Week 3: Data Visualisation

LSE MY472: Data for Data Scientists
https://lse-my472.github.io/

Autumn Term 2024

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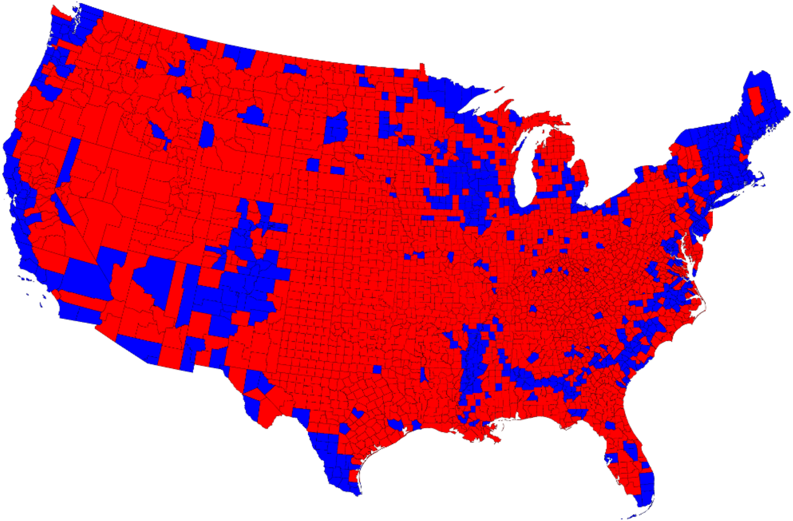
Why visualisation can be helpful: Anscombe examples

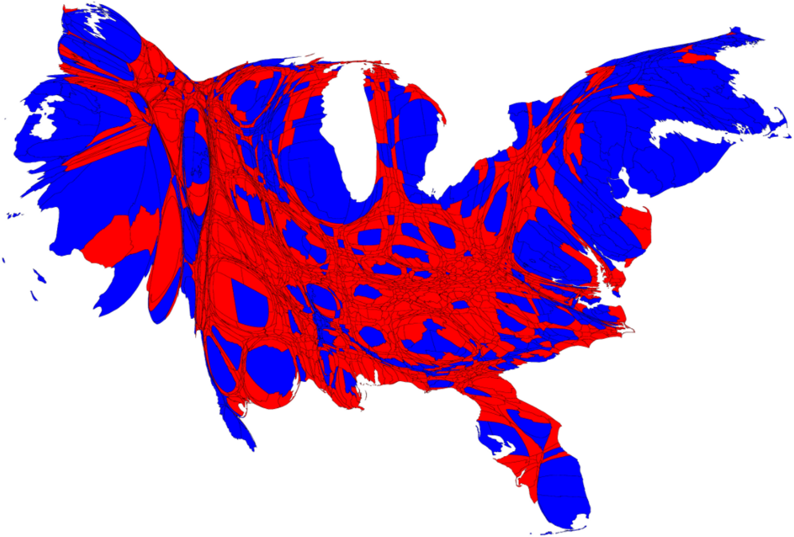
`01-anscombe.Rmd`

2012 US election



Source: Mark Newman (Michigan)

2012 US election



Source: Mark Newman (Michigan)

Plan for today

- Some principles of data visualisation
- Grammar of graphics and `ggplot`
- Coding

Some principles of data visualisation

Principles by Edward Tufte

- Show the data
- Avoid distorting what the data have to say
- Allow viewer to compare
- Serve a clear purpose: description, exploration, tabulation or decoration
- Be closely integrated with the statistical and verbal descriptions of the dataset
- Graphics can reveal data (e.g. Anscombe Quartet)

General guidelines

- Maximize data-to-ink ratio
- Avoid misleading decisions
  - Y axis starts at 0
  - Comparison of areas is hard
  - Use comparable units
  - Erase chart junk
- Use text to inform and contextualise. Add annotations
- Appropriate use of scales (x/y axes, color, size, shape. . .)
- Use small multiples to facilitate comparisons
- Always cite sources

Grammar of graphics and `ggplot`

A grammar for visualization?

- Linguistic grammar provides structure to words that help us convey more complex meaning (information)
- Leland Wilkinson (1999) argued graphics also have a deep structure–a “grammar”–that:
  - “Take us beyond a limited set of charts (words) to an almost unlimited world of graphical forms (statements)” (p.1).
- By combining various “aesthetics” we can reliably make meaningful *visual* representations of data

Fast forward a decade:

> ***The grammar of graphics.***
> *A statistical graph is a mapping from data to aesthetic attributes (color, shape, size) of geometric objects (points, lines, bars). The plot may also contain statistical transformations of the data and is drawn on a specific coordinate system. Faceting can be used to generate the same plot for different subsets of the data. It is the combination of these independent components that make up a graphic.*
> *Hadley Wickham, ggplot2, page 3*

➜ Layered version of Wilkinson's framework introduced as R package `ggplot2`

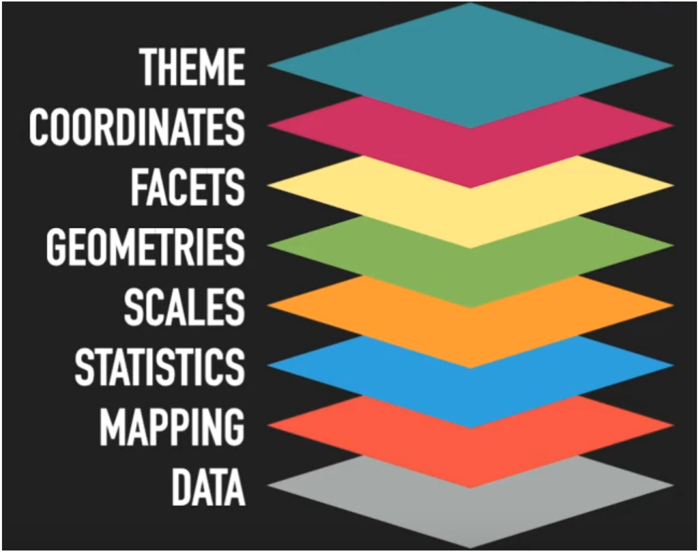
➜ Similar implementation in `plotnine` for Python

Data visualisation with `ggplot2`

Why `ggplot2`?

- ➜ Consistent, modular, and very flexible
- ➜ Sensible defaults for quick exploratory plots
- ➜ But also easy to customize and extend
- ➜ Excellent online resources

The grammar



Source: Thomas Lin Pedersen (https://youtu.be/h29g21z0a68)

Grammar

- **data**: Data to visualise, for `ggplot2` in a `tidy` format
- **(aesthetic) mapping**: Linking variables in the data to components of the graphic
- **stats**: Statistical transformations of the data, e.g. binning or averaging
- **scales**: Translation between variable ranges and graphical properties, e.g. linking values to colours/shapes
- **geom**: Geometric objects that are drawn to represent the data: bars, lines, points, etc. (plots can have multiple geometries)
- **facets**: Breaking up the data into subsets e.g. to be displayed independently on a grid
- **coordinates**: Coordinate system that e.g. provides axes and gridlines
- **theme**: Parts that do not follow from the data: Background colours, fonts, etc.

Layer = Data + Mapping + Statistics + Geom + Position

A layer contains (some) visual information we see on the graphic:

- ➜ Without **data**, we have an empty plot!
- ➜ **Mapping** links variables in the data to visual properties
- ➜ **Statistics** allows us to transform our input data
- ➜ A **geom** controls the type of plotting object
- ➜ A **position adjustment** allows us to, .e.g., prevent perfectly overlapping points

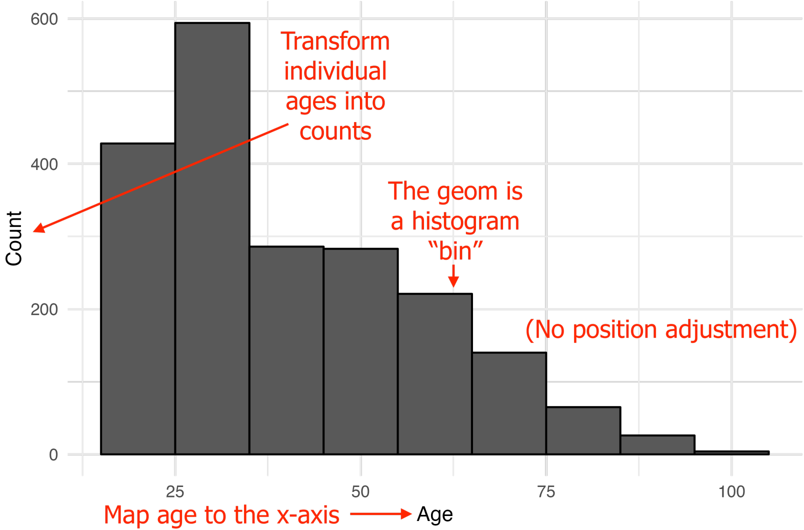
Example: distribution of age

Consider subject-level information about age:

```
#>  age
#> 1 20
#> 2 56
#> 3 40
#> 4 21
#> 5 38
#> 6 39
#> ...
```

How could we summarise this information visually?

Example: distribution of age



Transform individual ages into counts

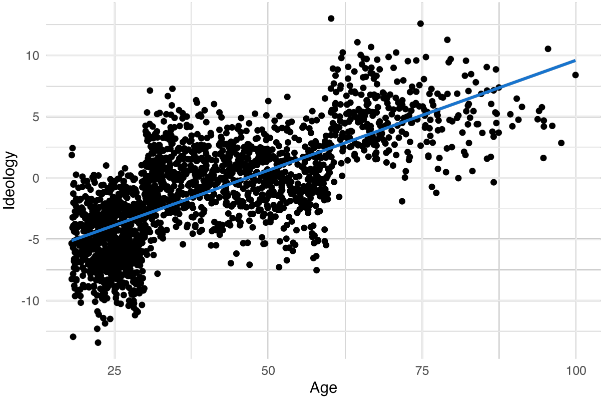
The geom is a histogram "bin"

(No position adjustment)

Map age to the x-axis

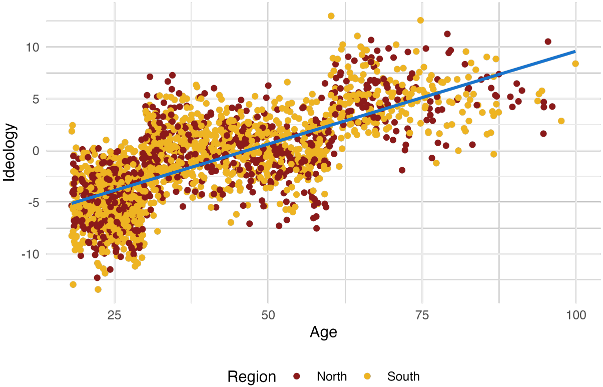
Layering

- Since layers are contained, we can overlay multiple layers at once
- This strategy is very common
  - A scatterplot + line of best fit
  - Coefficient estimates (points) + confidence intervals (errorbars)

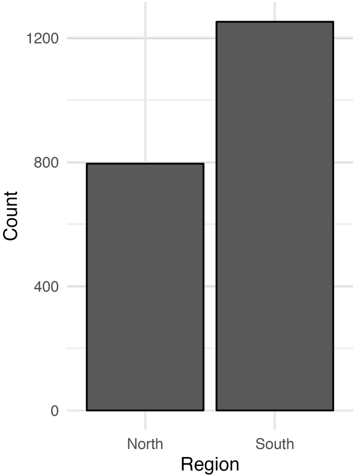


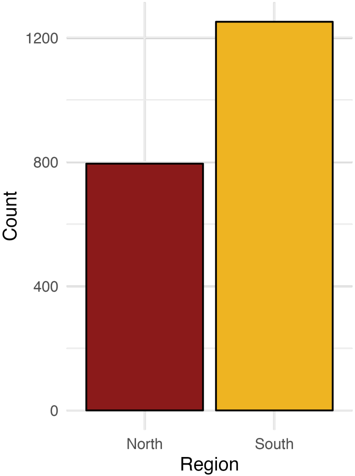
Scales

- Scales "translate" data ranges to property ranges
  - Map continuous numeric data to a color spectrum
  - Translate categorical data to different shapes
  - Map the size of a geom to some value (e.g. frequency)
  - Etc.
- Scales modify the geom object(s)



Which do you prefer?





Redundant scales

In the previous slide:

- Colouring the bars by region adds **no** new information
- We call this **redundancy**
  - When two (or more) scales translate the *same* variable to different aesthetics
- Redundancy can overly complicate plots...
- ... but can also add clarity

Facets and coordinates

Facets allow you to create **multiple** plots by mapping subsets of your data

- E.g. Plotting separate histograms by respondent's country of origin
- When you facet by a single variable we use a *wrap*
- When we facet by two (or more) variables, we use a *grid*

Coordinate systems "map the position of objects onto the plane of the plot" (Wickham 2010, p.13)

- In almost all cases we use **Cartesian coordinates**
  - Two orthogonal dimension (x, y)
- Alternative systems exist, like polar coordinates:
  - Allow you to draw circular distributions like pie-charts (eww!)

Why should we abide by the grammar of graphics?

- The system is very flexible
- Allows us to describe how to go from data to visuals
- Reduces the complexity and verbosity of graph construction
- Forces you to think about *what* information you want to convey

Online resources

- Main documentation page: https://ggplot2.tidyverse.org/
- Book by Hadley Wickham, Danielle Navarro, and Thomas Lin Pedersen: https://ggplot2-book.org/
- R Graph gallery for `ggplot2` https://www.r-graph-gallery.com/ggplot2-package.html
- Two recent video workshops by Thomas Lin Pedersen, video 1, video 2, and the repo with associated exercises
- StackOverflow, tag: `ggplot2` https://stackoverflow.com/questions/tagged/ggplot2

Coding

Coding

- `02-ggplot-walkthrough.Rmd`

For your reference:

- `03a-ggplot2-basics.Rmd`
- `03b-scales-axes-legends.Rmd`