
- Why do they want to know?
- What will they do with this knowledge?

Have a clear purpose

- What graph type do I want to create?

EXPLORATORY	EXPLANATORY
“I want to dig into the data”	“I want to communicate the results”
“I want to get familiar with the data”	“I want to tell the story in the data”
“I want to find the story in my data”	
The audience is: **YOU**	The audience is: **SOMEONE ELSE**

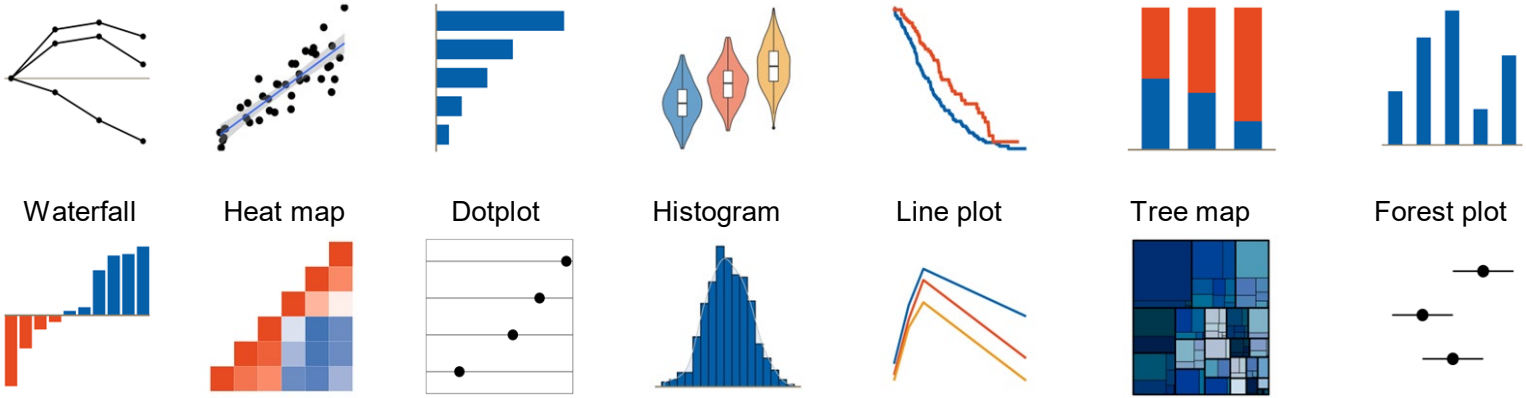
Credit Andrew Wright

2nd principle
Show the data clearly

Show the data clearly

- What is an appropriate base graph?

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



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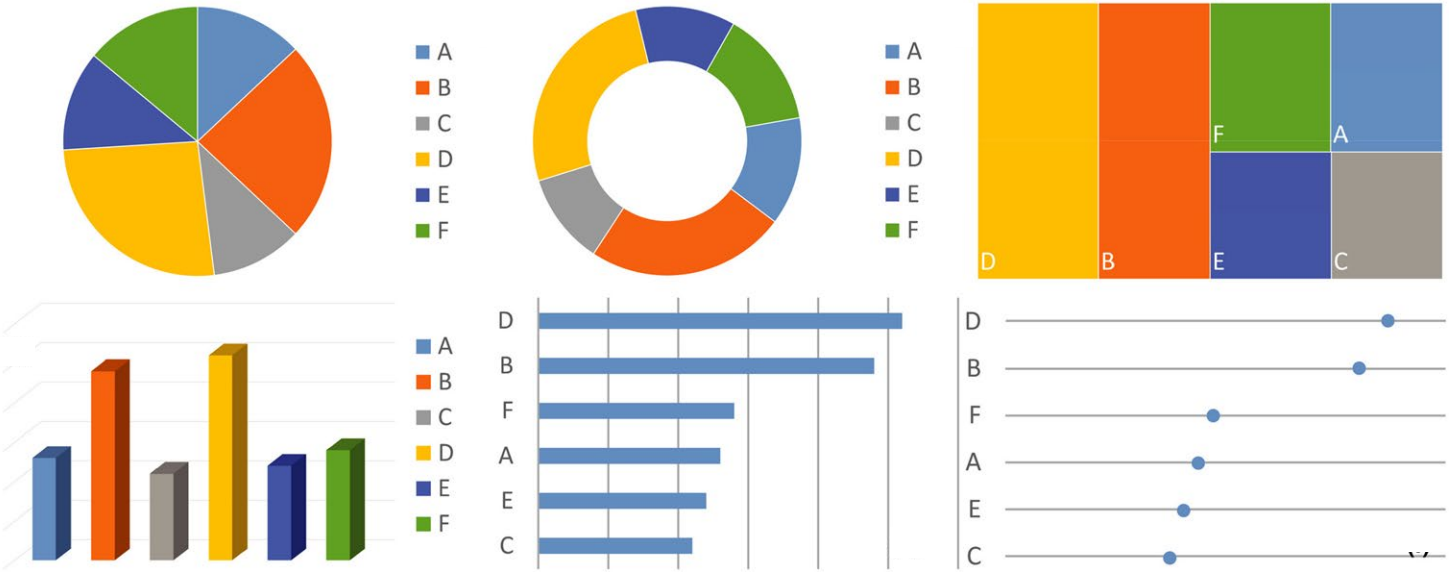
Show the data clearly

- What is an appropriate base graph?



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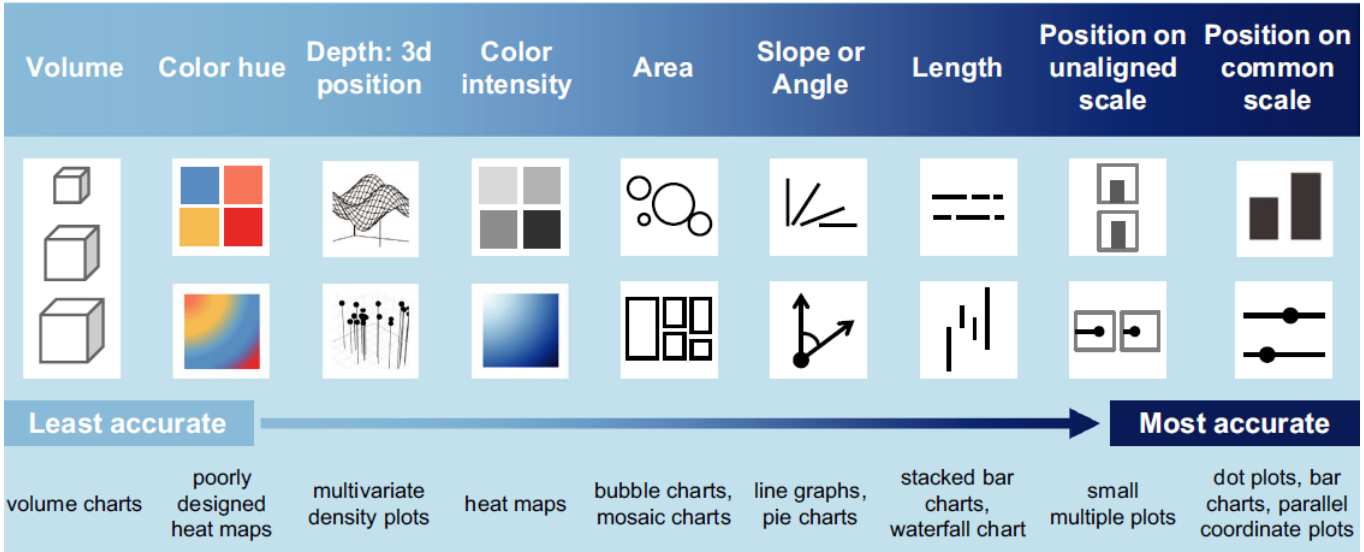
Show the data clearly

- What is an appropriate base graph?
- Is the data encoding effective?



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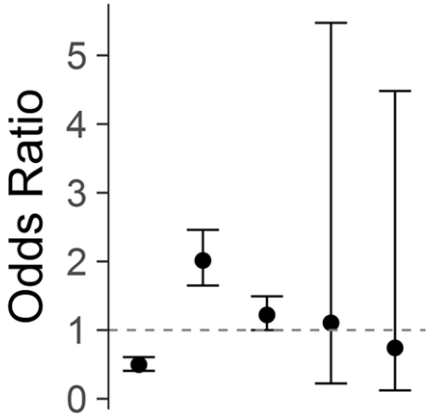
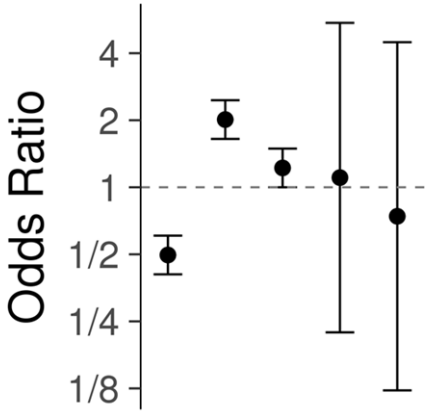
Show the data clearly

- What is an appropriate base graph?
- Is the data encoding effective?
- Do I represent the data faithfully?





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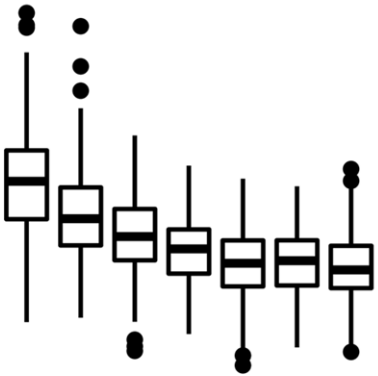
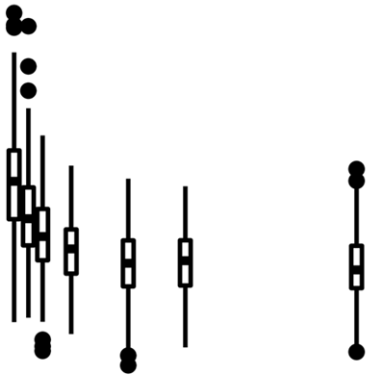




 https://github.com/GraphicsPrinciples/IBC2022

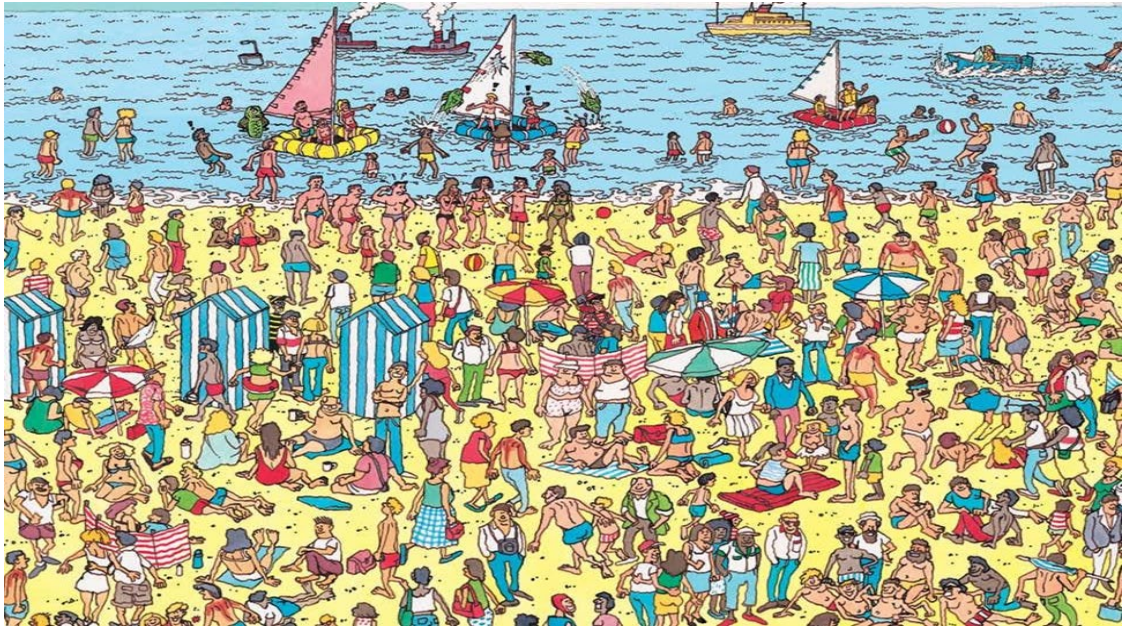
Show the data clearly

- What is an appropriate base graph?
- Is the data encoding effective?
- Do I represent the data faithfully?
- Do I show what's needed – and not more? → **Simplify to clarify!**

 https://github.com/GraphicsPrinciples/IBC2022

Show the data clearly

- Where’s Wally?



 https://github.com/GraphicsPrinciples/IBC2022

Show the data clearly

- Where’s Wally?

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3rd principle
Make the message obvious

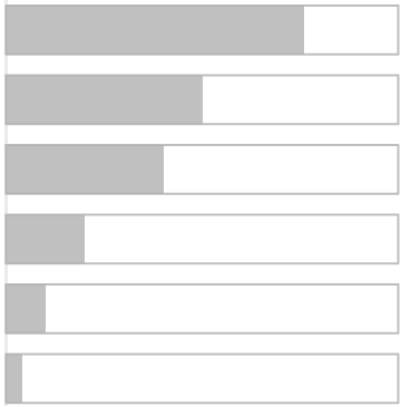
Make the message obvious

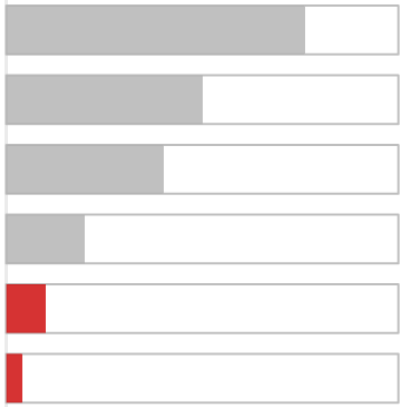
- Show the answer!

 https://github.com/GraphicsPrinciples/IBC2022

Make the message obvious

- Show the answer!
- Draw attention!

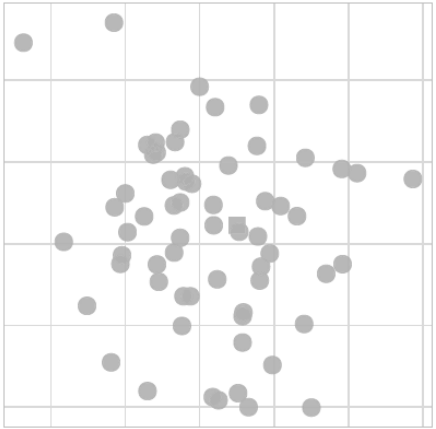


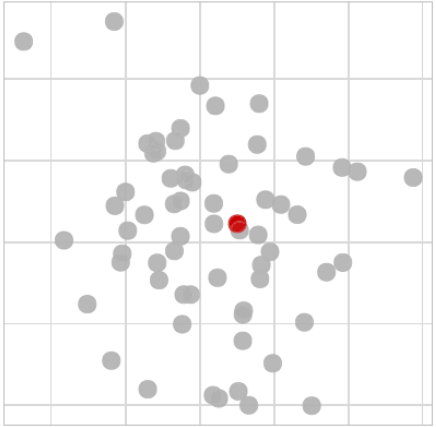


 https://github.com/GraphicsPrinciples/IBC2022

Make the message obvious

- Show the answer!
- Draw attention!
- Make use of pre-attentive processing

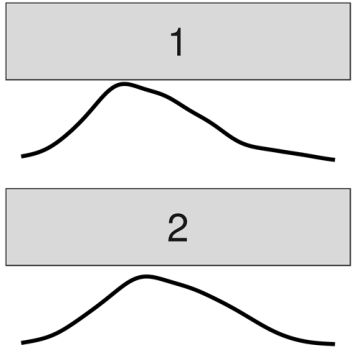


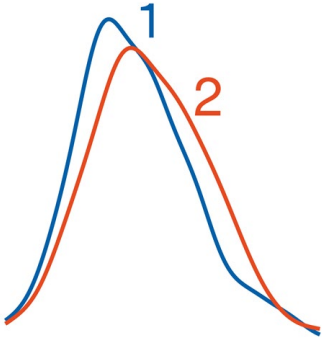


 https://github.com/GraphicsPrinciples/IBC2022

Make the message obvious

- Show the answer!
- Draw attention!
- Make use of pre-attentive processing
- Make use of alignment, proximity and visual grouping





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Make the message obvious

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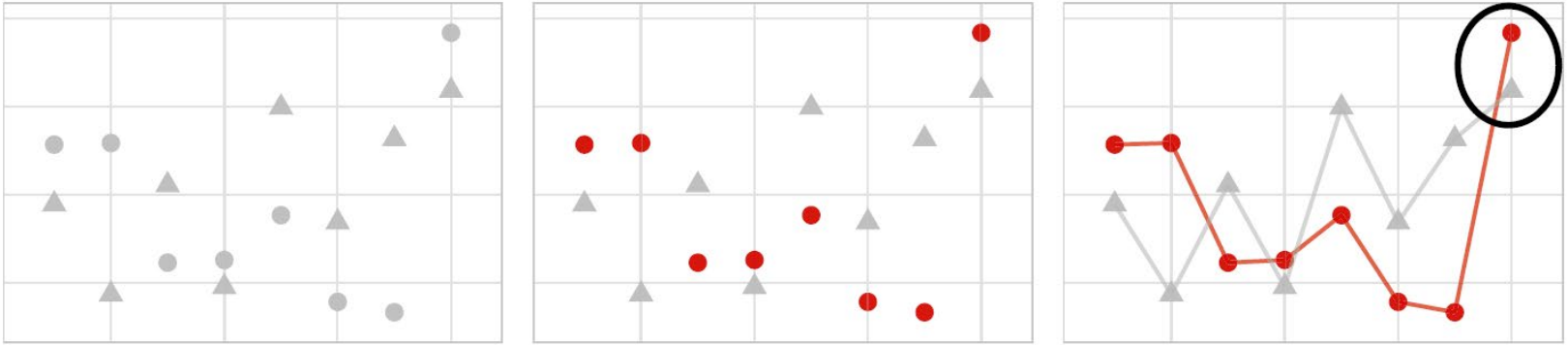

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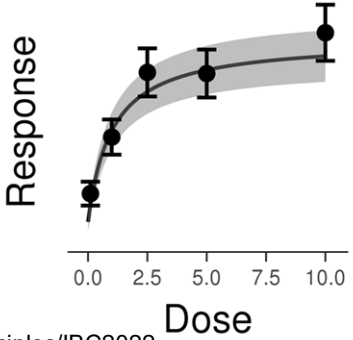
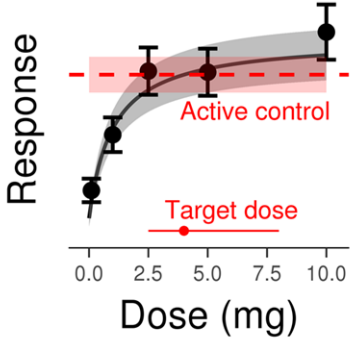
Make the message obvious

- Show the answer!
- Draw attention!
- Make use of pre-attentive processing
- Make use of alignment, proximity and visual grouping
- Use informative annotations





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Make the message obvious

- Show the answer!
- Draw attention!
- Make use of pre-attentive processing
- Make use of alignment, proximity and visual grouping
- Use informative annotations
- Add a meaningful title: state your conclusion

~~Plot of exposure by ethnicity~~

Exposure differs by ethnicity

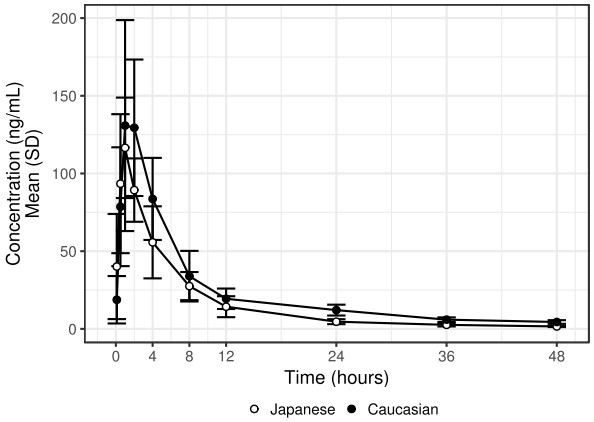
 https://github.com/GraphicsPrinciples/IBC2022

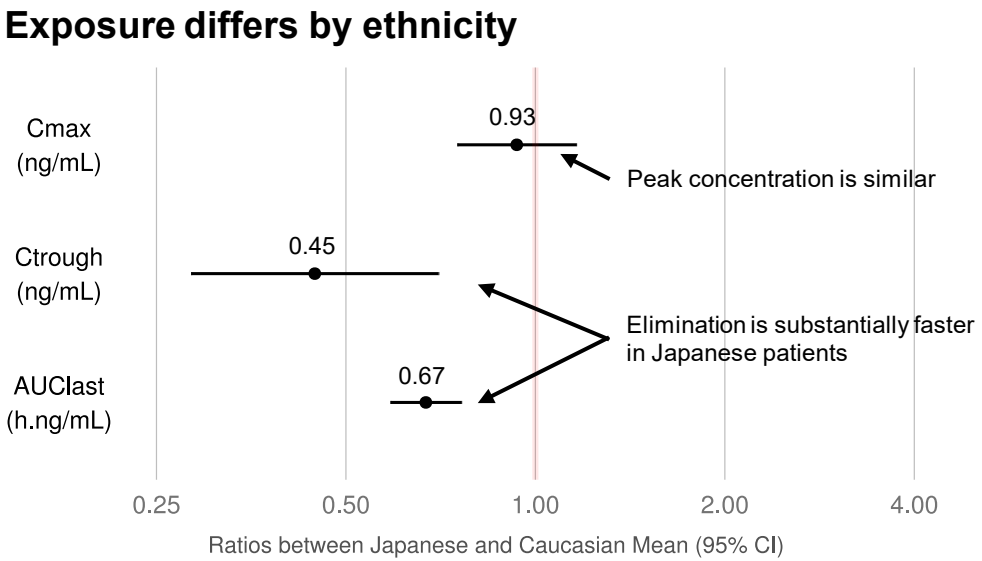
Make the message obvious

- Show the answer!
- Draw attention!
- Make use of pre-attentive processing
- Make use of alignment, proximity and visual grouping
- Use informative annotations
- Add a meaningful title: state your conclusion
- Make the message **impossible to miss**!

 https://github.com/GraphicsPrinciples/IBC2022

Back to the example: does exposure differ by ethnicity?





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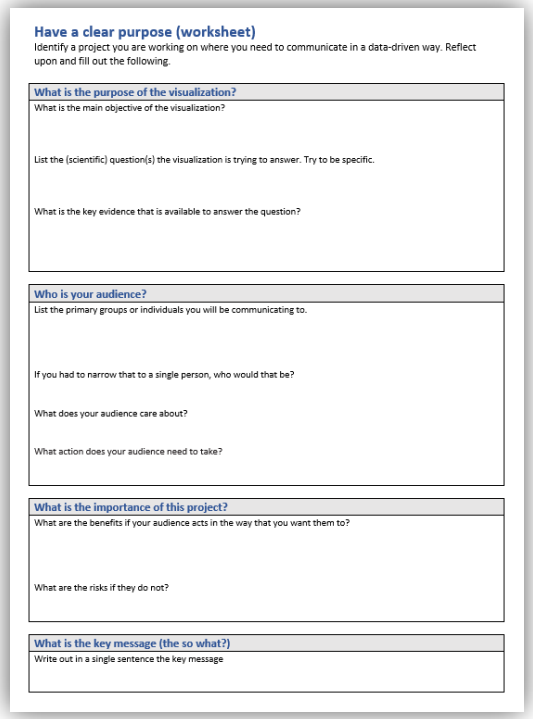
Purpose Worksheet

Mark

Purpose Worksheet

- Having a clear purpose for a visualization means having clarity in 4 areas:
  - What is the **purpose**?
  - Who is your **audience**?
  - What is the **importance** of this visualization?
  - What is the key **message** of this visualization?
- This worksheet can help define the purpose of the graph



Have a clear purpose (worksheet)

Identify a project you are working on where you need to communicate in a data-driven way. Reflect upon and fill out the following.

What is the purpose of the visualization?
What is the main objective of the visualization?
List the (scientific) question(s) the visualization is trying to answer. Try to be specific.
What is the key evidence that is available to answer the question?

Who is your audience?
List the primary groups or individuals you will be communicating to.
If you had to narrow that to a single person, who would that be?
What does your audience care about?
What action does your audience need to take?

What is the importance of this project?
What are the benefits if your audience acts in the way that you want them to?
What are the risks if they do not?

What is the key message (the so what?)
Write out in a single sentence the key message

The purpose worksheet is inspired by the big idea worksheet from the excellent book: Knaflic, Cole. Storytelling With Data: Let's Practice! Wiley, © 2019.

 https://github.com/GraphicsPrinciples/IBC2022

The 4 areas for a clear purpose

What is the purpose of the visualization?

- What is the main objective of the visualization?
- List the (scientific) question(s) the visualization is trying to answer. Be specific.
- What is the key evidence that is available to answer the question?

Who is your audience?

- List the primary groups or individuals you will be communicating to.
- If you had to narrow that to a single person, who would that be?
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What is the importance of this project?

- What are the benefits if your audience acts in the way that you want them to?
- What are the risks if they do not?

What is the key message (the “so what”?)

- Write out in a single sentence the key message

Graphics Principles Cheat Sheet

Marc

Cheat sheet

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).

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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.

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Good graph checklist

Clear Communication

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- ❑ Is the graph tailored to its primary purpose and audience?
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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.
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)

Authors

Alison Margolskee, Mark Baillie, Baldur Magnusson, Julie Jones, Marc Vandemeulebroecke

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https://github.com/GraphicsPrinciples/IBC2022

https://graphicsprinciples.github.io/cheatsheet.html

Planning questions

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)

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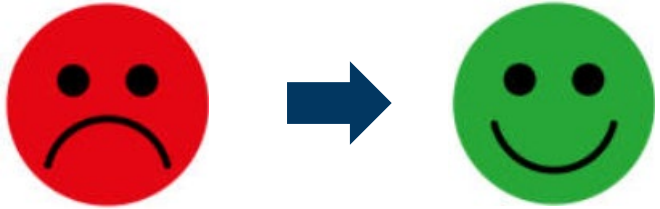
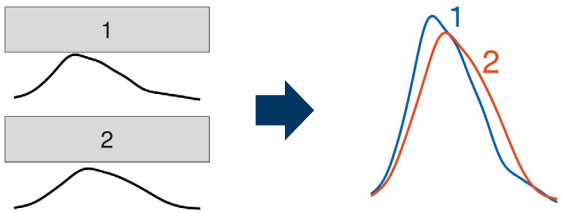
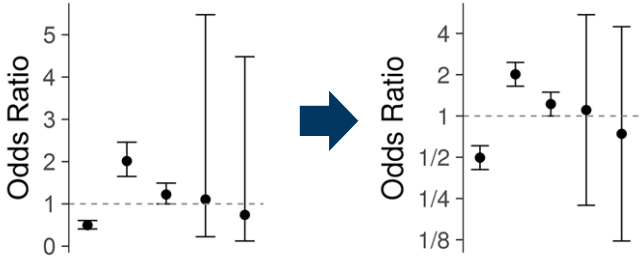
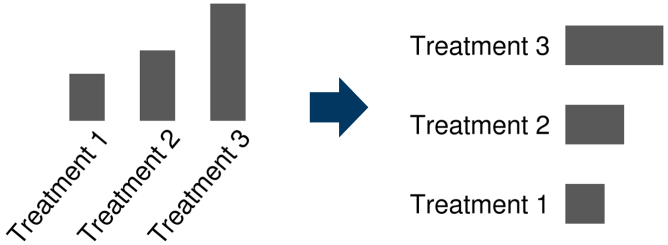
Tips & tricks









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Cheat sheet

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.

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Online resources:
https://www.perceptualedge.com/ (S. Few)
https://www.edwardtufte.com/tufte/ (E. Tufte)
http://flowingdata.com/ (N. Yau)
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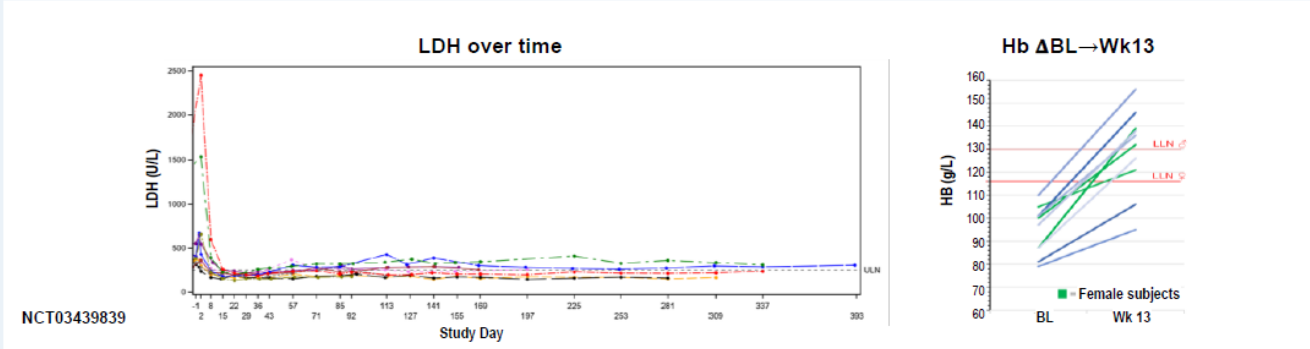
EVC in practice: Example walk-through

Mark

Early Phase 2 data support advancing LNP023 as a front-line treatment for PNH

In a Phase 2 PNH trial, LNP023 add-on to eculizumab in patients with hemolysis delivered consistent LDH normalization and transfusion-free hemoglobin increase in all patients

The ongoing LNP023 monotherapy trial in eculizumab-naive PNH patients shows early efficacy (LDH↓)



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LNP023 included from the public 2019 R&D day deck
https://www.novartis.com/sites/www.novartis.com/files/2019-12-05-novartis-r-d-day-investor-presentation.pdf

1st principle
Have a clear purpose

1st principle – have a clear purpose

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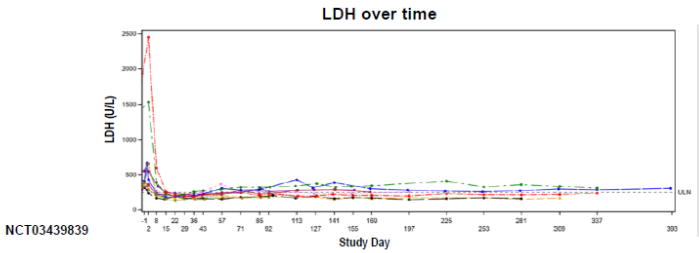

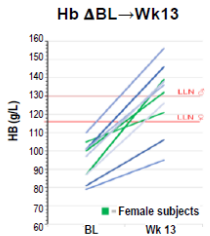

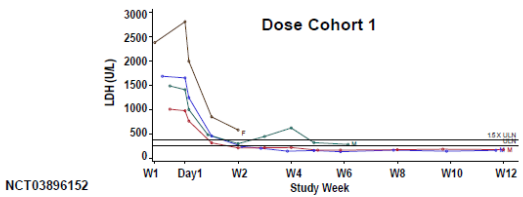

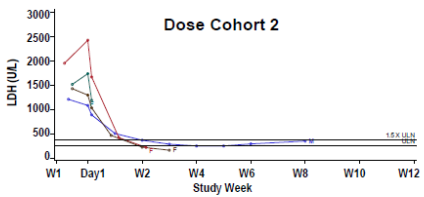

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Purpose

What is the purpose of the visualization?
What is the main objective of the visualization? *The visualization is to display supporting evidence that LNP023 has demonstrated proof of concept and is a good candidate to take into phase 3 development.* List the (scientific) question(s) the visualization is trying to answer. Try to be specific. - *Is there a decrease in LDH to "normal levels" post LNP023 dose as a mono and combo therapy?* - *Does LNP023 increase hemoglobin levels?* What is the key evidence that is available to answer the question? *Two studies.* *Two different dose cohorts in one study. Mono and combo.* *LDH is a surrogate measure of efficacy for PNH.* *Consistency across gender for Hemoglobin improvement.*

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Audience

Who is your audience?
List the primary groups or individuals you will be communicating to. *NVS senior management* *Investors* *Scientific community* If you had to narrow that to a single person, who would that be? *Development Unit Head.* What does your audience care about? *Clear demonstrable evidence that LNP023 has activity on markers related to PNH.* What action does your audience need to take? *A decision on whether to provide resources to take LNP023 to late stage development.*

 https://github.com/GraphicsPrinciples/IBC2022

Importance and message

What is the importance of this project?
What are the benefits if your audience acts in the way that you want them to? *This could improve lives of patients with an unmet need.* *This could lead to a new scientific breakthrough and understanding of the disease.* *This could be an asset to the company.* What are the risks if they do not? *Cancellation of an important compound.* *Patients untreated.*

What is the key message (the so what?)
Write out in a single sentence the key message *LNP023 reduces LDH levels to normal; strong evidence the compound may improve the lives of patients with PNH.*

 https://github.com/GraphicsPrinciples/IBC2022

2nd principle
Show the data clearly

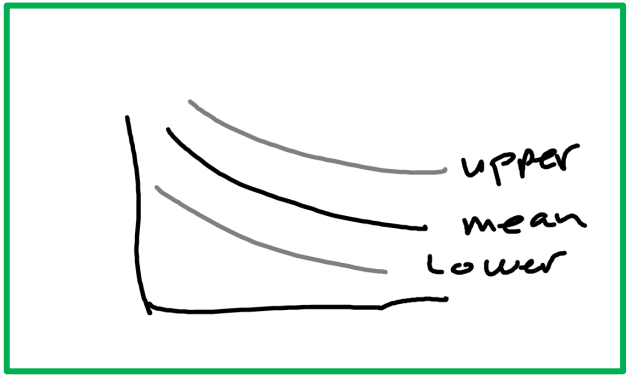
Show the data clearly, an iterative process

- The “purpose” worksheet is a guide to stay in line with the key evidence that supports your key message
- Try to display the same sets of data in different ways and select the one you consider the more adapted (often being the simplest)
- It is then time to iterate and eliminate clutter
  - Add what is missing to show your data clearly
  - Remove what is just adding noise

 https://github.com/GraphicsPrinciples/IBC2022

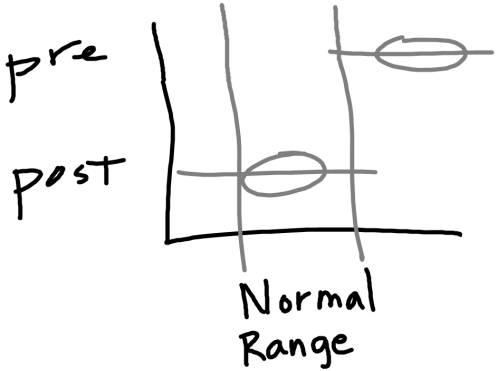
2nd principle – select the appropriate graph

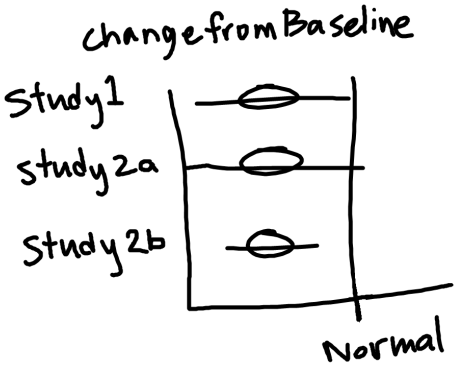
- Brainstorm different ways to display the data
- The more ideas the better!
- Select the display that supports the key message



Continuing with LNP example

- What is the key message:
  - LNP023 reduces LDH levels to normal
- The key evidence to support this:
  - Two studies with different dose cohorts
  - LDH as a surrogate for efficacy





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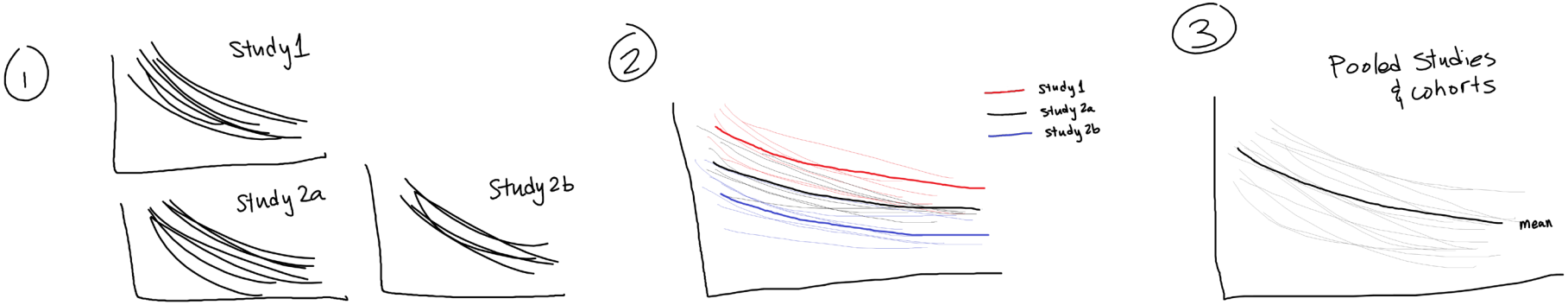
2nd principle – iterate and eliminate clutter



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3rd principle
Make the message obvious

Make your message obvious

- This 3rd principle applies particularly when communicating to others
- Draw the audience attention to the critical element(s)
- Each element of the slide fits in the story it is aiming to tell

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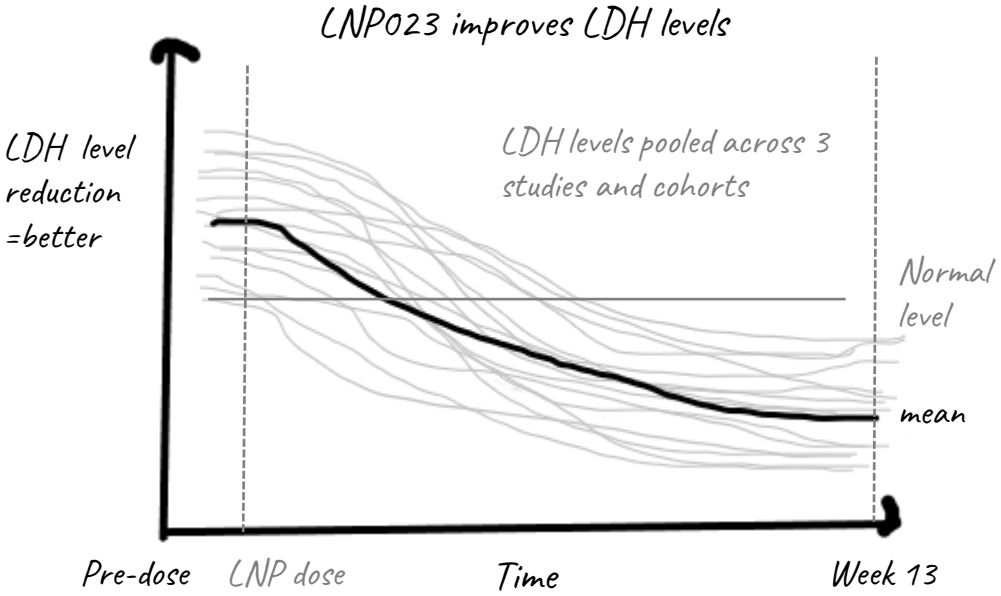
3rd principle – draw attention

- Draw the viewer's attention to points of interest
- Use arrows, labels, reference lines to drive home the message
- Make sure to have clear axis labels and informative titles



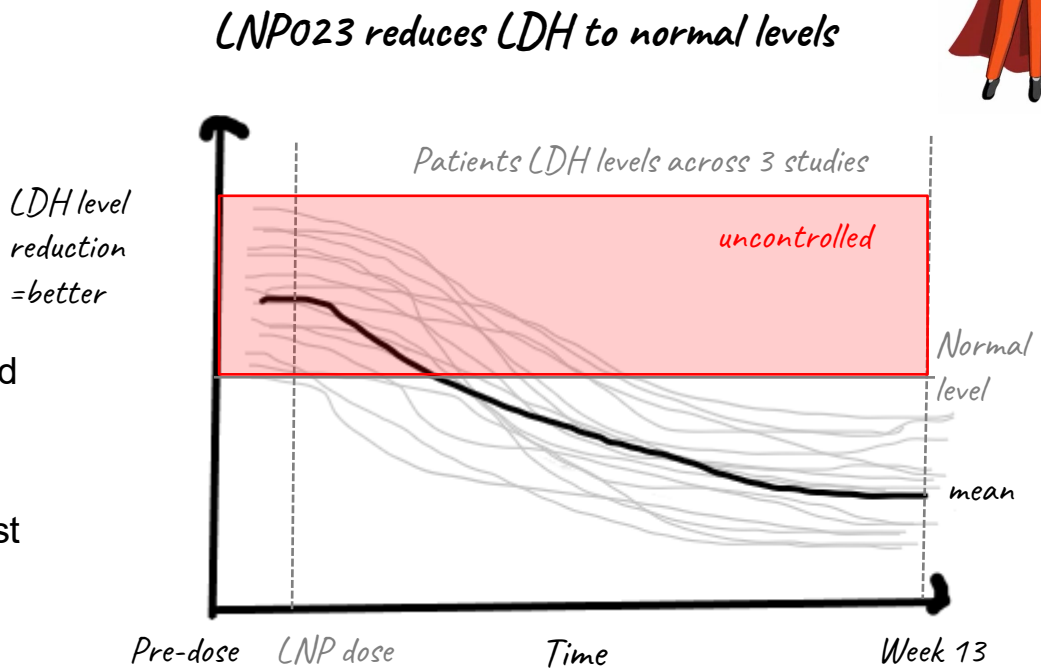
 https://github.com/GraphicsPrinciples/IBC2022

3rd principle – tell a story

Practice telling the story of your graph, and make sure your graph captures the key points

Example story:

- LDH is a biomarker of hemolysis, released during destruction of RBC
- LNP023 reduces LDH to normal levels in PNH patients, indicating protection against hemolysis
- Recommend advancement of LNP023 to Phase 3



- Normal LDH levels indicate protection against hemolysis
- Recommend advancement of LNP to Phase 3

 https://github.com/GraphicsPrinciples/IBC2022

https://github.com/GraphicsPrinciples/IBC2022

Your turn!

Mark / all

Your turn!

- Apply the 3 principles of Effective Visualization to an example of your own
  - Did you bring one? If not, can you think of one now?
  - Otherwise, take a graph we provide (handout)
- Assignment:
  1. Complete the Purpose Worksheet for the example you choose
  2. Select what data to display, and how to display it. Iterate through a few alternatives in quick sketches
  3. Choose a graph or two from the previous step, and refine to make the message obvious
- In Part 2 of this training, we will discuss selected examples in this group
  - Let us know if you don't want yours to be chosen

Note: For steps 2 and 3, you may choose to use pen and paper, or a drawing, graphing, or coding software. It's up to you!

 https://github.com/GraphicsPrinciples/IBC2022

Have a break – we start Part 2 at 4:30 pm

 https://github.com/GraphicsPrinciples/IBC2022

Effective Visual Communication (EVC) for Quantitative Scientists

Mark Baillie & Marc Vandemeulebroecke

International Biometric Conference (IBC), Riga, July 2022

https://graphicsprinciples.github.io/

Welcome back. Agenda – part 2

Timing	Agenda Item	Presenter
5 min	Welcome back / housekeeping	Marc
5 min	Recap of part 1	Marc
45 min	**Feedback** and **group discussion** on your work	All
15 min	Reflections, resources & close	Mark

Part 1 recap

Marc

Recap: 3 principles for better visual communication

1. **Have a clear purpose**
   - Understand the question you are trying to answer
   - Identify the quantitative evidence to answer that question
   - Know your audience and focus the design to support their needs

2. **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)

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

 https://github.com/GraphicsPrinciples/IBC2022

https://youtu.be/pfxulpF9XOw

Your turn!

- Apply the 3 principles of Effective Visualization to an example of your own
  - Did you bring one? If not, can you think of one now?
  - Otherwise, take a graph we provide (below)
- Assignment:
  1. Complete the Purpose Worksheet for the example you choose
  2. Select what data to display, and how to display it. Iterate through a few alternatives in quick sketches
  3. Choose a graph or two from the previous step, and refine to make the message obvious
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Note: For steps 2 and 3, you may choose to use pen and paper, or a drawing, graphing, or coding software. It's up to you!

Group examples – placeholder

 https://github.com/GraphicsPrinciples/IBC2022

Reflections, resources and close

Mark

Reflections on the exercise

- What surprised you during the exercise?
- What was the most useful thing you learned?
- How can you imagine yourself using these 3 principles when creating or reviewing visualizations in the future?

 https://github.com/GraphicsPrinciples/IBC2022

The 3 EVC principles are relevant for all communication

- Visual, verbal or written communication can benefit from the principles

Have a clear purpose

Show the data clearly

Make the message obvious

- Keep them in mind and use them in your day-to-day job
  - On your own or with your collaborators!

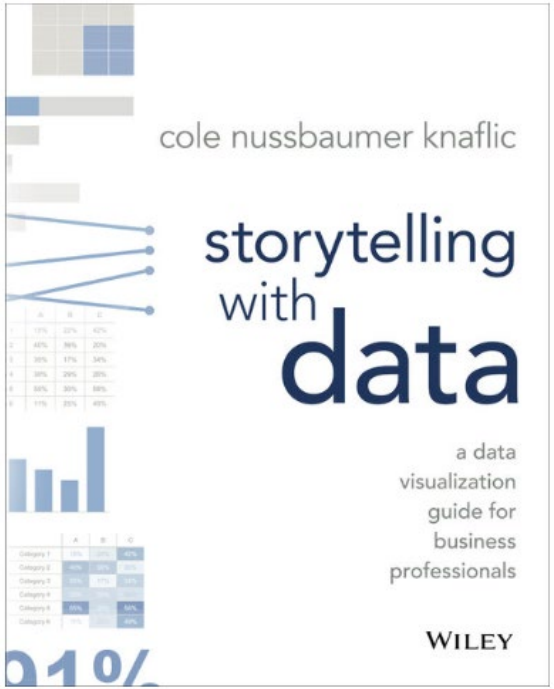
 https://github.com/GraphicsPrinciples/IBC2022

Learning outcomes

- Appreciate why Effective Visual Communication (EVC) is a key competency for the quantitative scientist.
- Explain the three principles of EVC (purpose, clarity and message).
- Design a visualization based on a specific purpose.
- Redesign a visualization to show data clearly.
- Enhance the message of a visualization.
- Recognize where to apply the three principles of effective visual communication in your daily work.

 https://github.com/GraphicsPrinciples/IBC2022

Resources: where to find out more?



http://www.storytellingwithdata.com/books

- Effective Visual Communication Website
  https://graphicsprinciples.github.io/
- PKPD Exploratory graphics (xGx)
  https://opensource.nibr.com/xgx
- Tutorial on effective visual communication
  https://ascpt.onlinelibrary.wiley.com/doi/full/10.1002/psp4.12455
- Video on the three principles
  https://youtu.be/pfxulpF9XOw
- Presentation checklist
  https://opensource.nibr.com/xgx/Resources/Presentation_Checklist_v2.03.pdf
- Wonderful Wednesdays
  https://www.psiweb.org/sigs-special-interest-groups/visualisation/welcome-to-wonderful-wednesdays

Cheat sheet

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.

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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)

Authors

Alison Margolskee, Mark Baillie, Baldur Magnusson, Julie Jones, Marc Vandemeulebroecke

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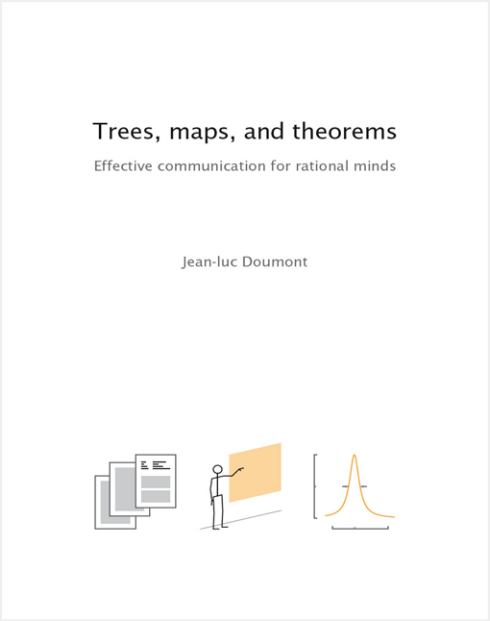
https://github.com/GraphicsPrinciples/IBC2022

https://graphicsprinciples.github.io/cheatsheet.html

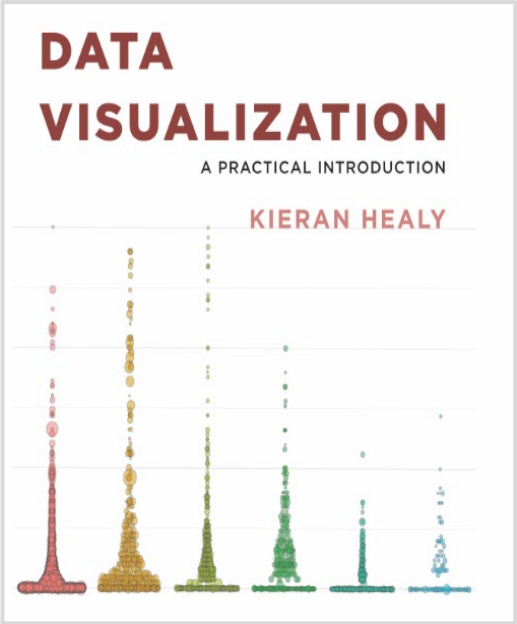
Play the EVC Cartoon

https://youtu.be/pfxulpF9XOw

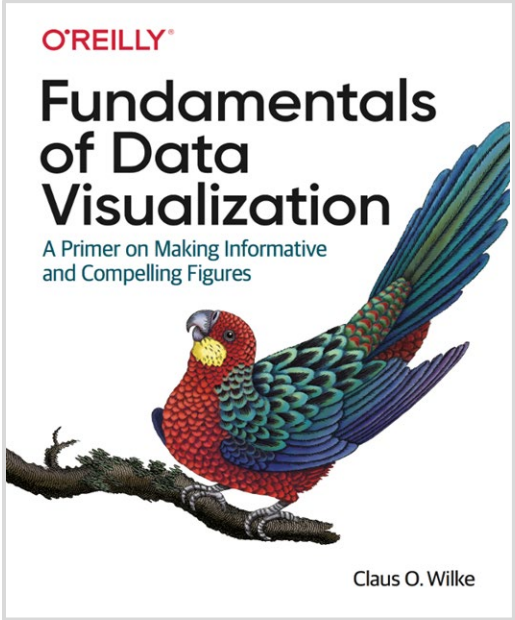
Even more resources?



https://www.principiae.be/book/



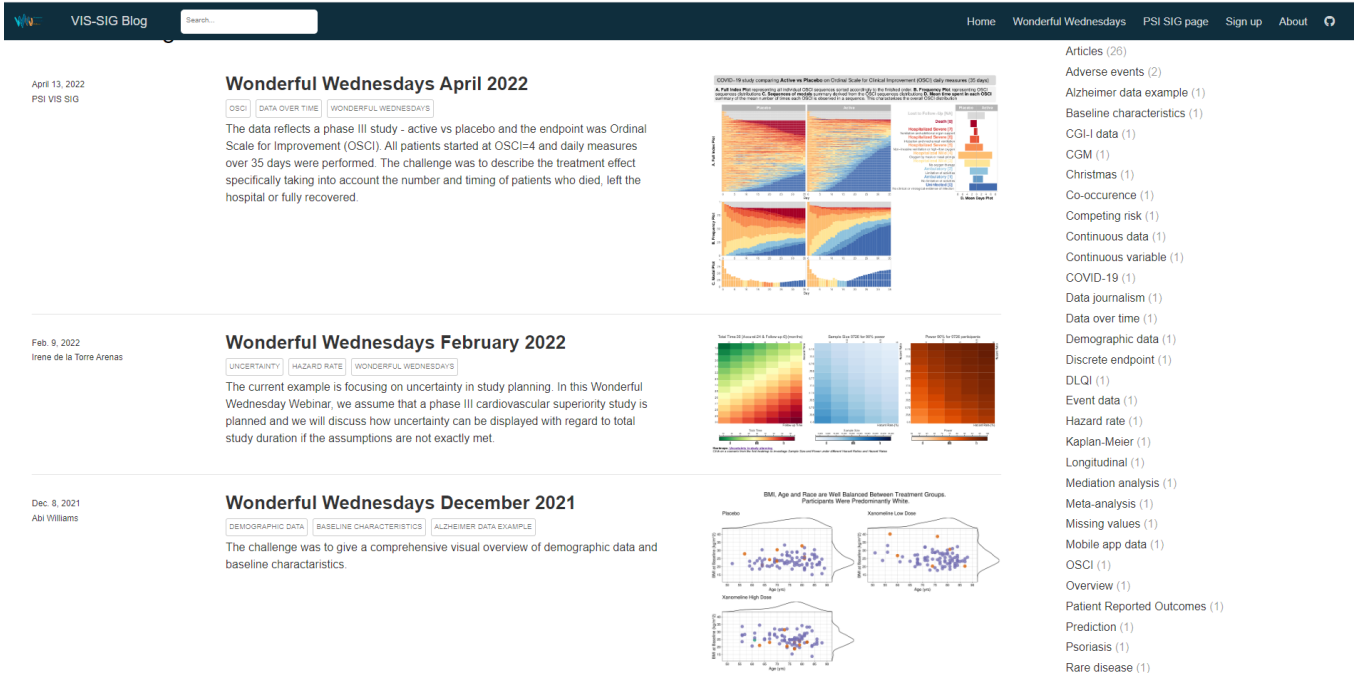
https://socviz.co/



https://serialmentor.com/dataviz/

 https://github.com/GraphicsPrinciples/IBC2022

Resources for practice



Blog, code and data @ https://vis-sig.github.io/blog/

Acknowledgements

- Alison Margolskee
- Julie Jones
- Ivo Masseling
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- Bonnie Petrucka
- Malika Cremer
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- Lorenz Uhlmann
- Baldur Magnusson
- Andrew Wright
- Ryan You
- Ivo Vranesic
- Meredith Godat
- Sam Maitra
- David Carr

And many more…

 https://github.com/GraphicsPrinciples/IBC2022

 https://github.com/GraphicsPrinciples/IBC2022

Thank you

Contact:
mark.baillie@novartis.com
marc.vandemeulebroecke@novartis.com

Your own example

Your example here!

Purpose worksheet, empty

Purpose Worksheet

Backup option: Efficacy of Capmatinib in NSCLC with MET mutations

- Background:
  - Phase 2 study of Capmatinib (MET receptor inhibitor) in NSCLC patients with various MET mutations
  - Primary endpoint: overall response (complete or partial response)
  - Secondary endpoint: duration of response
- Key question:
  - Does Capmatinib show meaningful response in patients with various types of MET mutation?

See reference for additional background, purpose and key messages:

Wolf et al. NEJM 2020; 383:944-957
https://www.nejm.org/doi/full/10.1056/NEJMoa2002787

Backup option: Efficacy of Capmatinib

Purpose worksheet, partially completed

Purpose Worksheet

See reference for additional background, purpose and key messages:

Wolf et al. NEJM 2020; 383:944-957
https://www.nejm.org/doi/full/10.1056/NEJMoa2002787

What is the purpose of the visualization?

What is the main objective of the visualization?
Summarize the efficacy results of the Capmatinib Phase 2 study in NSCLC patients with MET mutations

List the (scientific) question(s) the visualization is trying to answer. Try to be specific.
- Are the response rates clinically meaningful for patients with various types of MET mutation (exon 14 skipping, various degrees of amplification)?

What is the key evidence that is available to answer the question?
- Individual RECIST data, individual duration of response, overall response rates by cohort
- cohorts defined as MET exon 14 skipping mutation (with and without prior treatment), and MET amplification with various levels of gene copy number (GCN) (with and without prior treatment)
- clinically relevant response defined as >= 35% in previously treated patients (with 95% CI > 25%) and >= 55% in patients not previously treated (with 95% CI > 35%)

Who is your audience?

List the primary groups or individuals you will be communicating to.
- Capmatinib project team, NSCLC investigators, scientific community, head of oncology

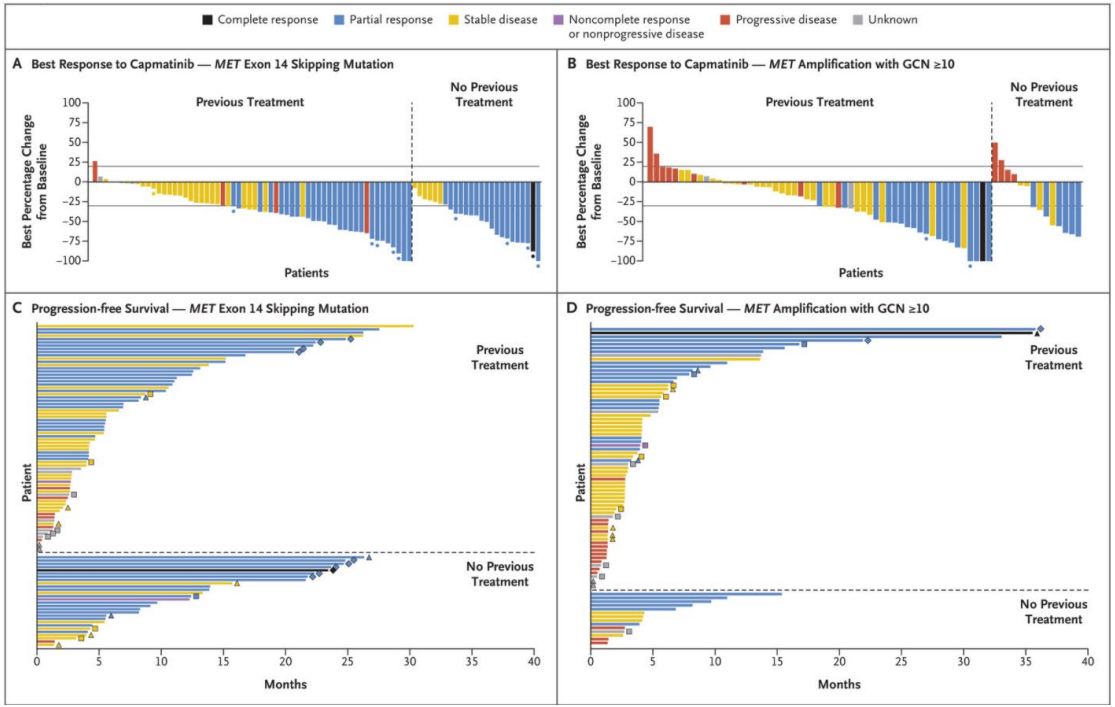
If you had to narrow that to a single person, who would that be?
Oncology development head

What does your audience care about?
- Whether Capmatinib appears to work in any of the cohorts

What action does your audience need to take?
- Decide whether to keep developing Capmatinib for NSCLC with MET mutations, and for which MET mutations specifically

Backup option: Efficacy of Capmatinib in NSCLC with MET mutations

- Right: Primary visualization of Phase 2 study results from Wolf et al. NEJM 2020
- Can you improve this graph, or create your own to display the key message(s)?



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