Chapter 6.2 – Gestalt Principles in Visualisation

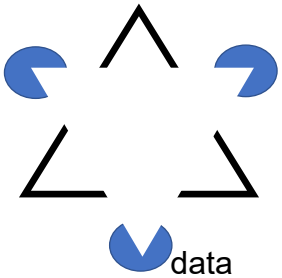
Contents

- Gestalt Psychology
- Proximity
- Similarity
- Simplicity
- Connectedness
- Enclosure
- Symmetry
- Figure-Ground

1

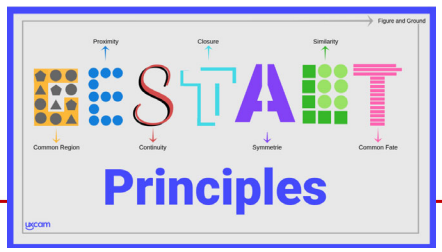
Gestalt Psychology

The Whole is Other than the Sum of Parts



- Gestalt psychology describes various principles or laws that govern how the human visual system forms **patterns** and **visual groupings** to simplify the interpretation of visual stimuli received.
- These Gestalt principles explain the **pattern-seeking** behaviour of human visual perception and should therefore be used in visualisation to help **communicate visual information** more effectively.
- Some Gestalt principles explored include:

• Proximity	• Connectedness	• Figure & Ground
• Similarity	• Continuity	
• Simplicity	• Symmetry	



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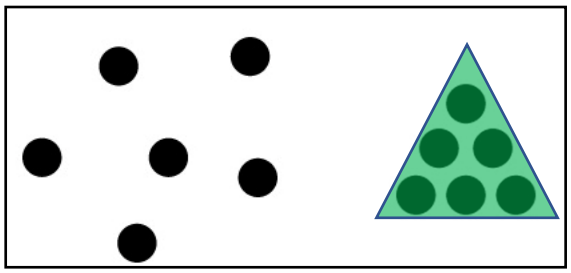
Proximity

Closer is Together

- Principle of **proximity** states that visual elements **close to** each other are perceived as **belonging** to the same group.

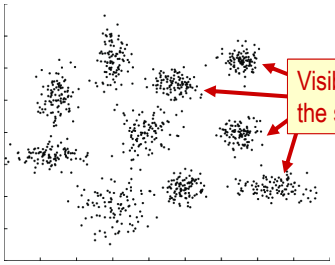


Proximity of shapes creates a larger unit entity

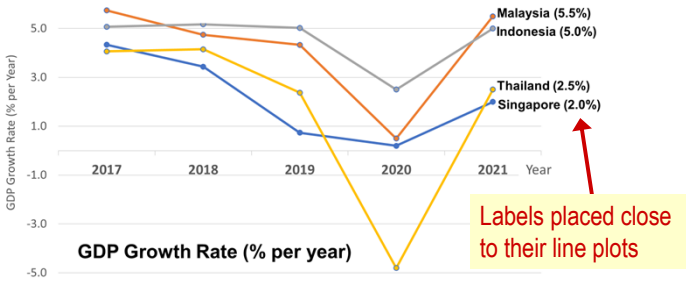
Proximity

Closer is Together

- Principle of **proximity** states that visual elements **close to** each other are perceived as **belonging** to the same group.
- Clusters in scatter plots are identified based on the proximity of the dots.
- Labels are placed close to their respective line plots to strengthen association to their corresponding lines[1].



Visible clusters in the scatter plot



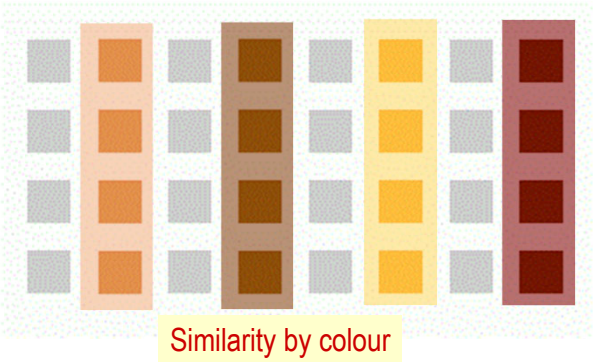
Labels placed close to their line plots

[1] Vidya Kesavan, Gestalt Laws Applied to Data Visualization (2018), https://medium.com/@vidya83.kesavan/gestalt-laws-applied-to-data-visualization-1e18385b7b00

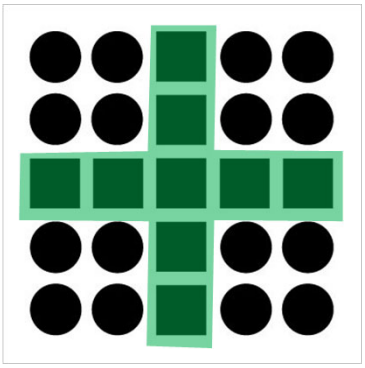
Similarity

Birds of a Feather Flock Together

- Principle of **similarity** states that visual elements that are **similar** to each other tend to be perceived as a **unified group**.



Similarity by colour



Similarity by shape

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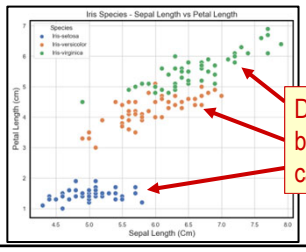
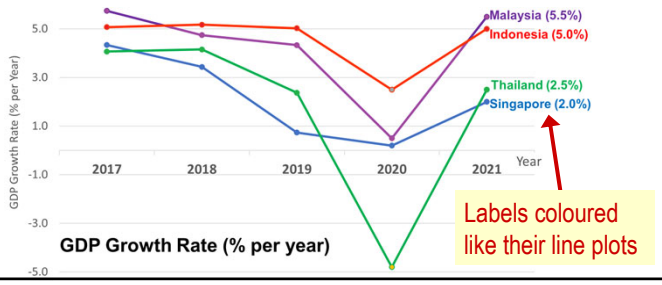
Similarity

Birds of a Feather Flock Together

- Principle of **similarity** states that visual elements that are **similar** to each other tend to be perceived as a **unified group**.
- Similarity-based perceptual grouping can be influenced by various visual features, including shape, colour, orientation, size or even motion.
- **Colour** can be used in scatter plots to identified data belonging to similar categories.
- Labels with the **same colour** as the line plots can further strengthen association to their corresponding lines.



Dots coloured based on their categories



Labels coloured like their line plots

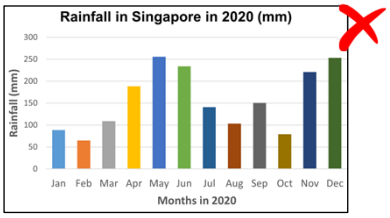
6

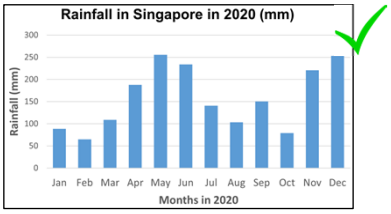
6

Similarity

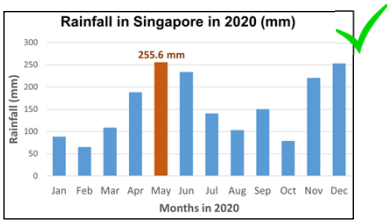
Exploiting Similarity

- Elements that share the **same visual attributes** will be perceived as being **related**. Consider carefully if the bar charts should have different hues or a uniform hue.
- Dissimilarity can be used to do the reverse and **highlight** a particular **exception** or **focal point** in the visualisation by giving it a distinctly different visual attribute.



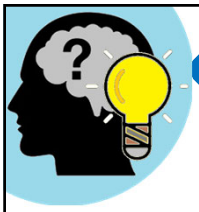


Ordinal categories (e.g. months in a year) should have uniform colour as varying hue increases cognitive load and disrupt clarity of changing trend [2]



Wettest month in 2020 made to stand out in a different colour [2]

[2] William Craig, How to Make Data Visualization Better with Gestalt Laws, https://www.webfx.com/blog/web-design/data-visualization-gestalt-laws/



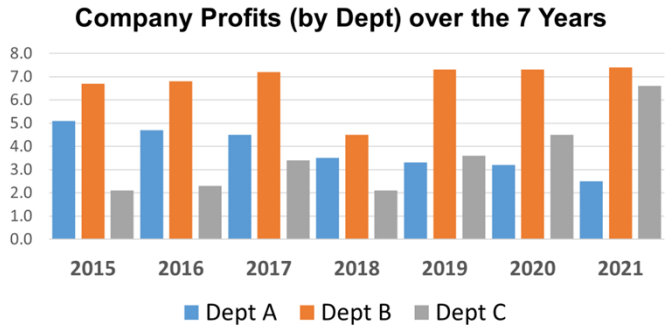
Think and Apply

Improving Visualisation using Gestalt Principles

- How can applying Gestalt principles improve the visualisation of the changing company profits over the years and the changing trend within each department?

	Profits in last 7 years (S$ M)		
Year	Dept A	Dept B	Dept C
2015	5.1	6.7	2.1
2016	4.7	6.8	2.3
2017	4.5	7.2	3.4
2018	3.5	4.5	2.1
2019	3.3	7.3	3.6
2020	3.2	7.3	4.5
2021	2.5	7.4	6.6

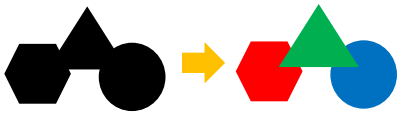
Table of each Department's Profits in the last 7 years



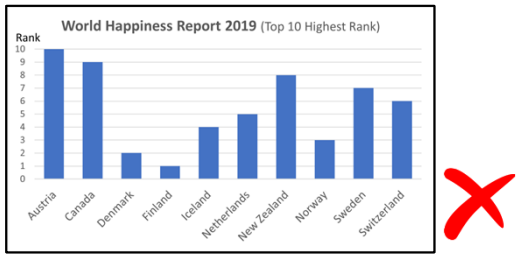
Visualisation of Company's Changing Profits

Simplicity

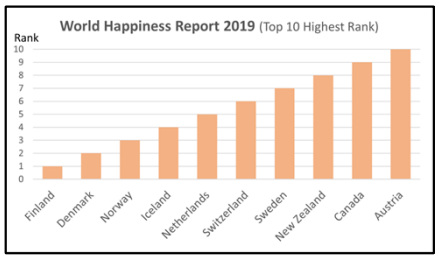
Simplicity is the Ultimate Sophistication



- Principle of simplicity states that visual elements are always perceived in the **easiest way possible**.
- **Ordering for simplicity** - visual information (e.g. values in bar charts) should be sorted and ordered (if possible) to increase its visual simplicity, thus easing interpretation.



Ordering based on category creates confusing visual



Value-based ordering improves visual simplicity of chart

Simplicity

Data-Ink Ratio

- Edward Tufte proposed the concept of **data-ink ratio** for data visualisation[3].
- This ratio measures the proportion of **ink** that is used to present **actual data** compared to the **total amount of ink** (or pixels) used in the entire visual.
- The goal in good data visualisation is to **maximise** the data-ink ratio.

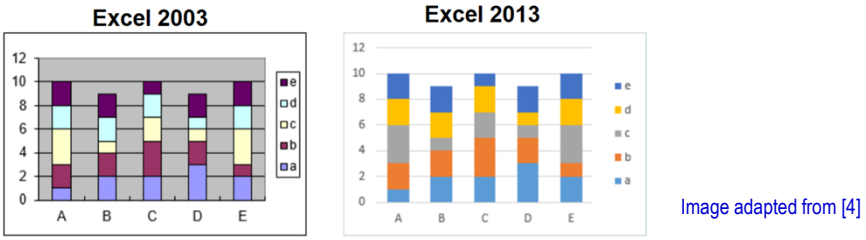


Image adapted from [4]

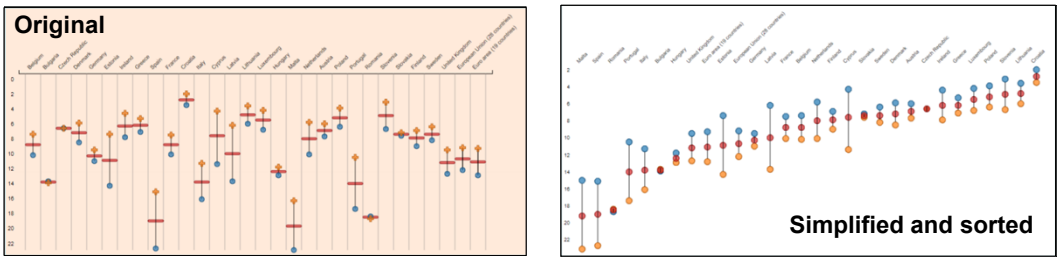
Changes to Excel charts over the years to maximise data-ink ratio

[3] Edward Tufte, The Visual Display of Quantitative Information Graphic Press, 2nd Ed (2001)
[4] Carlos Moura, Step 10 Visualisation - https://composite-indicators.jrc.ec.europa.eu/sites/default/files/COIN%202018%20Step%209%20Visualization.pdf

Simplicity

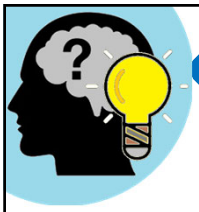
Data-Ink Ratio Maximisation

- Data-ink ratio can be maximised by considering what can be **removed** from the chart while **keeping the information** that needs to be communicated.
- Often unnecessary axes and background can remove without significantly affecting the ability to interpret the important information.



An example[4] of improving visual simplicity by maximising data-ink ratio and ordering the data

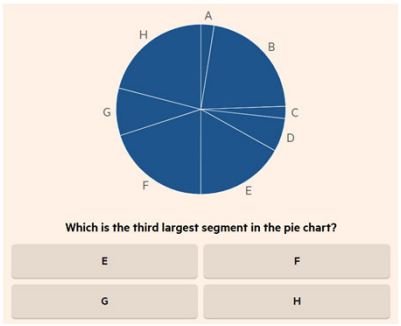
[4] Carlos Moura, Step 10 Visualisation - https://composite-indicators.jrc.ec.europa.eu/sites/default/files/COIN%202018%20Step%209%20Visualization.pdf

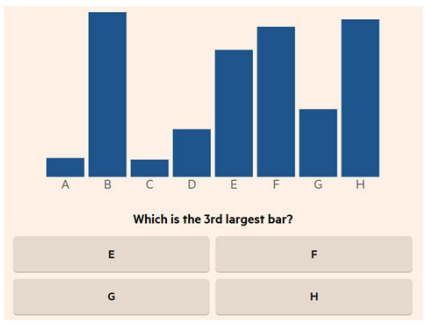


Think and Apply

Making it Easy for Others

- How would you redesign these charts to help the readers answer the quiz questions more easily?



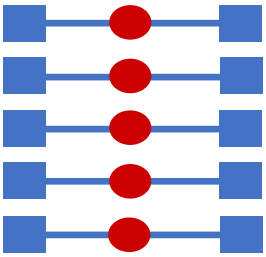


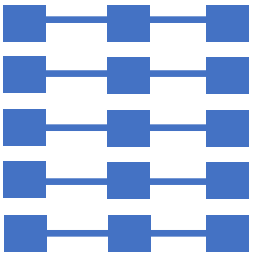
[5] Visuals for Quiz Questions taken from : https://ig.ft.com/science-of-charts/

Connectedness

Close Links Bond

- Principle of connectedness states that visual elements that are **connected** to each other are perceived as a **single unit**.

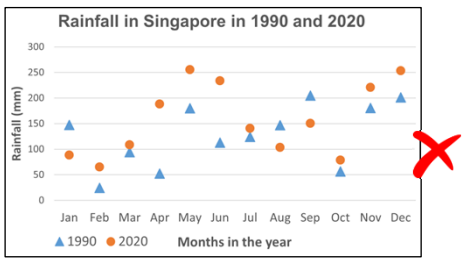


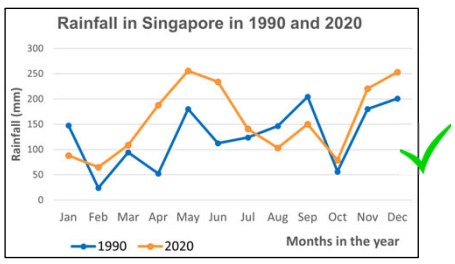


Connectedness

Close Links Bond

- Principle of connectedness states that visual elements that are **connected** to each other are perceived as a **single unit**.
- Related data points should be connected with appropriate lines to allow fast visual recognition of their grouping and allow changing trends to be readily perceived[6].





Lines in graphs create clear visual connection between related points that even similar colour and shape attributes cannot evoke.

[6] B. Wong, Gestalt Principles (Part 1), Nature Methods, Vol 7, pp. 863 (2010)), https://www.nature.com/articles/nmeth1110-863

Gestalt Principles in Data Visualisation

Continuation ……

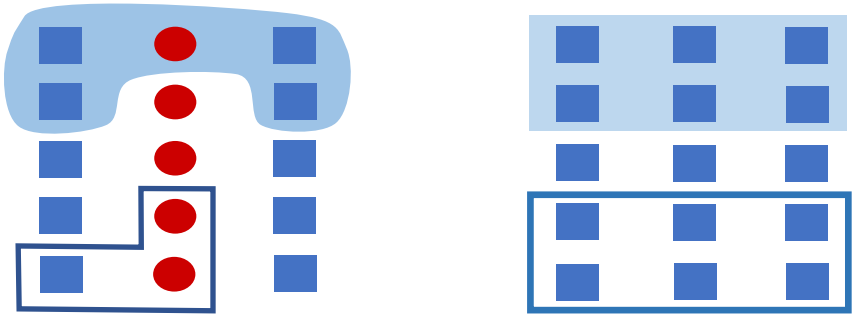
- The Gestalt principles explain the **pattern-seeking** behaviour of human visual perception and it perceive visual groupings to simplify the interpretation of visual stimuli.
- Some Gestalt principles explored last week include:

• Proximity	• Connectedness	• Symmetry
• Similarity	• Continuity	• Figure & Ground
• Simplicity	• Enclosure	

Enclosure

Feeling Boxed In

- Principle of enclosure states that visual elements are seen as belonging to a group if they are **enclosed** in a way that creates a **boundary** or **border around** them .



Enclosure

Feeling Boxed In

- Principle of enclosure states that visual elements are seen as belonging to a group if they are **enclosed** in a way that creates a **boundary** or **border around** them .

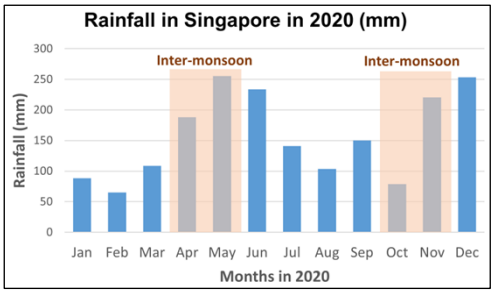
- Enclosure can be useful in organising a complex interface, like on the instrument dashboard of a 747 plane[7].
- Square and rectangular frames group similar categories of controls and display together.

[7] A. Rutledge, Gestalt Principles of Perception - 3: Proximity, Uniform Connectedness, and Good Continuation (2009) - https://www.andyrutledge.com/gestalt-principles-3.html

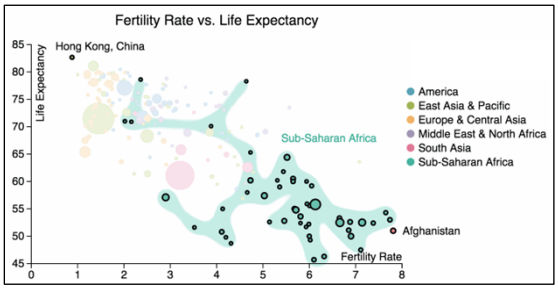
Enclosure

Feeling Boxed In

- Principle of enclosure states that visual elements are seen as belonging to a group if they are **enclosed** in a way that creates a **boundary** or **border around** them .
- Enclosure can be used to **highlight** and **group** specific data in the plot or chart.



Transparent enclosure used to highlight data points during the inter-monsoon period



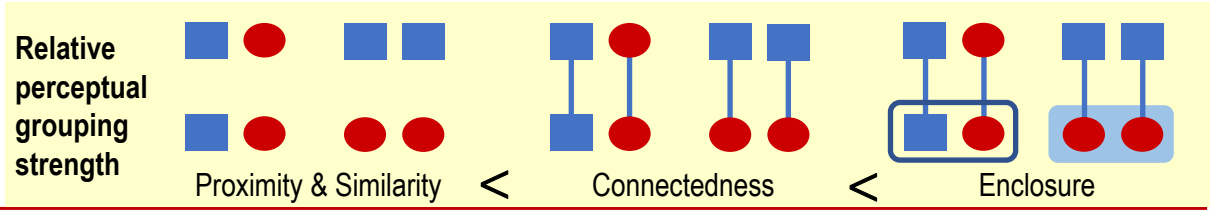
Enclosure used to group dots in scatter plot belonging to a highlighted category. Image from[8]

[8] ChartAccent, Visualisation Examples - https://chartaccent.github.io/

Enclosure

Dominant Gestalt Principles

- The relative strength each Gestalt principle exerts on perceptual grouping is not the same and there are many situations where different principles will compete to provide a different sense of visual grouping.
- Connectedness through the lines create a much stronger sense of grouping than either proximity or similarity[6].
- Grouping by enclosure resulting in elements bounded in a common region is powerful enough to overcome similarity, proximity and connection[6].

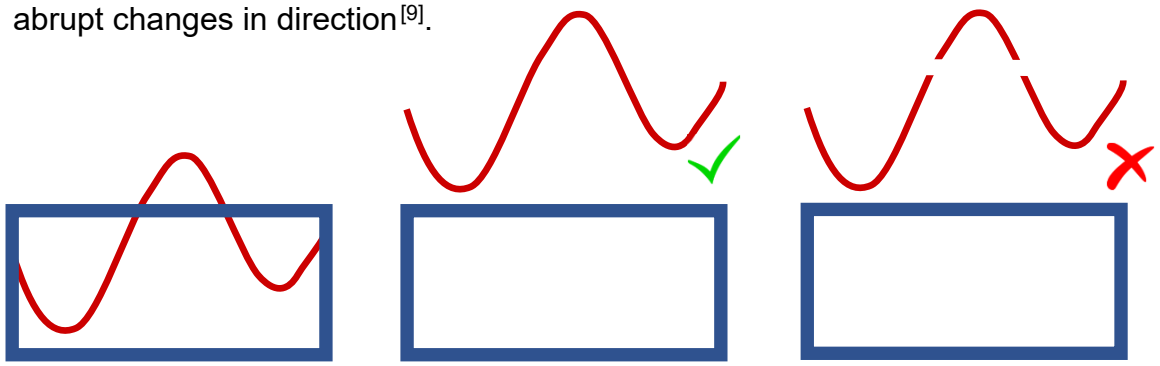


[6] B. Wong, Gestalt Principles (Part 1), Nature Methods, Vol 7, pp. 863 (2010)), https://www.nature.com/articles/nmeth1110-863

Continuity

It Cannot Change So Quickly

- Principle of continuity states that we are more likely to construct visual entities out of visual elements that are smooth and continuous, rather than ones that contain abrupt changes in direction[9].



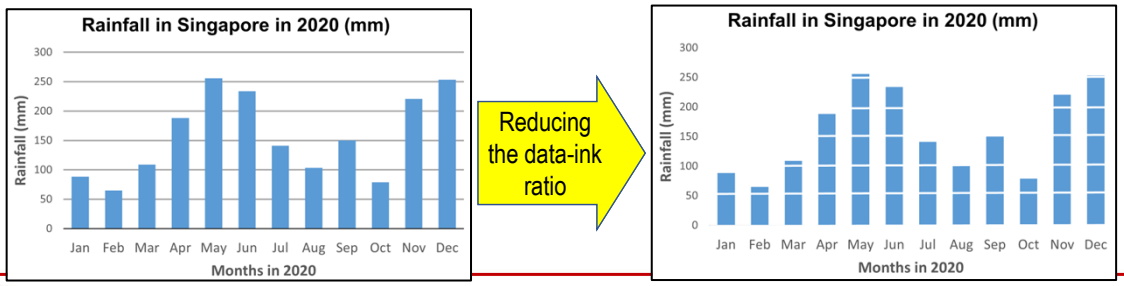
Our minds tend to perceive a line as continuous and continuing in its established direction.

[9] Colin Ware, Information Visualization, Morgan Kaufmann, 3rd Ed (2012)

Continuity

It Cannot Change So Quickly

- Principle of continuity states that we are more likely to construct visual entities out of visual elements that are smooth and continuous, rather than ones that contain abrupt changes in direction[9].
- This sense of continuity can be exploited to improve the data-ink ratio of bar charts by removing the axes and plotting the axes tick lines within the bars themselves[3].

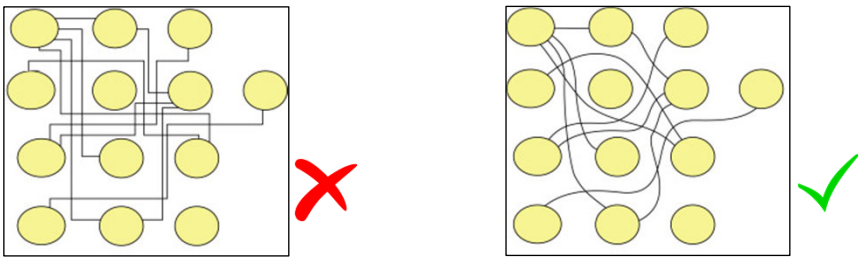


[3] Edward Tufte, The Visual Display of Quantitative Information Graphic Press, 2nd Ed (2001)

Continuity

We Follow Smooth Lines Better

- The principle of good continuity can be applied to the problem of drawing diagrams consisting of networks of **nodes** and the **links** between them.
- The human visual system finds it easier to identify the sources and destinations of **connecting lines** if they are **smooth** and **continuous**[9].



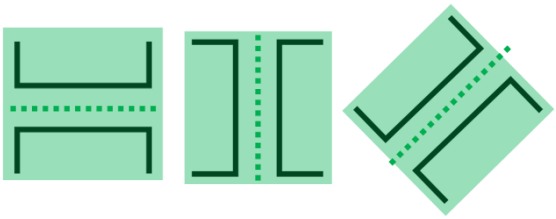
Where possible, smooth lines should be used to link nodes in a network graph

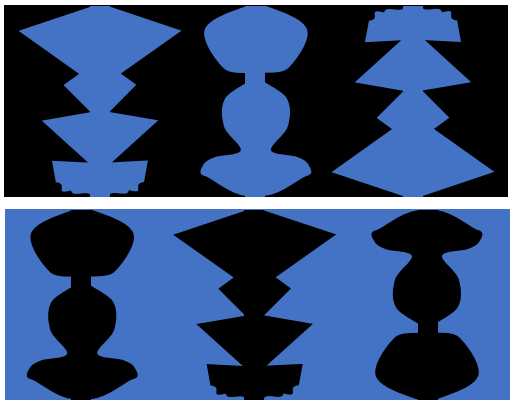
[9] Colin Ware, Information Visualization, Morgan Kaufmann, 3rd Ed (2012)

Symmetry

Seeing Both Sides

- The principle of symmetry states that visual elements that are symmetrical to each other tend to be perceived as a unified group.

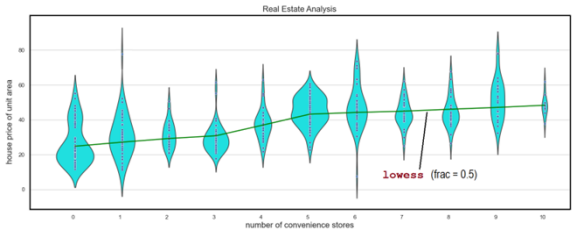




Symmetry

Seeing Both Sides

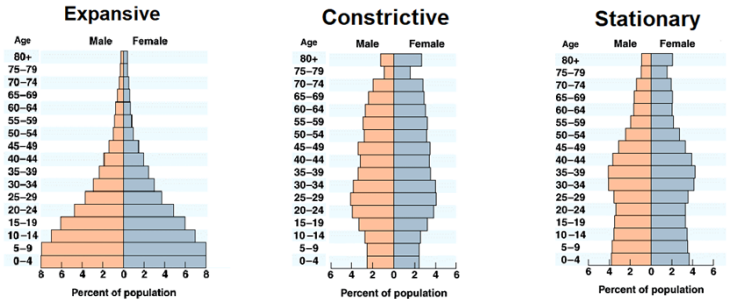
- The principle of symmetry states that visual elements that are symmetrical to each other tend to be perceived as a unified group.
- Symmetry can be exploited in **violin plots** to visualise the shape of the KDE distributions or the differences between two categories in a split violin plots.

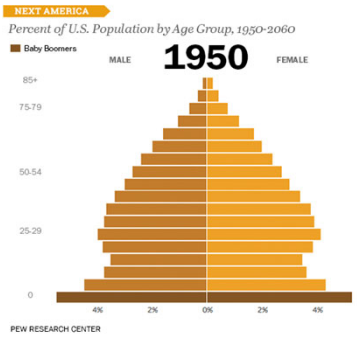


Symmetry

Population Pyramids

- These are graphs that show the distribution of ages across a population divided down the centre between the males and females in the population.
- **Expansive**, **constrictive** and **stationary** pyramids describe populations that are young & growing, elderly & shrinking and not growing respectively[10].





America's morphing age pyramid

[10] https://populationeducation.org/what-are-different-types-population-pyramids/

Figure-Ground

Standing Out from the Crowd

- The figure-ground principle states that people instinctively perceive objects as either being in the **foreground** or the **background**. They either **stand out** prominently in the front (the figure) or **recede** into the back (the ground)

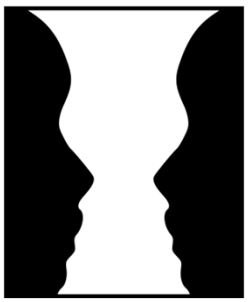


Image from Wikipedia

Image from Criminal Underworld poster series by Simon C. Page

Kiss of the Sea by Octavio Ocampo
https://www.wikiart.org/en/octavio-ocampo/kiss-of-the-sea

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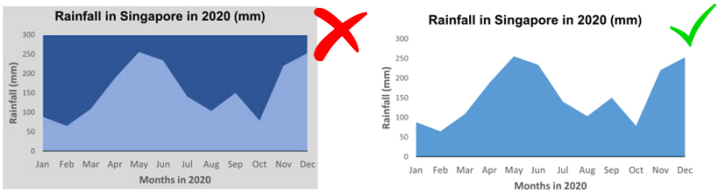
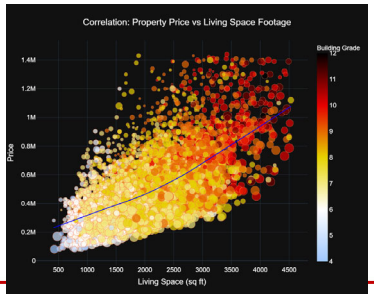
Figure-Ground

Standing Out from the Crowd

- The figure-ground principle states that people instinctively perceive objects as either being in the **foreground** or the **background**. They either **stand out** prominently in the front (the figure) or **recede** into the back (the ground)
- Information to be communicated must be made to move to the foreground by providing enough **contrast** between the foreground and background to make charts and graphs more legible and distinctive.



Use strong contrast to make foreground chart stand out from background



Good contrast Image from [11]

[11] E.V. Kazakova, The Psychology behind Data Visualization Techniques (2021)- https://towardsdatascience.com/the-psychology-behind-data-visualization-techniques-68ef12865720

Summary

Gestalt Principles in Data Visualisation

- Understanding how the human visual system constantly seeks out visual **patterns**, **groupings** and **meaningful interpretation** can help us design more **accessible** visualisation.
- **Proximity**, **similarity**, **connectedness** and **continuity** help us **quickly associate** related visual elements.
- **Simplicity** and **symmetry** facilitate the exploration and **identification** of **visual patterns**.
- **Enclosure** and good **figure-ground** separation helps **highlight** what is important to **focus on**.

References for Visual Encoding

[1] Vidya Kesavan, Gestalt Laws Applied to Data Visualization (2018) – https://medium.com/@vidya83.kesavan/gestalt-laws-applied-to-data-visualization-1e18385b7b00

[2] William Craig, How to Make Data Visualization Better with Gestalt Laws, https://www.webfx.com/blog/web-design/data-visualization-gestalt-laws/

[3] Edward Tufte, The Visual Display of Quantitative Information Graphic Press, 2nd Ed (2001)

[4] Carlos Moura, Step 10 Visualisation - https://composite-indicators.jrc.ec.europa.eu/sites/default/files/COIN%202018%20Step%209%20Visualization.pdf

[5] Visuals for Quiz Questions taken from : https://ig.ft.com/science-of-charts/

[6] B. Wong, Gestalt Principles (Part 1), Nature Methods, Vol 7, pp. 863 (2010)), https://www.nature.com/articles/nmeth1110-863

[7] A. Rutledge, Gestalt Principles of Perception - 3: Proximity, Uniform Connectedness, and Good Continuation (2009) – https://www.andyrutledge.com/gestalt-principles-3.html

[8] ChartAccent, Visualisation Examples - https://chartaccent.github.io/

[9] Colin Ware, Information Visualization, Morgan Kaufmann, 3rd Ed (2012)

[10] https://populationeducation.org/what-are-different-types-population-pyramids/

[11] E.V. Kazakova, The Psychology behind Data Visualization Techniques (2021) – https://towardsdatascience.com/the-psychology-behind-data-visualization-techniques-68ef12865720

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Note: All online articles were accessed between May to June 2021