Chart Design
General Principles and Best Practices

IT 7113 Data Visualization

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http://idi.Kennesaw.edu/it7113/

Content Overview

This lecture notes discuss some chart design principles and selected best practices.

- “CASE” design principles
- Example best practices and patterns aligned with the principles
- Develop and conform to guidelines and standards

Principles and Best Practices

- Principles are the high-level guidelines that may apply to a broader scope of applications.
  - Principles are usually summarized in highly concise terms or sentences
- Best practices are the lessons and design references at a very detailed level for specific cases and/or specific design elements (such as color, layout, slicers, etc.).
  - Best practices extend principles to more specific cases, and they should be related to principles.
  - Contains more details and contexts, may be limited in scope.
  - Often it is embodied in the form of “patterns”.
- Guidelines and standards are working rules set up for an environment (an organization or an industry)
- In practice, people use the terms loosely and generally refer to good practices and/or pitfalls.
- Examples of principles/best practices
  - https://www.linkedin.com/pulse/data-design-six-must-know-visualization-principles-everyone-eppler/
  - https://kevinlanning.github.io/DataSciLibArts/principles-of-data-visualization.html#tufte-first-principles
  - https://medium.com/google-design/redefining-data-visualization-at-google-9bdcf2e447c6

Basic Design Principles

- The **CASE** principles

Clarity	The chart delivers the message and makes the point clearly.
Accuracy	Avoid data visual distortion and disinformation.
Simplicity	Perceptually easy to locate and identify key data and other information.
Elegance	Visual quality to attract audience and sustain that sentiment and interest – Andy Kirk.

Clarity

- Clarity means being clear and straightforward, causing no confusion, and with sound logic
- Clear message serving the purpose
  - Right chart for the purpose.
  - The chart delivers the message and makes the point, straightforward and clearly.
  - Self explanatory: use proper labels and annotations: title, legend, label, etc.
  - Avoid unnecessary implication
- Consistency
  - Message consistent with chart: scale consistency, color consistency, unit consistency
- Relevancy
  - The visualized data are relevant to the purpose and message.
  - Show context that helps understand the message.
- Readability
  - Ease to read and find information and data in the visualization.

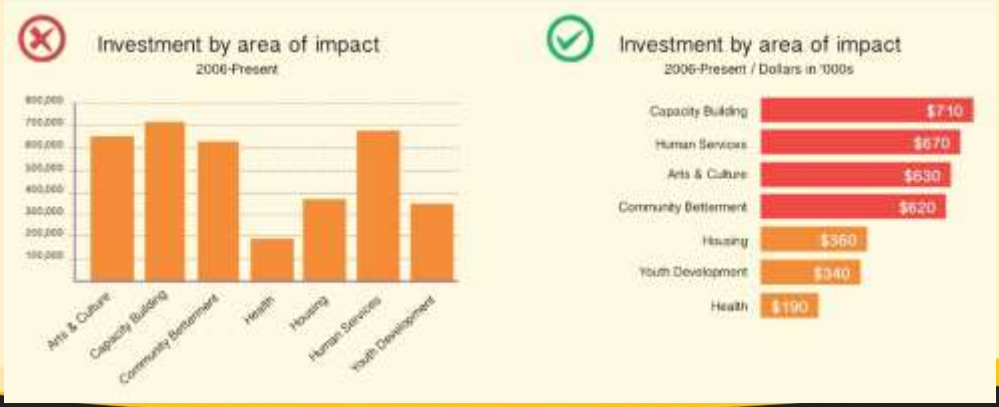
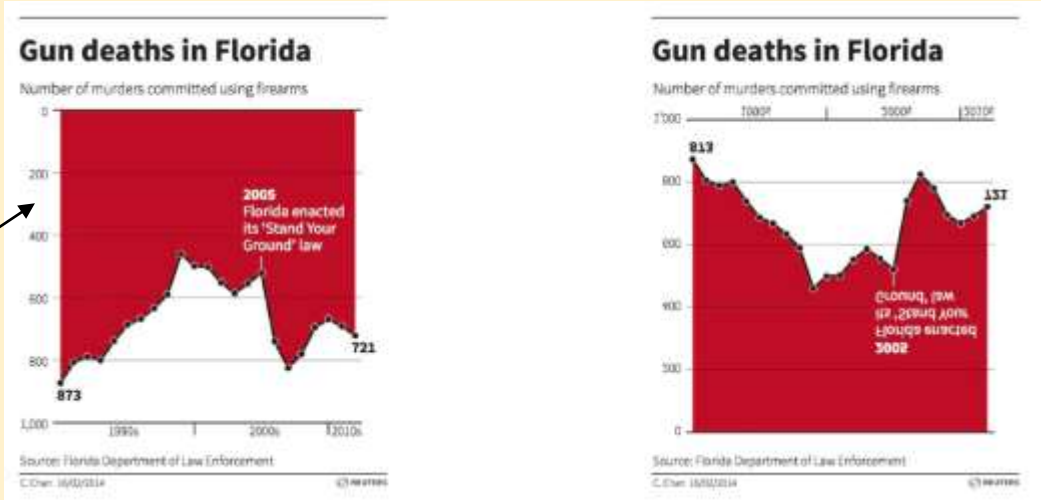


Image from https://visme.co/blog/dos-and-donts-chart-making/
Case from https://www.storytellingwithdata.com/blog/2012/10/my-penchant-for-horizontal-bar-graphs

Clear and Unconfusing Message

- Don’t go against intuition and convention

The convention is values on the Y axis goes up, not down



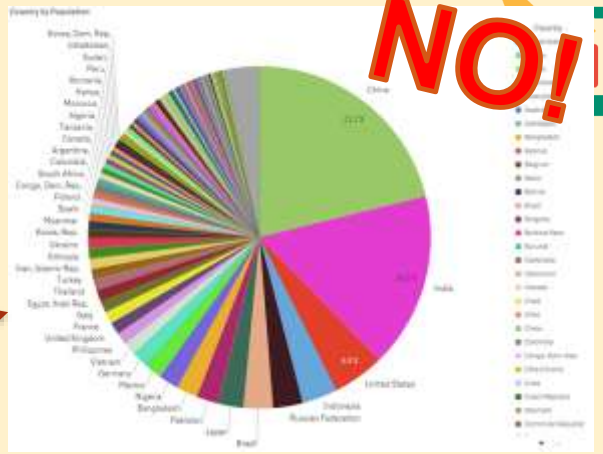
- Avoid potential uninteded implications

The use of the bright green implies unnecessary attention – unless it is intended.

Image from https://filwd.substack.com/p/clarity-and-aesthetics-in-data-visualization

Readability

- Clear and easy to see the main objects, entities and data.
- Readability of data labels and associations
- Non-cluterred: control the number of items displayed at once.
  - Limit data items in certain chart types like pie chart and data serials column chart and line chart
  - Related to simplicity – simplicity improves readability
- Highlight the important
- Avoid distracting backgrounds and colors.



https://www.qlik.com/blog/data-

https://visme.co/blog/dos-and-donts-of-data-viz/

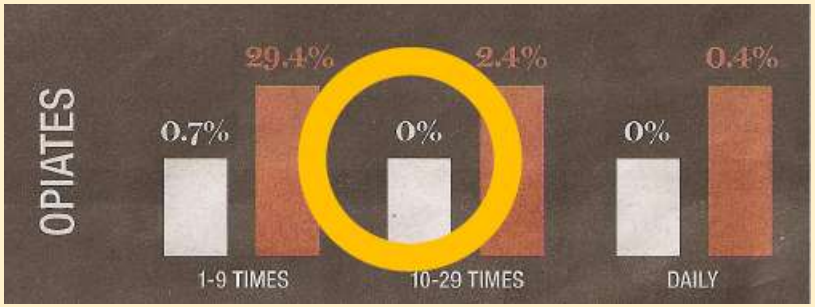
Accuracy

- Accuracy is the correct representation (coding) of data, so it matches people's perception.
  - Inaccurate visualizations impact human perceptions and decisions. Resulting in false perception and incorrect conclusions
    - Hard mistakes: value coded wrong
    - Soft mistakes: gives wrong perception because of user's visual limitations or different perspectives
  - Relates to visual or graphical integrity https://www.linkedin.com/pulse/edward-tuftes-six-principles-graphical-integrity-radhika-raghu/

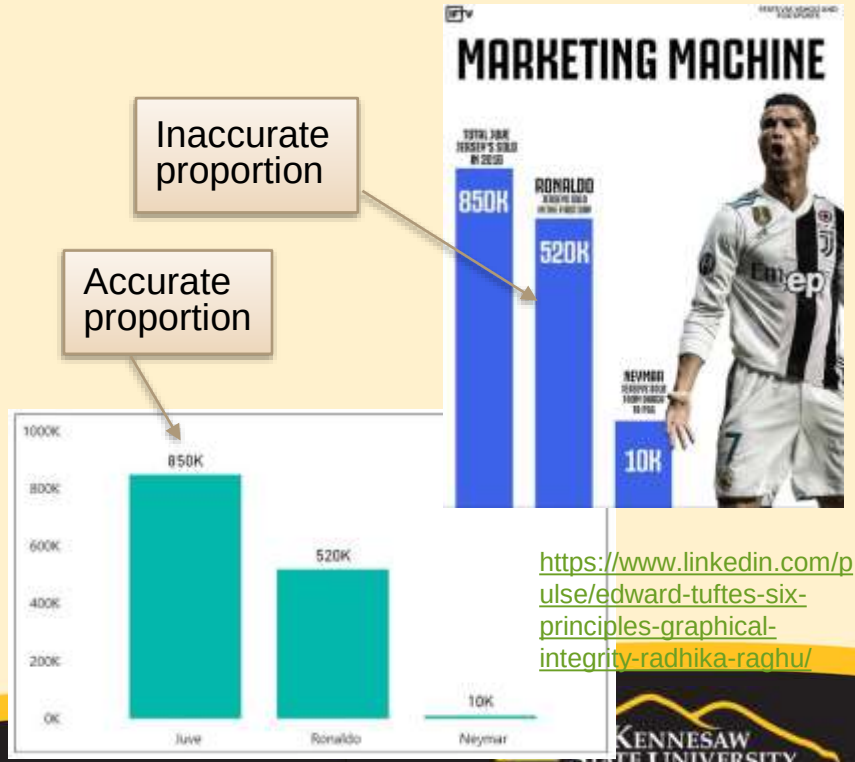
- Types
  - Disproportion
  - Distortion
  - Narrative / visual mismatch, or out of context, irrelevant
  - Inconsistency

- Cause of Inaccuracy
  - Design mistakes. Examples:
    - Use circle size to represent values: value coded as area or diameter?
    - Truncated axis
    - 3D decoration (pie): view perspectives affect size perception.
  - Data reference/calculation mistakes

- See more collections of bad chart examples
  - https://viz.wtf
  - https://www.reddit.com/r/dataisugly/



Ethical and Deceptive Visualization
Michael Correll
https://courses.cs.washington.edu/courses/cse412/21sp/lectures/CSE412-EthicalDeceptive-MichaelCorrell.pdf

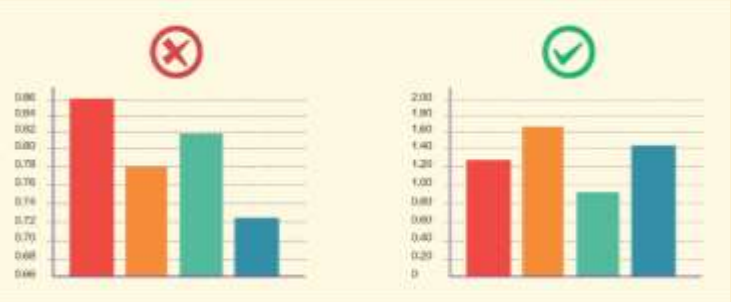


https://www.linkedin.com/pulse/edward-tuftes-six-principles-graphical-integrity-radhika-raghu/

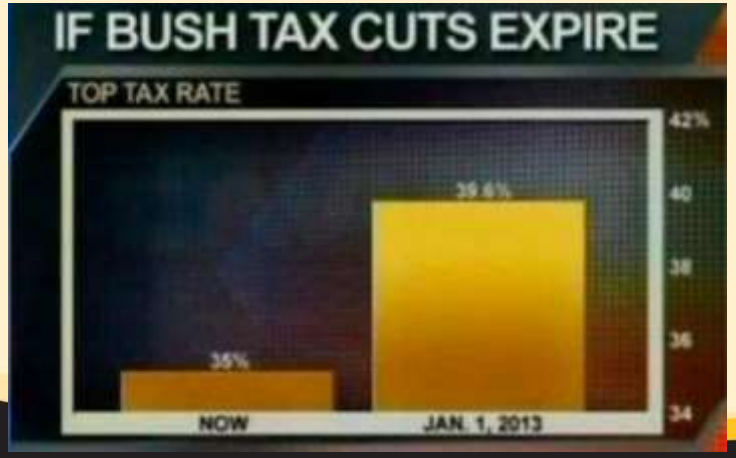
Disproportion

- Avoid axis truncation, as it gives wrong impression of exaggerated differences.
  - An exception to always starting an axis at zero is found in the case of certain line graphs. When the data tends to vary minimally at a quantity far above zero, it is difficult to read. In this situation, starting a baseline at a quantity closer to the data brings the variations to light.

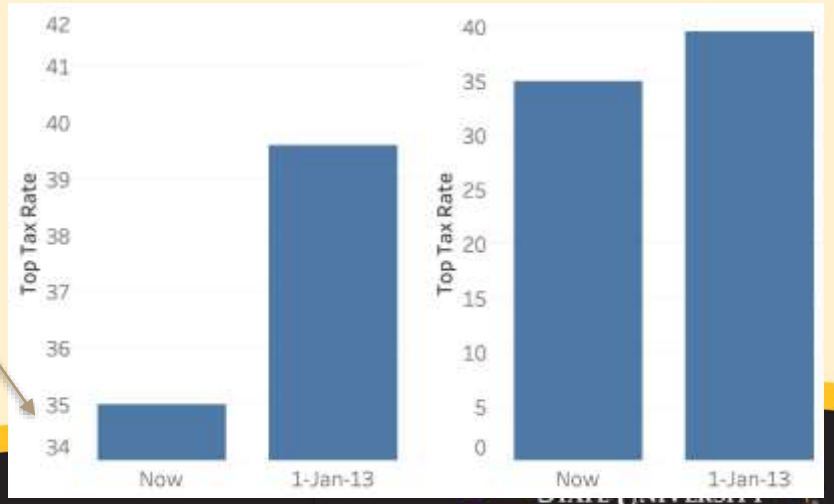
https://viz.wtf/post/649279158970646528/chilean-president-uses-disproportionate-bar-chart



https://visme.co/blog/dos-and-donts-chart-making/

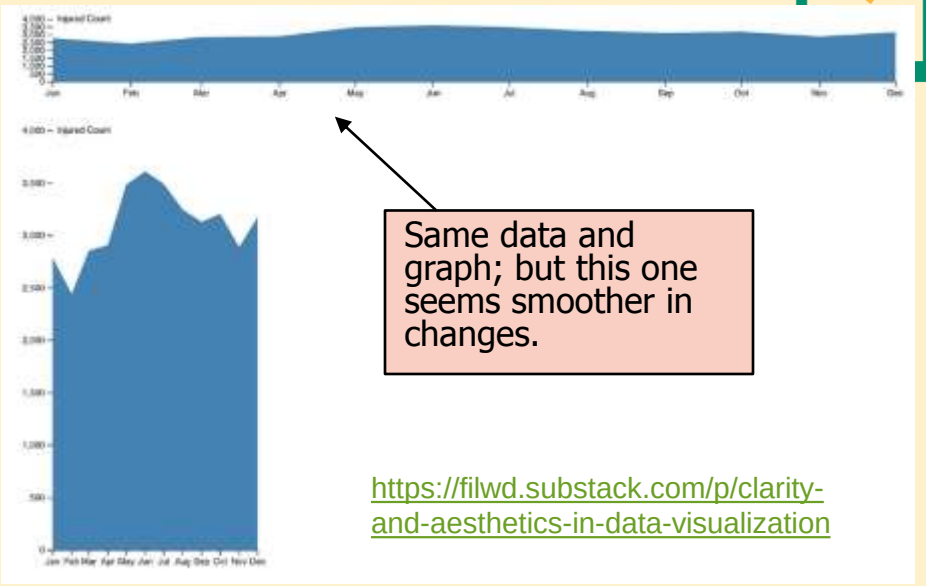


Axis truncation leads to disproportion



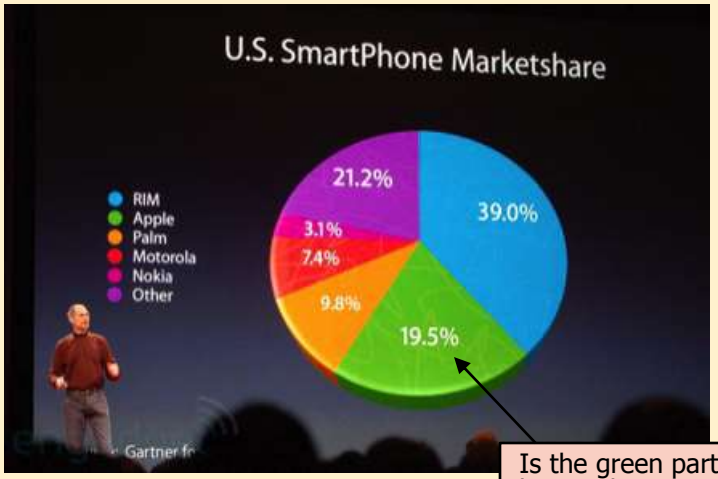
Distortion

- Distortion is the change of shape or size
- Maybe because of viewing perspective or inappropriate proportion
- Examples
  - Disproportionate X/Y axis
  - 3D Pie chart distortion https://peltiertech.com/extra-distortion-in-a-pie-chart/



Same data and graph; but this one seems smoother in changes.

https://filwd.substack.com/p/clarity-and-aesthetics-in-data-visualization



Is the green part bigger than the purple part?

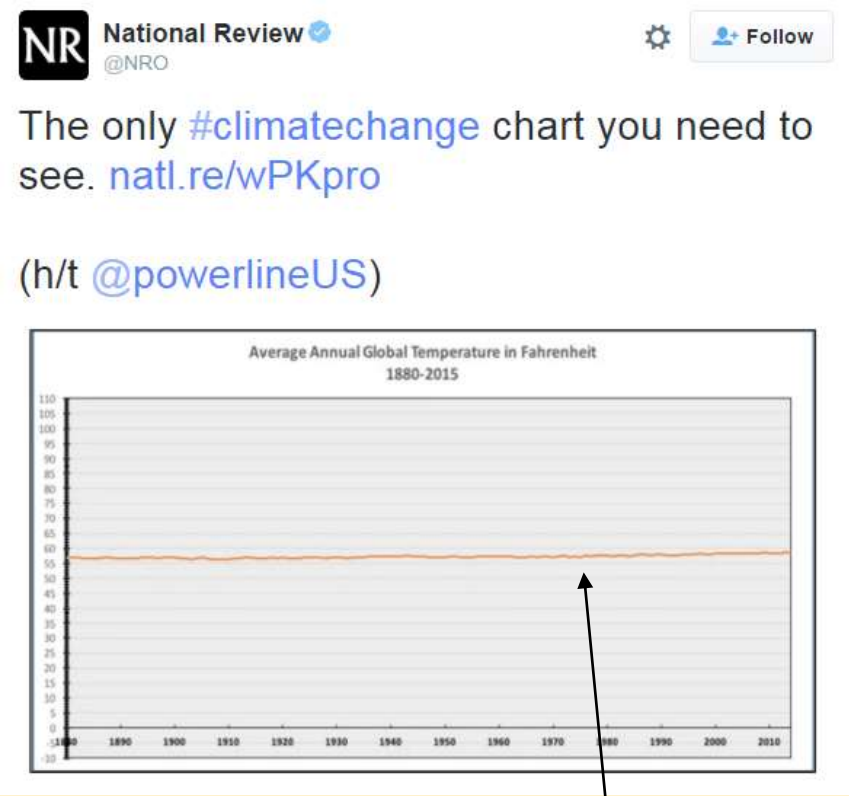
Jobs's smart phone chart
http://www.labo.mathieurella.fr/?p=403

Photo from https://www.engadget.com/2008-01-15-live-from-macworld-2008-steve-jobs-keynote.html

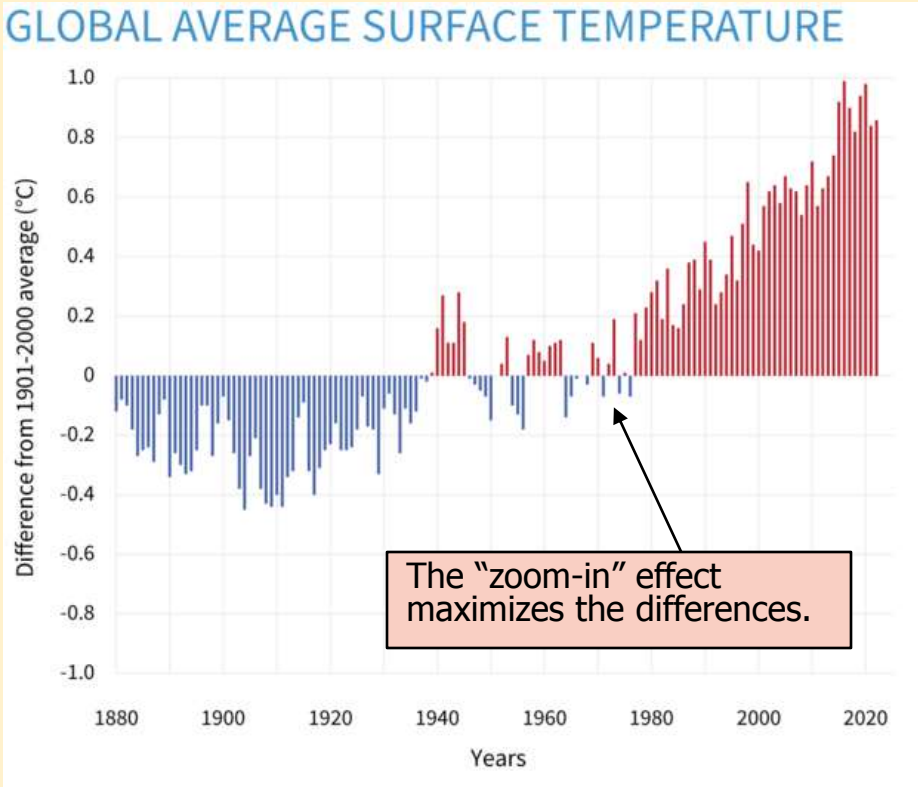
Units Scaling

- Axis scaling also affects perception

Either chart may have a specific message to deliver, with different interpretations.



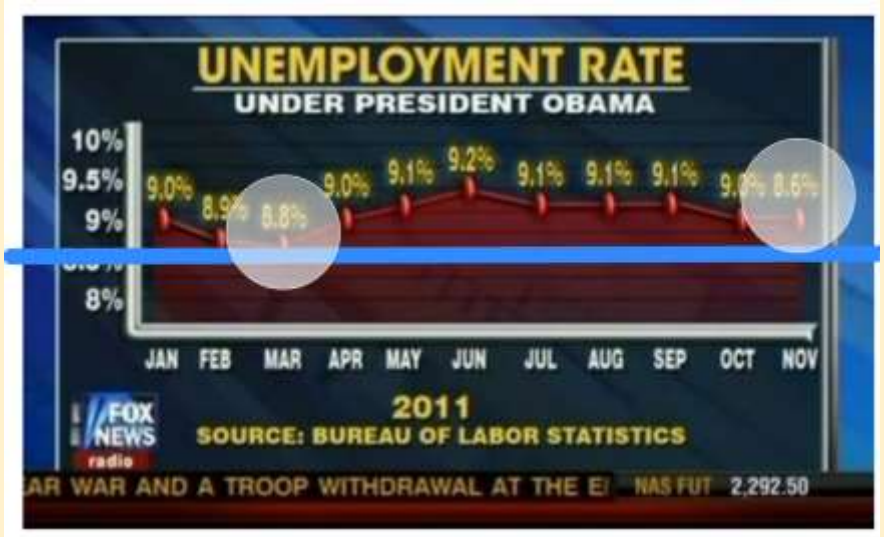
The "zoom-out" effect minimizes the differences.

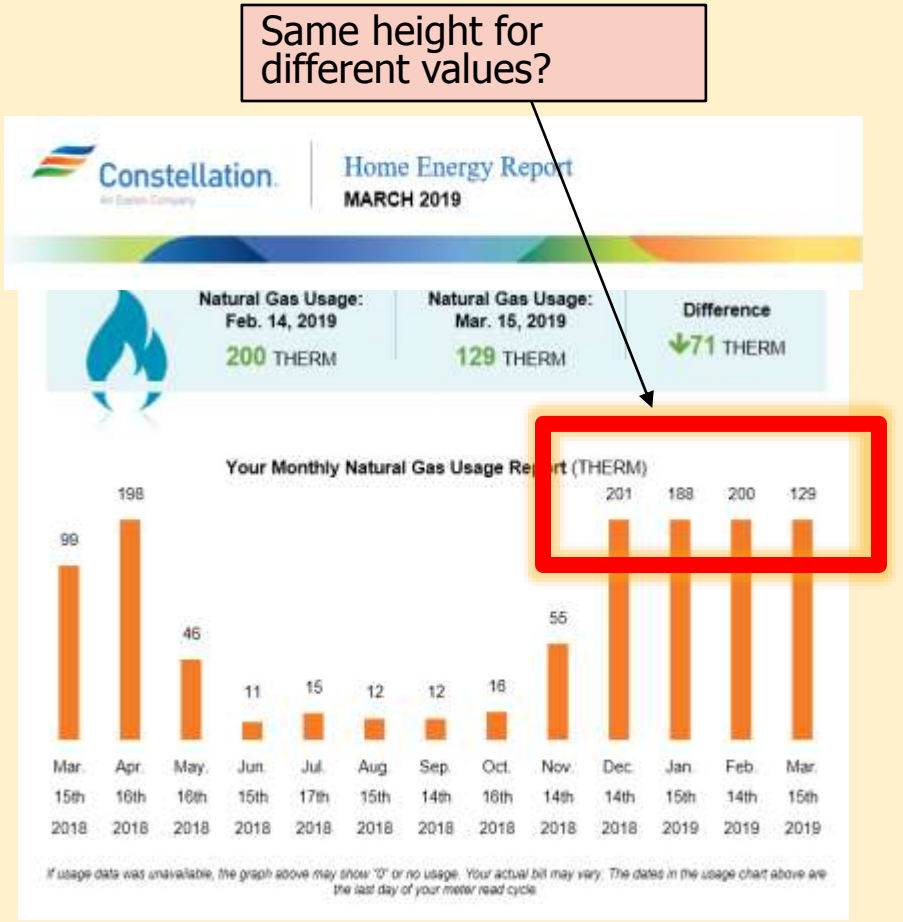


https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

Pure Mistake

- ? Hard to explain
  - Sometimes it may be the programming error



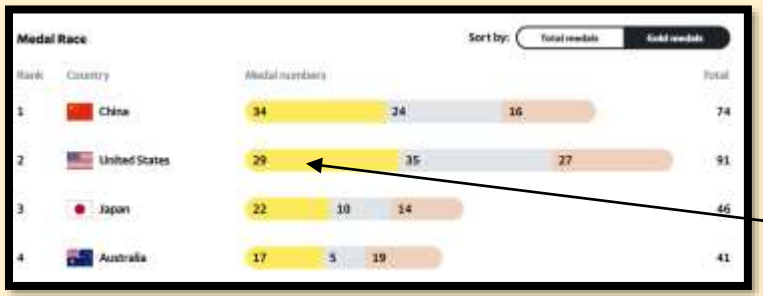


Intentional vs. Unintentional

- Intentional distortion or disinformation: “tempt to use visual displays that bend the truth to benefit one’s own interest”
  - Bias
  - Deception

Extended reading
https://dark-star-161610.appspot.com/secured/_book/design-and-integrity.html#ethical-principles

- Unintentional: out of expectation
  - Data source mistake
  - Design mistake
  - Algorithm (mapping) mistake



https://sports.yahoo.com/olympics/tokyo-2021/medals/
(the bars were corrected later)

29 bar is longer than 34 bar. The size (length) of the part represents the weight of the total (%) instead of the absolute number. The inconsistency causes the confusion and wrong impression if numbers are ignored.

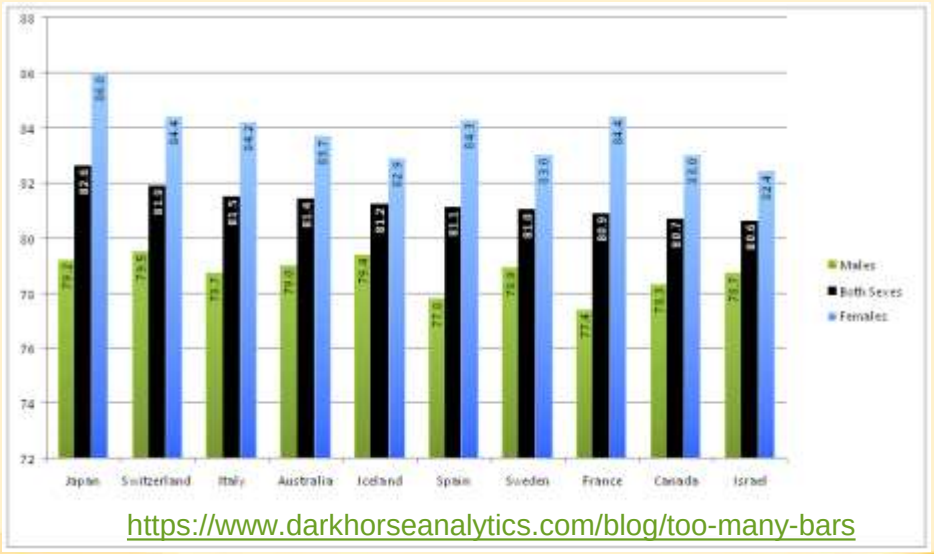
Simplicity

- Simplicity means using the simple design to achieve the outcome
  - Start with simple; do not change if there is no problem.
  - Simple does not mean minimalism. It is a balance between simplicity and functionality. It should not impact the clarity of the visual.
- Best practices
  - Declutter
  - Data ink ratio https://infovis-wiki.net/wiki/Data-Ink_Ratio

Declutter

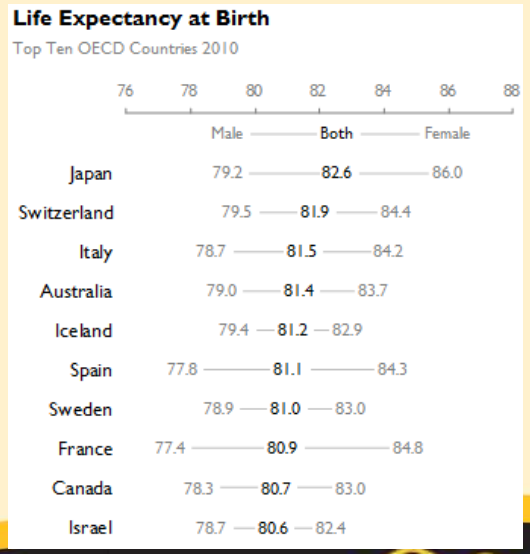
- Use simpler color systems
- Control the number of objects/elements or data point
- Use lighter visual marks – column vs dot/line

https://www.fluencetech.com/post/lessons-from-ibcs-eliminating-chart-clutter



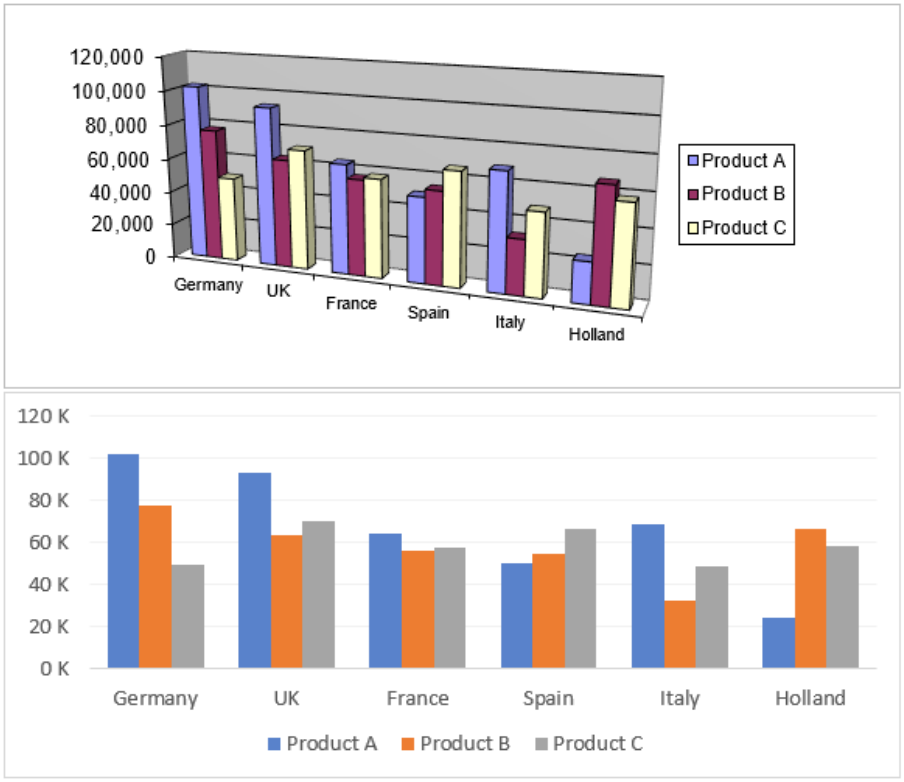
https://www.darkhorseanalytics.com/blog/too-many-bars

declutter



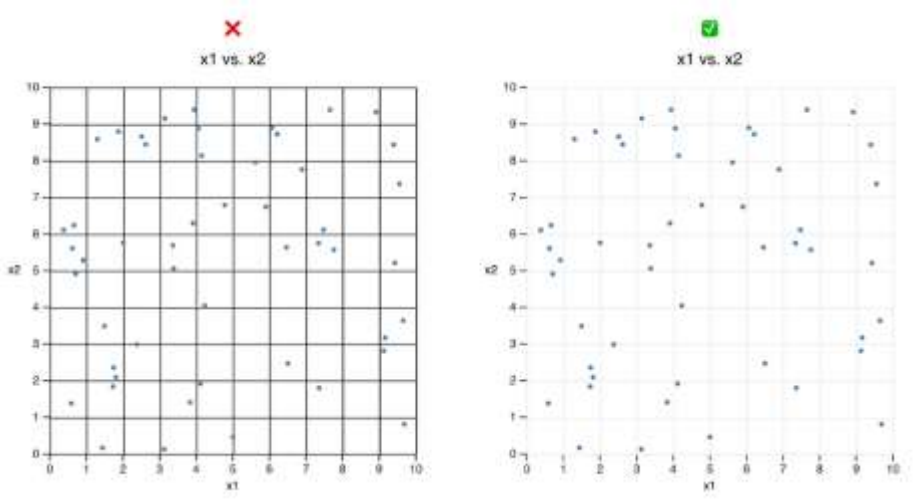
Declutter Case

- https://www.fluencetech.com/post/lessons-from-ibcs-eliminating-chart-clutter
- Techniques applied to the upper chart:
  - The chart clutter which has been removed or toned down includes:
  - Remove the 3D effect – it never (ever!) helps…
  - Grey backfill on the chart area
  - Borders on the columns
  - Border on the legend
  - Heavy gridlines have been subdued
  - Vertical axis bar
  - Axis now displayed in thousands

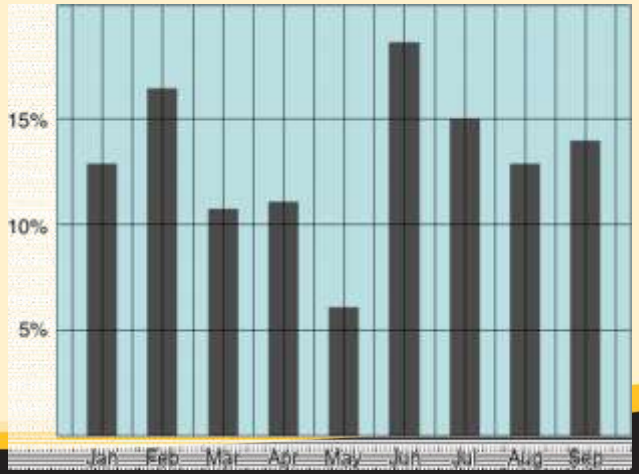


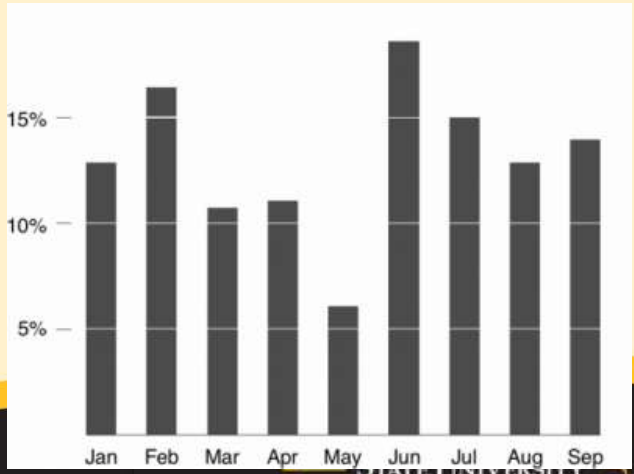
Data Ink Ratio

- Data ink
  - It basic refers to the salience of objects and visual properties that directs represents data, e.g, bars, lines, dots, etc. (vs. non-data ink like grid lines, border, background, etc.)
  - https://infovis-wiki.net/wiki/Data-Ink_Ratio
- Some practices
  - Be ware of flashy decorative effects such as textured background, shadow, 3D, etc., unless they are absolutely needed or associated with a particular meaning.
  - Avoid heavy (dark and/or bold) grid lines and borders



https://filwd.substack.com/p/clarity-and-aesthetics-in-data-visualization

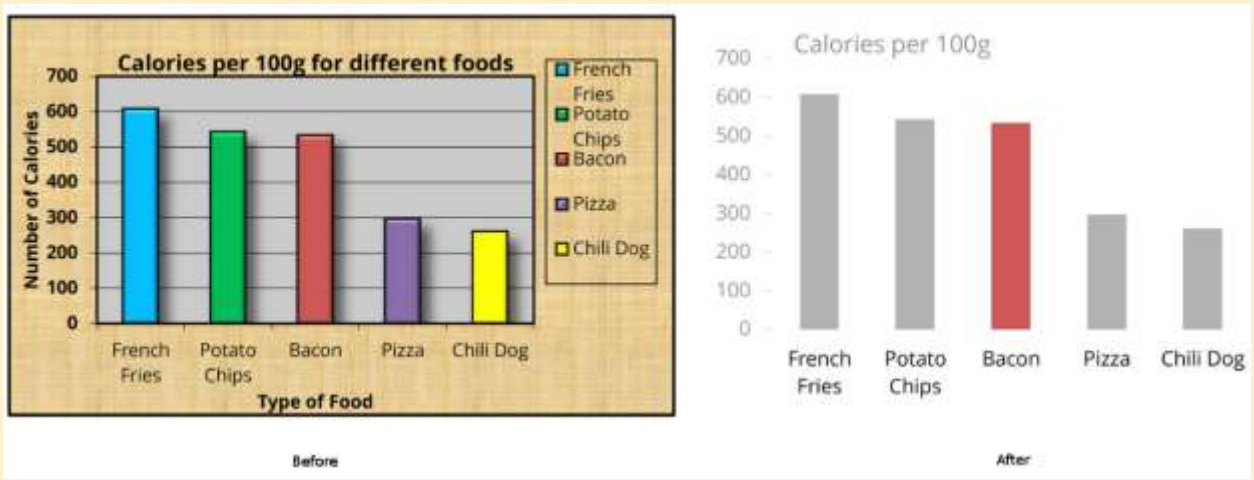




https://classes.engr.oregonstate.edu/eecs/winter2018/cs519-400/modules/4-data-visualization/1-excellence-integrity/

Data Ink Case Study

- Case on simplifying charts
  - https://www.darkhorseanalytics.com/blog/data-looks-better-naked/
- A similar case with step-by-step explanation
  - https://blog.hubspot.com/marketing/data-graph-design-powerpoint-tips-ht

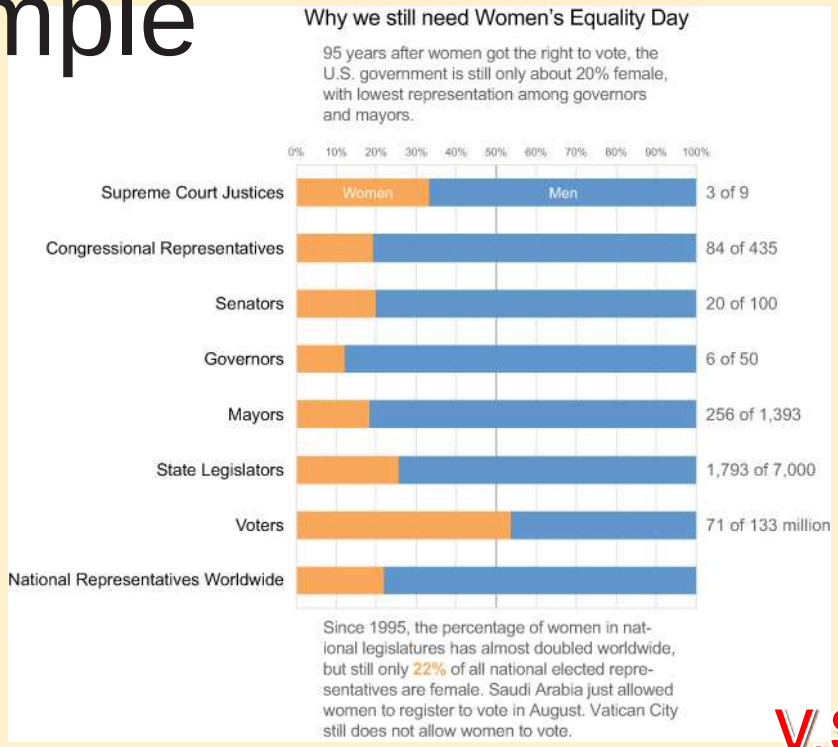


Elegance

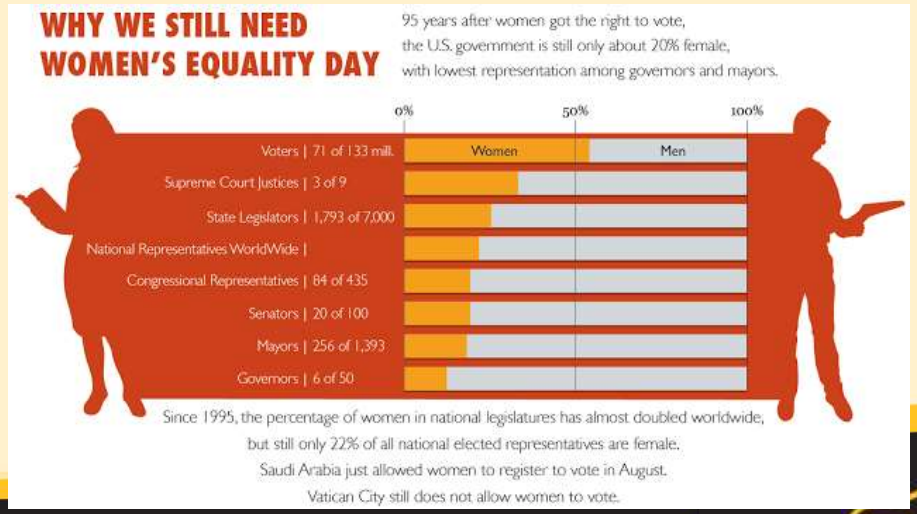
- Elegance is a visual quality to attract audience and sustain that sentiment and interest – Andy Kirk
  - This means visual appealing and some level of beauty and creativity
  - Should not interfere with other three principles
- Example best-practices
  - Using predefined color sets instead of random color combinations
  - Using themes (or consistent styles)
  - Associate color/texture/shape/icon with a particular meaning to boost understanding and emotion
  - Using round corner bars/columns
  - Choosing proper font family
  - Reasonably vary the use of chart types (which serves the same purpose) https://www.darkhorseanalytics.com/blog/too-many-bars
- This class does not focus on this principle; you may refer to other resources like
  - Andy Kirk's book "Data Visualization" https://nightingaledvs.com/what-makes-a-data-visualisation-elegant/
  - https://creativemarket.com/blog/10-basic-elements-of-design

Elegance Example

- Balancing Accuracy, Engagement, and Tone
  - https://www.datarevelations.com/balancing-accu-ement-and-tone/
- Original post by Steven Few
  - http://www.perceptualedge.com/blog/?p=2121
- Alberto Cairo's reply
  - "Tufte's 'data-ink-ratio' rule leads to charts that lack elegance."
  - And his redesign http://www.thefunctionalart.com/2015/09/stephen-few-asked-me-what-i-thoughts.html
- Stephen Few's comments upon seeing the redesign:
  - "Alberto, You're the man! I love your improvements to the graphic. You described your version as middle ground between my position and that of the embellishers, but I don't see it that way. I'm an advocate of the kinds of embellishments that you added to the graphic for journalistic purposes, for they don't detract from the information in any way. I've always said that journalistic infographics can be both informative and beautiful without compromising either. ..."



V.S.



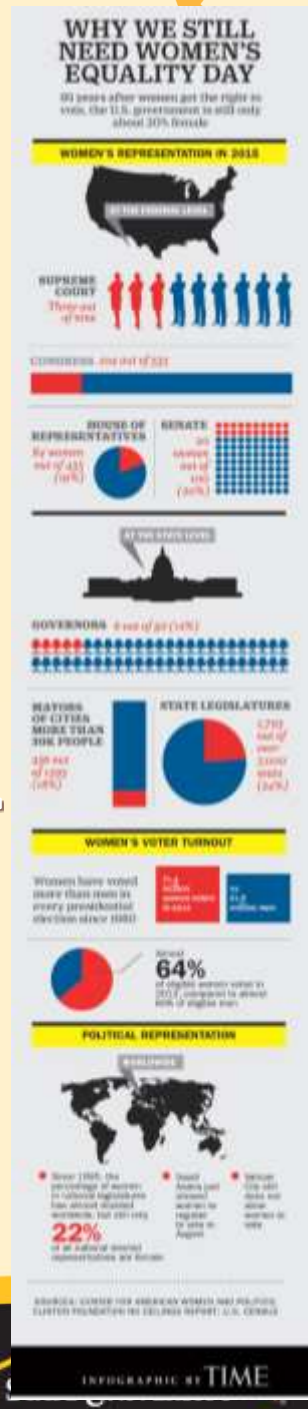


Chart Redesign Cases

- https://excelcharts.com/data-visualization-elegant-not-beautiful/
- https://www.datarevelations.com/balancing-accu-ement-and-tone/
- https://www.darkhorseanalytics.com/blog/data-looks-better-naked/
- https://blog.hubspot.com/marketing/data-graph-design-powerpoint-tips-ht
- https://www.storytellingwithdata.com/blog/2021/1/10/lets-improve-this-graph-yt9xj

Guideline and Standard

- Establish a general guideline or standard that everyone can follow
  - Guidelines and standards embodies principles and best practices, and provides clear expectations
  - Promotes consistency across stakeholders, projects, and units.
  - Facilitates communication and understanding
- Many organizations realize the importance of data visualization and set up guidelines or standards.
  - It is difficult and to make and require standards at a larger scale in the visualization and design industry.
  - Many of them are more like guidelines, even called standards.
  - A bit different from standards from engineering, food processing, or manufacturing.
  - They are also in various forms with varied complexity and details.
- Exemplar guidelines/standards
  - IBCS https://www.ibcs.com/standards/ is a comprehensive guidebook
  - US Census Bureau xd.gov https://xdgov.github.io/data-design-standards/ focuses more on individual chart type and chart component
  - European Environment Agency (eea.europa.eu) has a set of usability guidelines for improving visualisations https://www.eea.europa.eu/data-and-maps/daviz/learn-more/chart-dos-and-donts - these are more like a simple list (used to be a 25-point list; recently organized into categories)
  - Google data visualization guidelines https://material.io/design/communication/data-visualization.html

IBCS

- International business communication standard (ibcs.com) defines a set of standards for business communication, including the visual communication part.
  - The International Business Communication Standards (IBCS®) are practical proposals for the design of reports, presentations, dashboards and the diagrams and tables contained therein.
- Current version 1.2
  - https://www.ibcs.com/ibcs-standards-1-2/
  - https://ibcs.konveio.site/ibcs-standards-12
- IBCS explained
  - https://www.youtube.com/watch?v=VkCyNOioUQQ
  - https://www.ibcs.com/resource/rolf-hichert-about-ibcs/
  - https://www.youtube.com/c/IBCS-Institute/featured
- The “Perceptual Rules” section define some standard chart types and their usage (https://ibcs.konveio.site/ibcs-standards-12#page=82)
  - “The perceptual rules from the EXPRESS (choose proper visualization), SIMPLIFY (avoid clutter), CONDENSE (increase information density), and CHECK (ensure visual integrity) sections help to clearly relay content by using an appropriate visual design. They are based on the work of authors such as William Playfair, Willard Cope Brinton, Gene Zelazny, Edward Tufte and Stephen Few.”

IBCS Templates and Tools

- Chart templates
  - https://www.ibcs.com/resource_category/chart-templates/
- Some BI tools have adopted IBC
  - https://www.ibcs.com/software/
- Power BI - Charts through third party addons
  - https://www.truechart.com/software/truechart4powerbi/
  - https://zebrabi.com/ibcs/
  - https://appsource.microsoft.com/en-us/product/power-bi-visuals/WA200002681
- Tableau has not adopted IBCS completely but can be customized to comply the standard
  - https://public.tableau.com/app/profile/ceterisag/viz/ibcs/IBCS

Specific Best Practices

- This course does not focus on design details for each type of charts.
- We discuss some selected best practices through selected special topics in module 3 to 5.
- Use references like the standards mentioned earlier.
- Please do some research yourself and apply based on your own study and experience.

Key Readings

- Example principles https://www.linkedin.com/pulse/data-design-six-must-know-visualization-principles-everyone-eppler/
- Clarity: https://filwd.substack.com/p/clarity-and-aesthetics-in-data-visualization
- Accuracy/integrity: https://www.linkedin.com/pulse/edward-tuftes-six-principles-graphical-integrity-radhika-raghu/
- Simplicity: https://blog.hubspot.com/marketing/data-graph-design-powerpoint-tips-ht
- Elegance
  - https://excelcharts.com/data-visualization-elegant-not-beautiful/
  - https://www.datarevelations.com/balancing-accu-ement-and-tone/
- IBCS Standards version 1.2 Perceptual Rules Section https://ibcs.konveio.site/ibcs-standards-12#page=81 – particularly the following sections. Other sections optional.
  - Express (page 68-86) https://ibcs.konveio.site/ibcs-standards-12#page=82
  - Simplify (page 113-119) https://ibcs.konveio.site/ibcs-standards-12#page=127
  - Check (page 135 to 142) https://ibcs.konveio.site/ibcs-standards-12#page=149

Additional Good Resources

- https://dark-star-161610.appspot.com/secured/_book/design-and-integrity.html#ethical-principles
- What Makes a Data Visualisation Elegant? https://nightingaledvs.com/what-makes-a-data-visualisation-elegant/
- Selected chart design best practices
  - https://visme.co/blog/dos-and-donts-chart-making/
  - Accurate vs. Emotional Comparisons – Sometimes Pies, Bubbles, and Waffles are the Better Choice https://www.datarevelations.com/accurate-vs-emotional-comparisons-sometimes-pies-bubbles-and-waffles-are-the-better-choice.html
  - Too many bars: https://www.darkhorseanalytics.com/blog/too-many-bars
  - https://trinachi.github.io/data-design-builds/ch14.html
  - https://www.geckoboard.com/best-practice/data-visualization-tips/
- Other principles/guidelines/standards
  - US Census Bureau xd.gov https://xdgov.github.io/data-design-standards/ focuses more on individual chart type and chart component
  - European Environment Agency (eea.europa.eu) has a set of usability guidelines for improving visualisations https://www.eea.europa.eu/data-and-maps/daviz/learn-more/chart-dos-and-donts - these are more like a simple list (used to be a 25-point list; recently organized into categories)
  - Google data visualization guidelines https://material.io/design/communication/data-visualization.html
  - https://kevinlanning.github.io/DataSciLibArts/principles-of-data-visualization.html#tufte-first-principles
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- Problematic chart collection
  - Visualizations that make no sense https://viz.wtf and https://twitter.com/WTFViz
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