

COMP4131: Data Modelling and Analysis

Lecture 3: Data Visualisation

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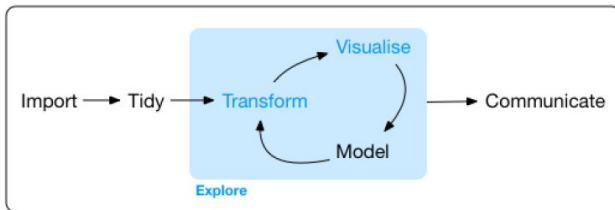
February 26, 2025

Outline

- 1 Introduction to Data Visualisation
- 2 Types of Data Visualisations
- 3 Principles of Effective Data Visualisation
- 4 Design and Aesthetics in Data Visualisation
- 5 Data Storytelling

Recap - Data Modelling and Analysis Pipeline

- We have discussed:
 - The pipeline of data modelling and analysis
 - Data wrangling and pre-processing



From: R for Data Science, Wickham and Golemund

By the end of this lecture, you will be able to:

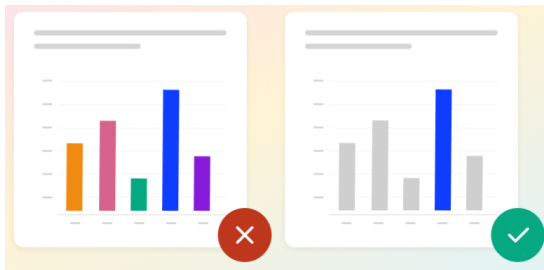
- Understand the importance of data visualisation in data analysis and decision-making.
- Identify the key principles of effective data visualisation.
- Choose the right chart types for different types of data and analysis goals.
- Apply design and storytelling techniques to create compelling visualisations.

Introduction to Data Visualisation

What is Data Visualisation?

Definition:

- Data visualisation is the graphical representation of data to communicate information clearly and effectively.
- Helps in identifying patterns, trends, and outliers.
- Enables better decision-making by presenting data in an understandable format.

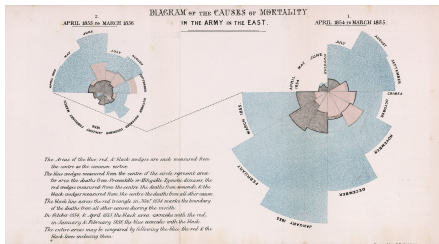


Source:

<https://www.polymersearch.com/blog/10-good-and-bad-examples-of-data-visualization>

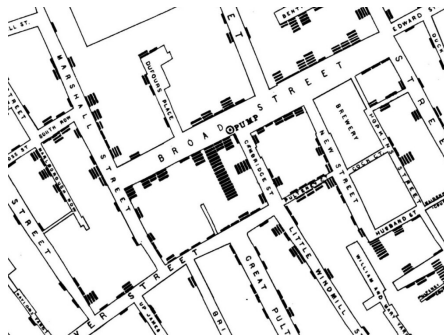
Historical Context of Data Visualisation

- Florence Nightingale's Coxcomb chart (1858): Visualized mortality data during the Crimean War.



Source: Florence Nightingale: Pioneer of Data Visualization

- John Snow's cholera map (1854): Identified the source of a cholera outbreak in London.



Source: Vintage John Snow Cholera Map
of London 1854

Key Goals of Data Visualisation

Data visualisation serves three primary goals:

• Exploration

- Discover patterns, trends, and relationships in data.
- Identify outliers and anomalies.

• Analysis

- Understand data distributions and correlations.
- Extract actionable insights from data.

• Communication

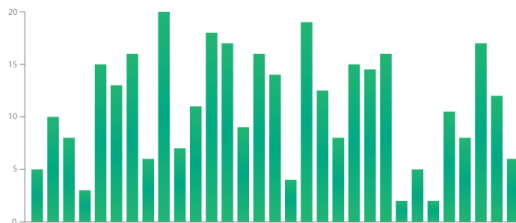
- Present findings clearly and effectively.
- Tell a compelling story with data.
- Support decision-making for stakeholders.

Types of Data Visualisations

Basic Charts: Bar Charts

Bar Charts:

- Compare categories or groups.
- Use horizontal or vertical bars.

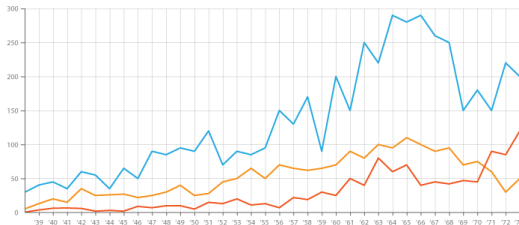


Source: Data Viz Catalogue - Bar Chart

Basic Charts: Line Charts

Line Charts:

- This chart is used to display quantitative values over a continuous interval or time period.
- A line chart is most frequently used to show trends and analyse how the data has changed over time.



Source: Data Viz Catalogue - Line Graph

Basic Charts: Pie Charts

Pie Charts:

- Pie charts help show proportions and percentages between categories, by dividing a circle into proportional segments (use sparingly).
- Each arc length represents a proportion of each category, while the full circle represents the total sum of all the data, equal to 100%.

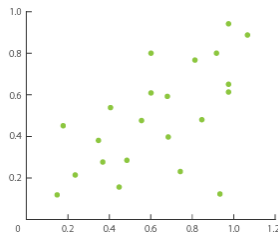
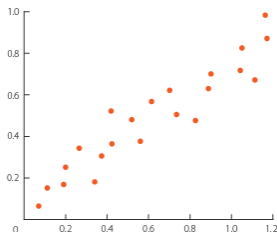


Source: Data Viz Catalogue - Pie Chart

Advanced Charts: Scatter Plots

Scatter Plots:

- Reveal relationships between two variables.
- Identify correlations or clusters.

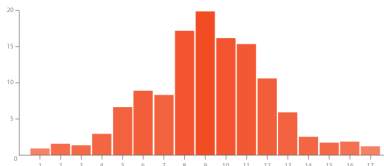


Source: Data Viz Catalogue - Scatter Plot

Advanced Charts: Histograms

Histograms:

- A histogram visualises the distribution of data over a continuous interval.
- Each bar in a histogram represents the tabulated frequency at each interval/bin.
- Histograms help give an estimate as to where values are concentrated, what the extremes are and whether there are any gaps or unusual values.

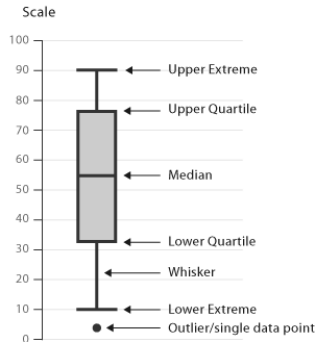


Source: Data Viz Catalogue - Histogram

Advanced Charts: Box Plots

Box Plots:

- Summarize data distribution (median, quartiles, outliers).
- The lines extending parallel from the boxes are known as the “whiskers”, which are used to indicate variability outside the upper and lower quartiles.
- Outliers are sometimes plotted as individual dots that are in-line with whiskers.

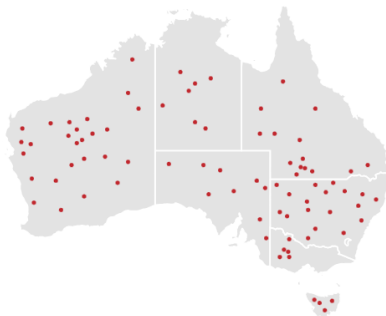


Source: Data Viz Catalogue -
Boxplot

Geospatial Visualisations: Maps

Maps:

- Display data with geographic context.
- A way of detecting spatial patterns or the distribution of data over a geographical region.
- Examples: Point maps, heatmaps.



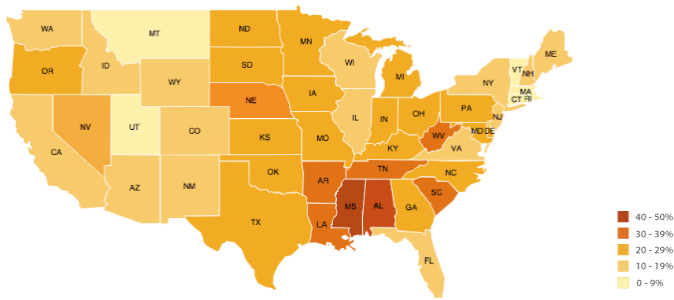
Source: Data Viz Catalogue - Dot Map

Source: Johns Hopkins University's COVID-19 dashboard.

Geospatial Visualisations: Choropleth Maps

Choropleth Maps:

- Use shading or patterns to represent data values.
- Examples: Election results, population density.

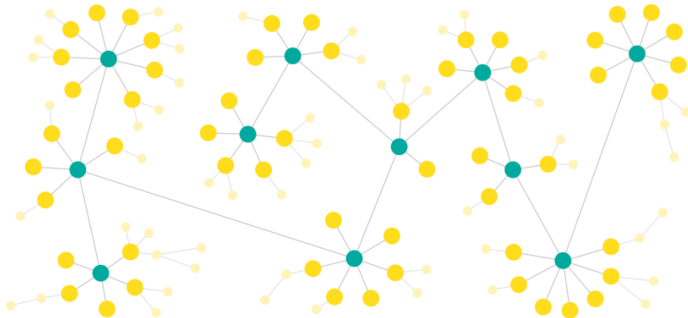


Source: Data Viz Catalogue - Choropleth Map

Network Graphs

Network Graphs:

- Visualise relationships between entities.
- Examples: Social networks, transportation networks.

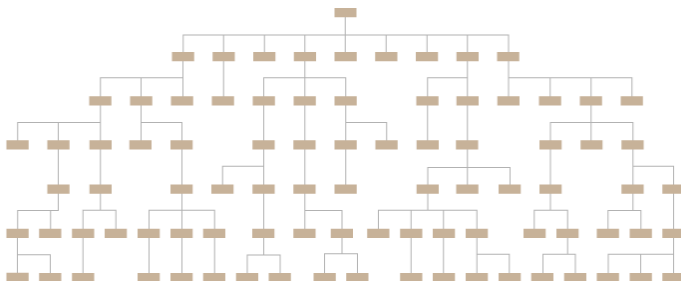


Source: From Data to Viz - Network Graph

Tree Maps

Tree Maps:

- Display hierarchical data as nested rectangles.
- Examples: File system structures, budget allocations.

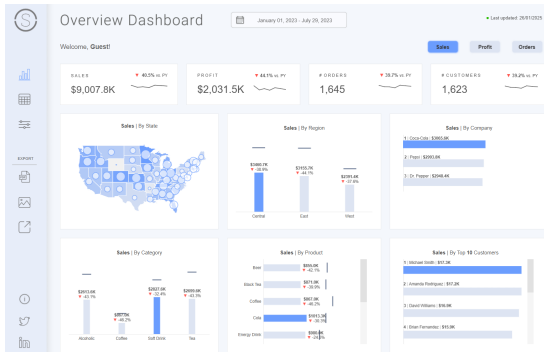


Source: Data Viz Catalogue - Tree Map

Interactive Visualisations: Dashboards

Dashboards:

- Combine multiple visualisations into a single interface.
- Examples: Business intelligence dashboards.



Source: Tableau - Data Dashboards

Principles of Effective Data Visualisation

Key Principles:

- **Clarity:** Ensure the visualisation is easy to understand.
- **Accuracy:** Represent data truthfully without distortion.
- **Efficiency:** Convey information quickly and effectively.
- **Aesthetics:** Make the visualisation visually appealing.

Choosing the Right Chart Type

Match the chart to the data:

- **Bar charts:** Compare categories.
- **Line charts:** Show trends over time.
- **Scatter plots:** Reveal relationships between variables.
- **Pie charts:** Display proportions (use sparingly).
- **Heatmaps:** Visualise density or correlations.

Importance of Color Theory

Color best practices:

- Use color to highlight, not distract.
- Choose colorblind-friendly palettes (e.g., ColorBrewer).
- Avoid using too many colors in a single chart.
- Use consistent colors for the same categories across visualisations.



Source: Data Visualization: Design Considerations
Useful link: [ColorBrewer](#)

Ethical guidelines:

- Avoid manipulating data to mislead.
- Be transparent about data sources and methods.
- Respect privacy and confidentiality.
- Ensure accessibility for all audiences.

Avoiding Chart Junk and Misleading Visualisations

Common pitfalls:

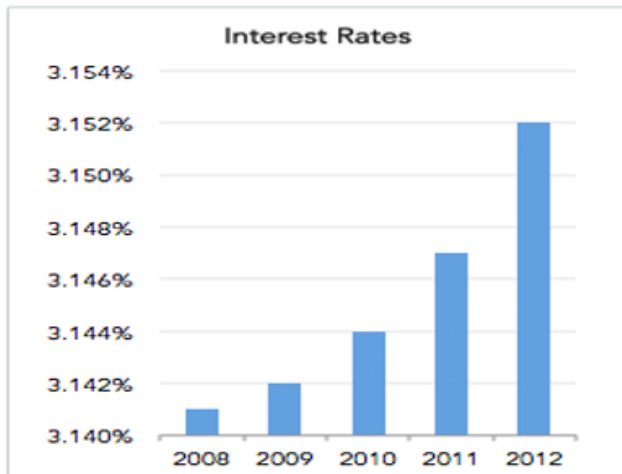
- **Chart junk:** Unnecessary decorations (e.g., 3D effects, excessive gridlines).
- **Misleading scales:** Truncated axes or inconsistent intervals.
- **Overloading:** Too much information in one chart.



Video: How to spot a misleading graph - Lea Gaslowitz

ACTIVITY . THINK-PAIR-SHARE

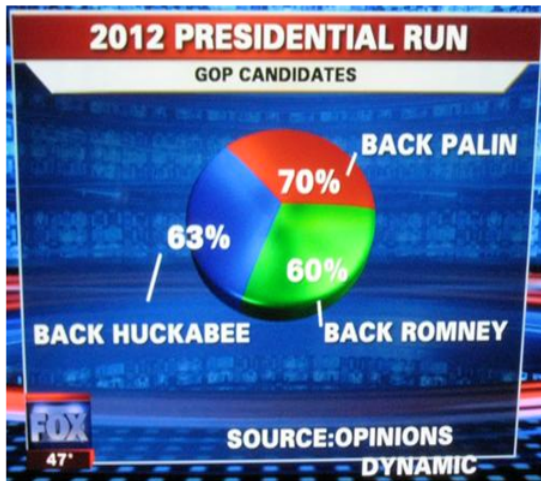
- What's wrong with this visualisation?



Source: CMSC320 - Introduction to Data Science

ACTIVITY . THINK-PAIR-SHARE

- What's wrong with this visualisation?



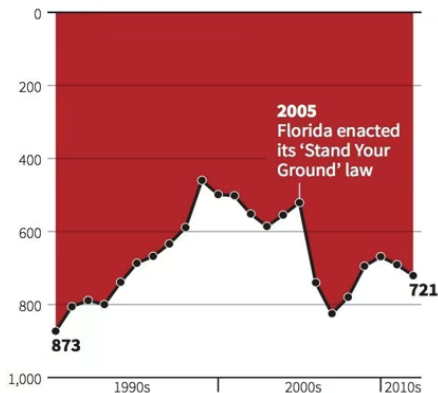
Source: CMSC320 - Introduction to Data Science

ACTIVITY . THINK-PAIR-SHARE

- What's wrong with this visualisation?

Gun deaths in Florida

Number of murders committed using firearms



Source: Florida Department of Law Enforcement

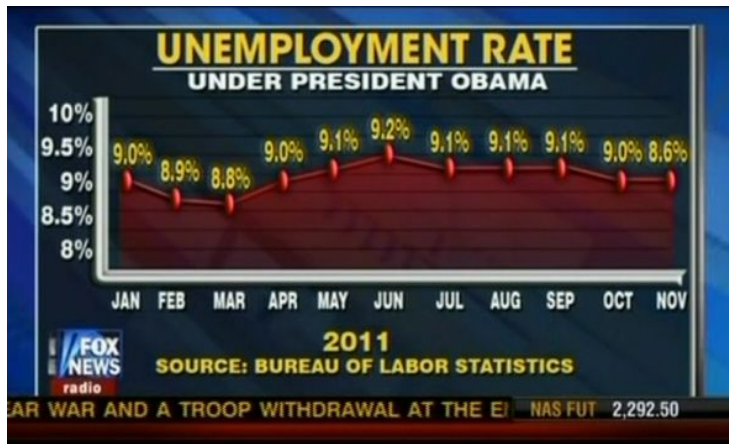
C. Chan 16/02/2014

REUTERS

Source: CMSC320 - Introduction to Data Science

ACTIVITY . THINK-PAIR-SHARE

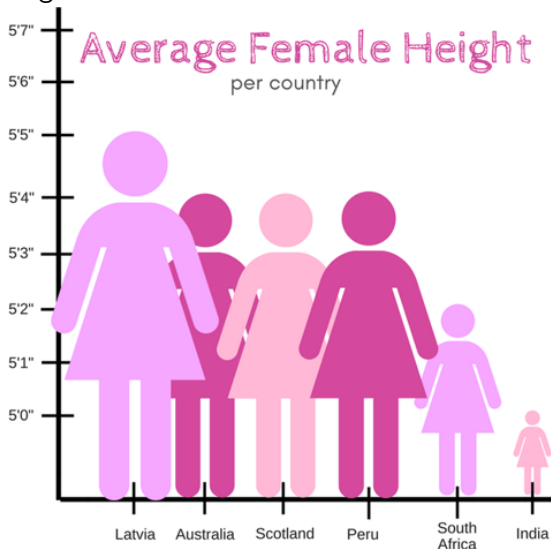
- What's wrong with this visualisation?



Source: CMSC320 - Introduction to Data Science

ACTIVITY . THINK-PAIR-SHARE

- What's wrong with this visualisation?



Source: CMSC320 - Introduction to Data Science

Takeaway

Be careful when designing visualisations, and **be extra careful** when interpreting graphs created by others.

Design and Aesthetics in Data Visualisation

Why Design Matters:

- Enhances clarity and understanding.
- Makes visualisations more engaging and memorable.
- Builds trust and credibility with the audience.

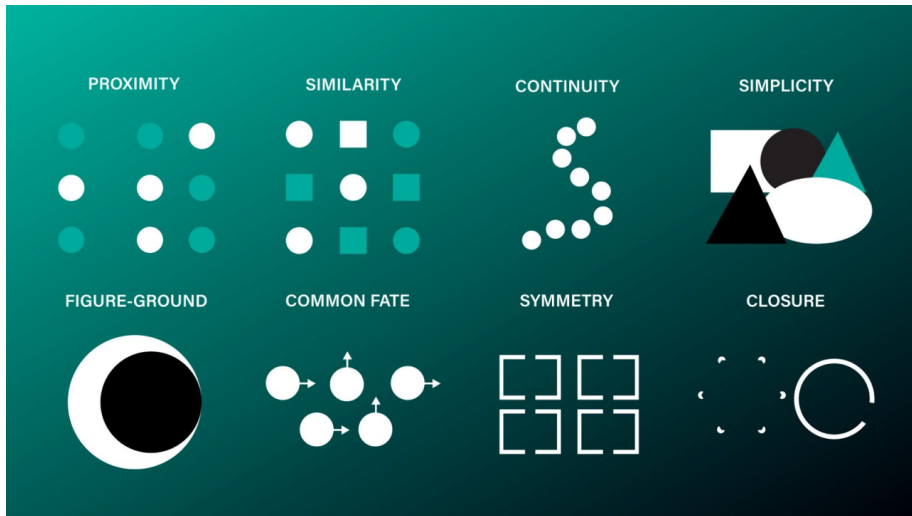
What are Gestalt Principles?

- A set of principles that describe how humans naturally organize visual elements into groups or unified wholes.
- These principles help designers create clear, intuitive, and effective visualisations.

Key Principles:

- **Proximity**
- **Similarity**
- **Continuity**
- **Closure**
- **Figure/Ground**
- **Common Fate**
- **Symmetry and Order**
- **Prägnanz (Simplicity)**

Gestalt Principles in Visualisation

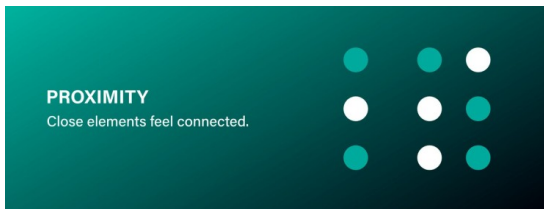


Source: Enhancing User Experience with Gestalt Principles

Gestalt Principle: Proximity

Proximity:

- Elements that are close to each other are perceived as related.
- Use spacing to group related items and separate unrelated ones.

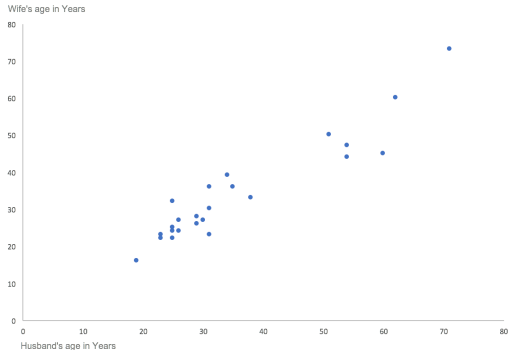


Source: Enhancing User Experience with Gestalt Principles

Gestalt Principle: Proximity

Proximity:

- In this chart, we see 2 groups or clusters of dots, though there are no visible markings of a group.

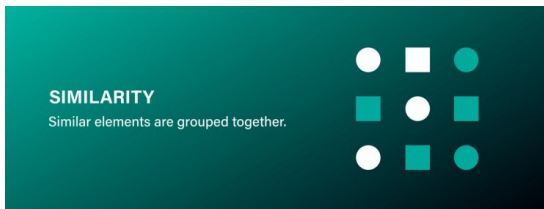


Source: Gestalt Laws Applied to Data Visualization

Gestalt Principle: Similarity

Similarity:

- Elements that look similar (e.g., color, shape, size) are perceived as related.
- Use consistent styles to group similar items.

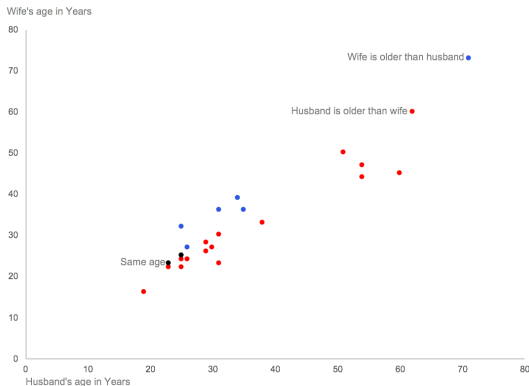


Source: Enhancing User Experience with Gestalt Principles

Gestalt Principle: Similarity

Similarity:

- We see 3 groups in this chart – dots of colour Red, Blue and Black. Though the Red dots do not appear close together, we see them as a group since they are all Red.

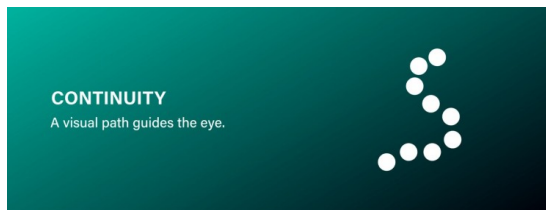


Source: Gestalt Laws Applied to Data Visualization

Gestalt Principle: Continuity

Continuity:

- Elements arranged in a line or curve are perceived as related.
- Use alignment to guide the viewer's eye through the visualisation.

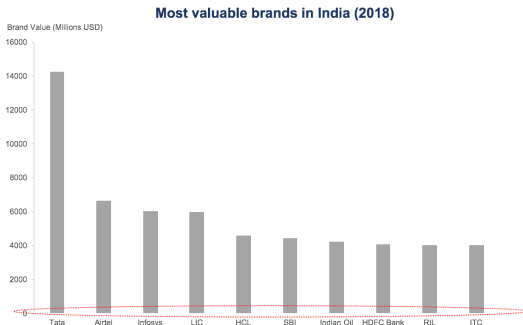


Source: Enhancing User Experience with Gestalt Principles

Gestalt Principle: Continuity

Continuity:

- If you look closely, we haven't used the X-Axis line in this chart. But we see these bars as sharing a common baseline due to the law of continuity.

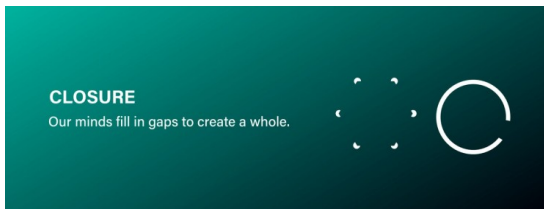


Source: Gestalt Laws Applied to Data Visualization

Gestalt Principle: Closure

Closure:

- The mind fills in missing parts of a shape or design.
- Use partial shapes to imply completeness.

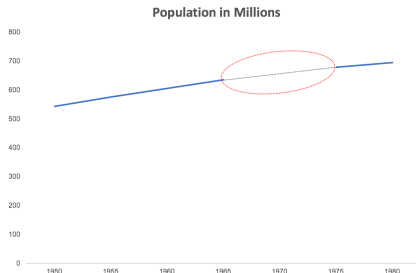
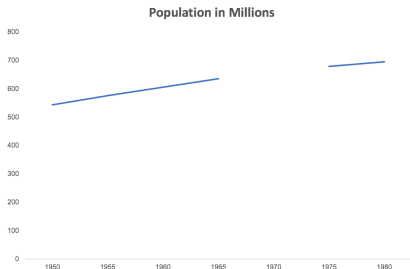


Source: Enhancing User Experience with Gestalt Principles

Gestalt Principle: Closure

Closure:

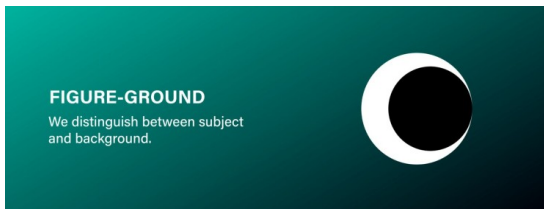
- Here is a chart with some missing data for the year 1970. When we look at this, our minds automatically imagine a line connecting the 2 broken lines.
- This is one of the pitfalls of the law of closure. We should be careful when showing graphs with breaks because our minds tend to form complete shapes even if the shape is incomplete.



Gestalt Principle: Figure/Ground

Figure/Ground:

- The mind separates elements into foreground (figure) and background (ground).
- Use contrast to distinguish important elements from the background.

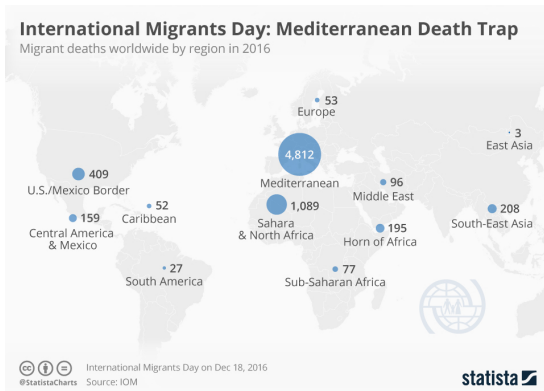


Source: Enhancing User Experience with Gestalt Principles

Gestalt Principle: Figure/Ground

Figure/Ground:

- The blue bubbles form the figure in the chart, they are in the forefront and capture our attention. The map in the background comes into focus next.

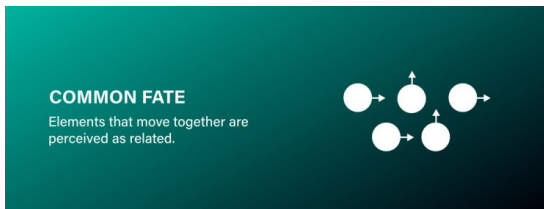


Source: Gestalt Laws Applied to Data Visualization

Gestalt Principle: Common Fate

Common Fate:

- Elements that move in the same direction are perceived as related.
- Use motion or directional cues to group elements.

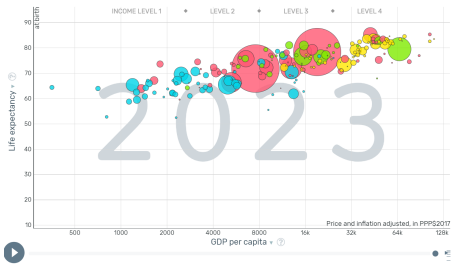


Source: Enhancing User Experience with Gestalt Principles

Gestalt Principle: Common Fate

Common Fate:

- We perceive elements moving together in the same speed and/or direction as belonging to a group.
- In this chart from Gapminder, we can see the bubbles move right and upward. We perceive this as an improvement in Life Expectancy with increase in GDP. The elements that move in the same direction are perceived to have the same fate.



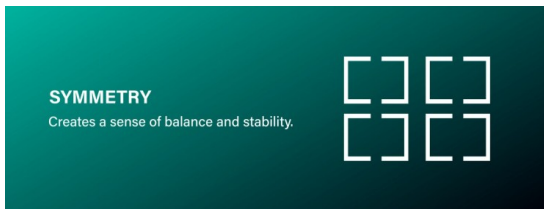
Link: Gapminder

Source: Gestalt Laws Applied to Data Visualization

Gestalt Principle: Symmetry and Order

Symmetry and Order:

- The mind perceives symmetrical elements as part of the same group.
- Use symmetry to create balance and organization.



Source: Enhancing User Experience with Gestalt Principles

Gestalt Principle: Symmetry and Order

Symmetry and Order:

- The Law of Symmetry states that visual elements that are symmetrical to each other tend to be perceived as a unified group.
- This principle is not used frequently in data visualization; however, it might be compelling when creating “Before and After” visuals or comparing two similar groups of elements.

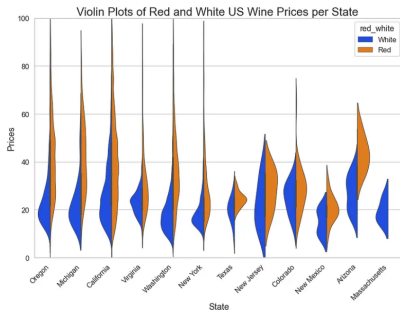


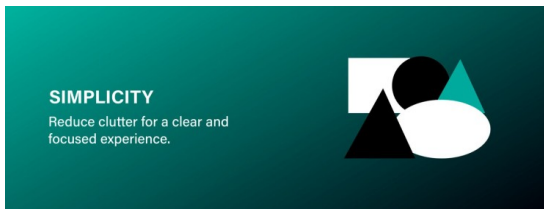
Illustration of Gestalt Symmetry principle, image by Author

Source: The Psychology behind Data Visualization Techniques

Gestalt Principle: Prägnanz (Simplicity)

Prägnanz (Simplicity):

- The mind prefers simple, clear, and stable interpretations of complex shapes.
- Avoid unnecessary complexity in visualizations.

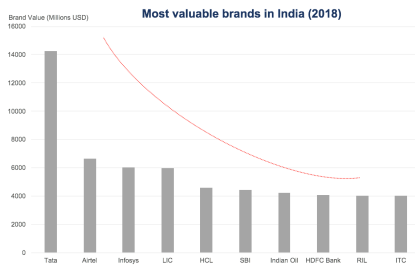
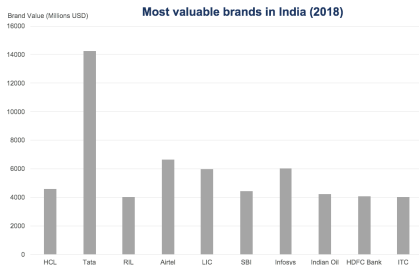


Source: Enhancing User Experience with Gestalt Principles

Gestalt Principle: Prägnanz (Simplicity)

Prägnanz (Simplicity):

- Prägnanz is a German word that means “pithiness” or “concise and meaningful”.
- Our eyes tend to find simplicity in complex shapes, preventing us from being overwhelmed by information overload.
- When the same chart is sorted in order, we find much more clarity in it.



Source: Gestalt Laws Applied to Data Visualization

Data Storytelling

What is Data Storytelling?

- The art of using data, visuals, and narrative to communicate insights effectively.
- Combines data analysis, visualization, and storytelling techniques.

Why is it important?

- Helps audiences understand complex data.
- Drives decision-making and action.

Three Key Elements:

- **Data:** Accurate and relevant data to support the story.
- **Visuals:** Clear and engaging visualisations.
- **Narrative:** A compelling storyline to connect the data and visuals.

Storytelling with Data

Key elements:

- Start with a clear question or problem.
- Use data to build a narrative.
- Highlight key insights and conclusions.
- End with actionable recommendations.



Source: Hans Rosling's TED Talk

Useful link: [Gapminder](#)

- **Useful link 1:** From Data to Viz
- **Useful link 2:** The Data Visualisation Catalogue
- David McCandless' TED Talk: [The Beauty of Data Visualization](#)
- A video from Alberto Cairo: [A Brief History of Data Visualization](#)