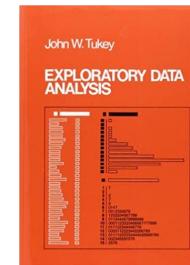




Data visualisation

66

*The greatest value of a picture
is when it forces us to notice
what we never expected to see.
-- John W. Tukey*

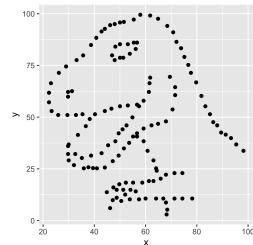


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numbers vs plots

dino

```
#> # A tibble: 142 x 2
#>   x     y
#>   <dbl> <dbl>
#> 1 55.4  97.2
#> 2 51.5  96.0
#> 3 46.2  94.5
#> 4 42.8  91.4
#> 5 40.8  88.3
#> 6 38.7  84.9
#> # ... with 136 more rows
```



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numbers vs plots

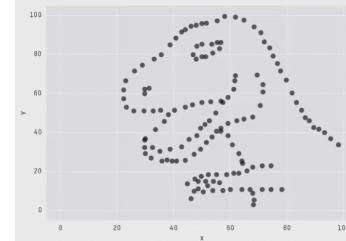


image credit: Steph Locke

X Mean: 54.2659224
Y Mean: 47.8313999
X SD : 16.7649829
Y SD : 26.9342120
Corr. : -0.0642526

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Why data visualisation? 📊

“

A picture is worth a thousand words. -- Henrik Ibsen

1. Data visualisation communicates information much quicker than numerical tables.
2. Data visualisation can reveal unexpected structures in data; it is not surprising that data visualisation is one of the key tools in exploratory data analysis.
3. Data plot is usually more eye-catching even if you lose accuracy of the information.

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Charts 📈 Graphics

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A toy example

```
sci_tbl  
  
#> # A tibble: 4 × 2  
#>   dept      count  
#>   <chr>     <int>  
#> 1 Physics      12  
#> 2 Mathematics    8  
#> 3 Statistics    20  
#> 4 Computer Science 23
```

➤ dept: discrete/categorical
➤ count: quantitative/numeric

What types of plots can we make?

1. bar plot for counts
2. pie chart for proportions

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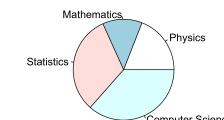
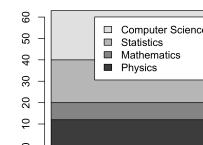
Named charts

➤ Bar plot

```
barplot(as.matrix(sci_tbl$count),  
       legend = sci_tbl$dept)
```

➤ Pie chart

```
pie(sci_tbl$count,  
    labels = sci_tbl$dept)
```



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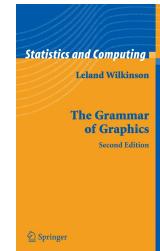
Seems convenient, but ...

- ✗ a limited set of named charts
- ✗ single purpose functions
- ✗ inconsistent inputs

```
barplot(as.matrix(sci_tbl$count),  
       legend = sci_tbl$dept)
```

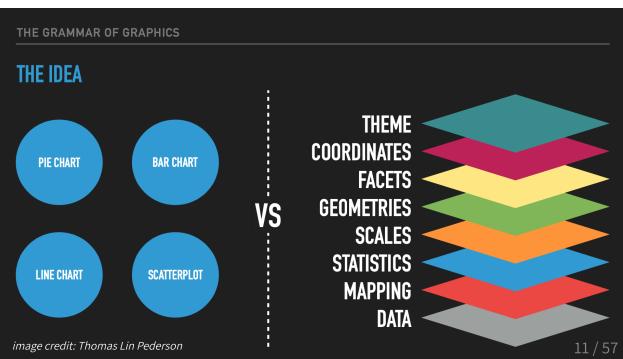
```
pie(sci_tbl$count,  
    labels = sci_tbl$dept)
```

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Grammar makes language expressive. A language consisting of words and no grammar (statement = word) expresses only as many ideas as there are words. By specifying how words are combined in statements, a grammar expands a language's scope.

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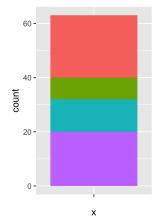


The *grammar of graphics* takes us beyond a limited set of **charts (words)** to an almost unlimited world of **graphical forms (statements)**.

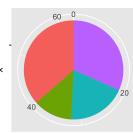
{ggplot2} provides a cohesive system for declaratively creating elegant graphics, based on The Grammar of Graphics.

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```
library(ggplot2)
ggplot(data = sci_tbl) +
  geom_bar(
    aes(x = "", y = count, fill = dept),
    stat = "identity"
  )
```



```
ggplot(data = sci_tbl) +
  geom_bar(
    aes(x = "", y = count, fill = dept),
    stat = "identity"
  ) +
  coord_polar(theta = "y")
```



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A graphing template

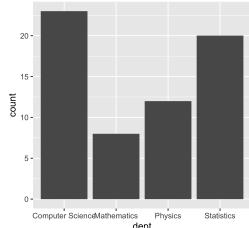
```
ggplot(data = <DATA>, mapping = aes(<MAPPINGS>)) +
  layer(geom = <GEOM>, stat = <STAT>, position = <POSITION>) +
  layer(geom = <GEOM>, stat = <STAT>, position = <POSITION>)
```

1. **data:** tibble/data.frame.
2. **mapping:** aesthetic mappings between data variables and visual elements, via `aes()`.
3. **layer ():** a graphical layer is a combination of data, stat and geom with a potential position adjustment.
 - **geom:** geometric elements to render each data observation.
 - **stat:** statistical transformations applied to the data prior to plotting.
 - **position:** position adjustment, such as "identity", "stack", "dodge" etc.

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Layers: a bar chart

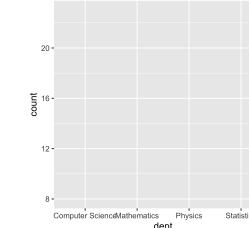
```
ggplot(data = sci_tbl, mapping = aes(x = dept, y = count)) +
  layer(geom = "bar", stat = "identity", position = "identity")
```



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Aesthetic mapping: positional

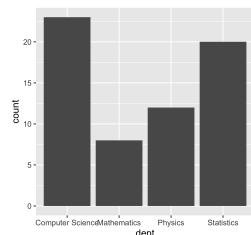
```
p <- ggplot(sci_tbl, aes(x = dept, y = count))
```



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Geoms (a shorthand to layer())

```
p +  
  geom_bar(stat = "identity")
```



```
p +  
  geom_col()
```

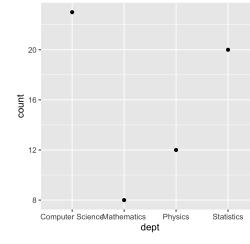
- `stat = "identity"` leaves data as is.
- `geom_col()` is a shortcut to `geom_bar(stat = "identity")`.

Generally, we use `geom_*`() instead of `layer()` in practice.

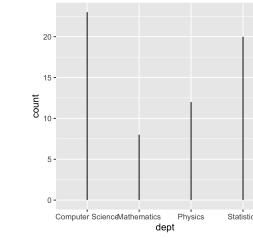
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Geoms

```
p +  
  geom_point()
```



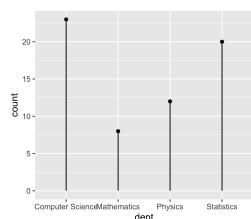
```
p +  
  geom_segment(aes(xend = dept, y = 0, yend = count))
```



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Composite geoms: lollipop 🍬 = points + segments

```
p +  
  geom_point() +  
  geom_segment(aes(xend = dept, y = 0, yend = count))
```



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Geom catalogue

geom

`geom_abline`, `geom_hline`,
`geom_vline`

Reference lines: horizontal, vertical, and diagonal

`geom_bar`, `geom_col`

Bar charts

`geom_bin2d`

Heatmap of 2d bin counts

`geom_blank`

Draw nothing

`geom_boxplot`

A box and whiskers plot (in the style of Tukey)

Previous 1 2 3 4 5 6 7 Next

source code: Emi Tanaka

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Stats

» Aggregated (pre-computed)

```
sci_tbl  
#> # A tibble: 4 x 2  
#>   dept      count  
#>   <chr>     <int>  
#> 1 Physics      12  
#> 2 Mathematics    8  
#> 3 Statistics     20  
#> 4 Computer Science 23  
#> # ... with 57 more rows
```

» Disaggregated

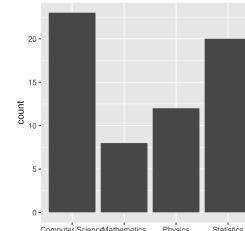
```
sci_tbl0
```

```
#> # A tibble: 63 x 1  
#>   dept  
#>   <chr>  
#> 1 Physics  
#> 2 Mathematics  
#> 3 Statistics  
#> 4 Computer Science  
#> 5 Physics  
#> 6 Mathematics  
#> 7 Statistics  
#> 8 Physics  
#> 9 Mathematics  
#> 10 Statistics  
#> 11 Physics  
#> 12 Mathematics  
#> 13 Statistics  
#> 14 Physics  
#> 15 Mathematics  
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#> 56 Physics  
#> 57 Mathematics  
#> 58 Statistics  
#> 59 Physics  
#> 60 Mathematics  
#> 61 Statistics  
#> 62 Physics  
#> 63 Mathematics  
#> 64 Statistics
```

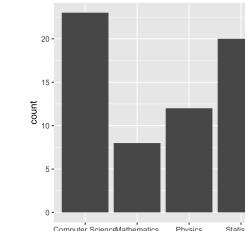
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Stats

```
ggplot(sci_tbl, aes(x = dept, y = count)) +  
  geom_bar(stat = "identity")
```



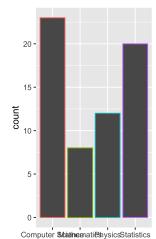
```
ggplot(sci_tbl0, aes(x = dept)) +  
  geom_bar(stat = "count")
```



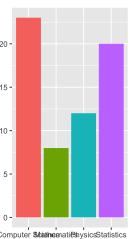
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Aesthetic mapping: visual

```
p +  
  geom_col(aes(colour = dept))
```



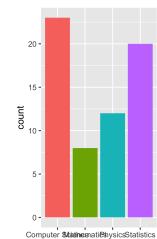
```
p +  
  geom_col(aes(fill = dept))
```



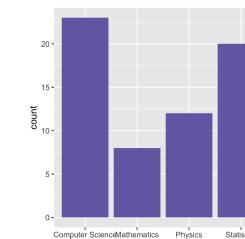
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Mapping variables / Setting constants

```
p +  
  geom_col(aes(fill = dept))
```



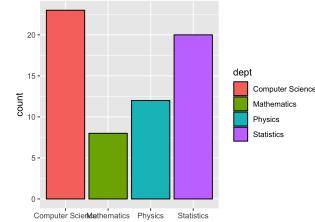
```
p +  
  geom_col(fill = "#756bb1")
```



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Mapping variables + Setting constants

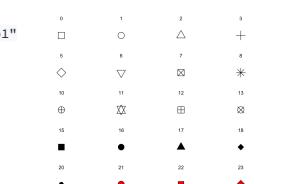
```
p +
  geom_col(aes(fill = dept), colour = "#000000")
```



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Visual aesthetics

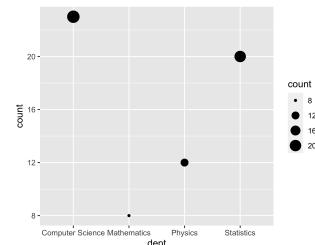
- colour/color, fill:
 - named colours, e.g. "red"
 - RGB specification, e.g. "#756bb1"
- alpha: opacity between 0 and 1
- shape:
 - an integer between 0 and 25
 - a single string, e.g. "triangle open"
- linetype:
 - an integer between 0 and 6
 - a single string, e.g. "dashed"
- size, radius: a numerical value (in millimetres)



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Your turn

Describe a bubble chart in terms of grammar of graphics.

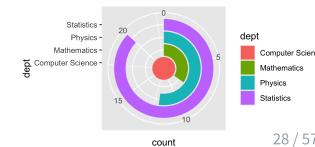


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Coords

- Coordinate systems
 - coord_cartesian() (default)
 - coord_flip() (deprecated; now you can simply swap x and y)
 - coord_map()
 - coord_polar()

```
p +
  geom_col(aes(fill = dept)) +
  coord_polar(theta = "y")
```



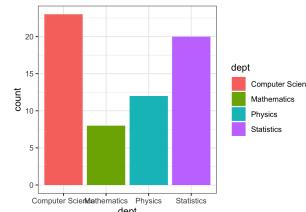
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Themes: modify the look

Built-in ggplot themes

- » `theme_gray()`/`theme_gray()`
- » `theme_bw()`, `theme_linedraw()`
- » `theme_light()`, `theme_dark()`
- » `theme_minimal()`,
- `theme_classic()`
- » `theme_void()`

```
p +
  geom_col(aes(fill = dept)) +
  theme_bw()
```



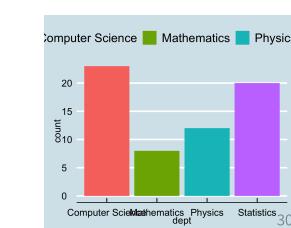
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Themes: modify the look

Many R packages provide themes.

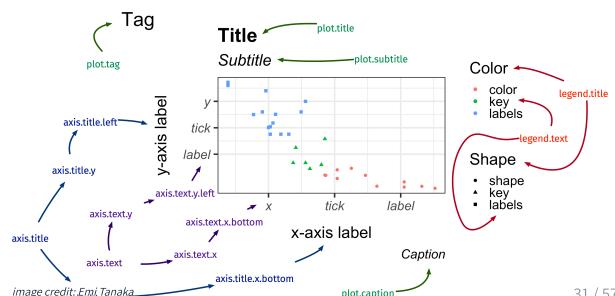
- » `(ggthemes)`
- » `(gghthemr)`
- » `(hrbthemes)`
- » `(ggtech)`

```
library(ggthemes)
p +
  geom_col(aes(fill = dept)) +
  theme_economist()
```



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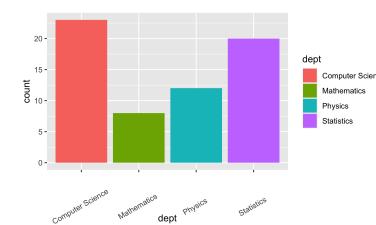
Modify the look of texts with `element_text()`



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Modify the look of texts with `element_text()`

```
p +
  geom_col(aes(fill = dept)) +
  theme(axis.text.x = element_text(angle = 30, vjust = 0.1))
```



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Modify the look of *lines* with element_line()

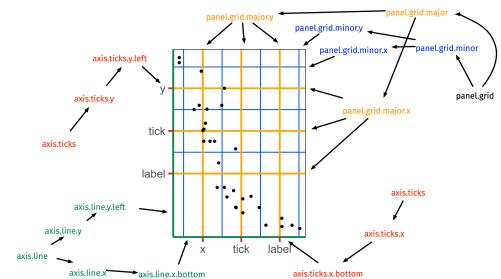


image credit: Emi Tanaka

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Modify the look of *regions* with element_rect()

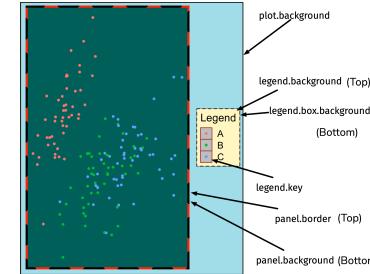


image credit: Emi Tanaka

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Small multiples (or trellis/faceting plots)

💡 the idea of conditioning on the values taken on by one or more of the variables in a data set

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Facets

mpg data available from {ggplot2}

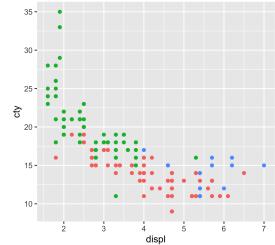
mpg

```
#> # A tibble: 234 x 11
#>   manufacturer model displ year cyl trans drv cty hwy fl class
#>   <chr>        <chr>  <dbl> <int> <chr>  <chr> <int>
#> 1 audi         a4      1.8  1999   4 auto(l5) f     18
#> 2 audi         a4      1.8  1999   4 manual(m_ f     21
#> 3 audi         a4      2    2008   4 manual(m_ f     20
#> 4 audi         a4      2    2008   4 auto(av) f     21
#> 5 audi         a4      2.8  1999   6 auto(l5) f     16
#> 6 audi         a4      2.8  1999   6 manual(m_ f     18
#> # ... with 228 more rows, and 3 more variables: hwy <int>,
#> #   fl <chr>, class <chr>
```

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Facets

```
p_mpg <- ggplot(mpg, aes(displ, cty)) +  
  geom_point(aes(colour = drv))  
p_mpg
```

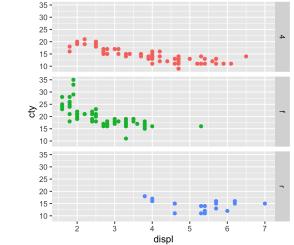


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Facets

- `facet_grid()`

```
p_mpg +  
  facet_grid(rows = vars(drv))  
# facet_grid(~drv)
```

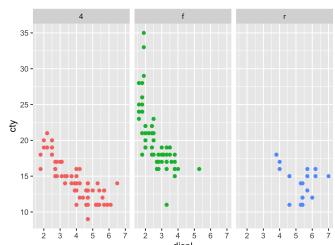


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Facets

- `facet_grid()`

```
p_mpg +  
  facet_grid(cols = vars(drv))  
# facet_grid(drv ~ .)
```

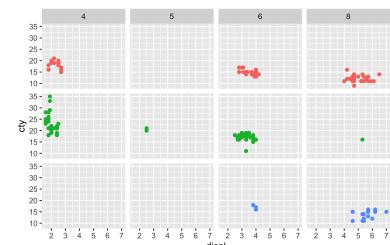


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Facets

- `facet_grid()`

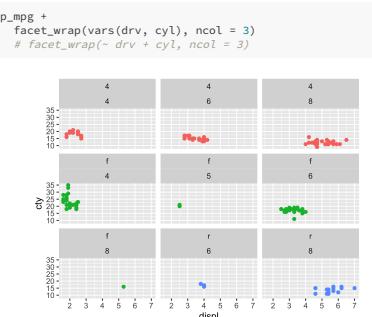
```
p_mpg +  
  facet_grid(rows = vars(drv), cols = vars(cyl))  
# facet_grid(cyl ~ drv)
```



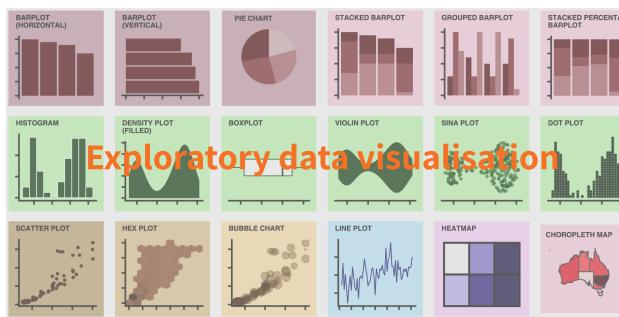
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Facets

- `facet_grid()`
- `facet_wrap()`



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Exploratory data visualisation

Yumi Tanaka

case study

```
#> # A tibble: 3,201 x 16
#>   Title          US_Gross Worldwide_Gross US_DVD_Sales
#>   <chr>         <int>           <dbl>           <int>
#> 1 The Land Girls 146083            146083            146083
#> 2 First Love, Last Ri... 10876            10876            10876
#> 3 I Married a Strange... 203134            203134            203134
#> 4 Let's Talk About Sex 373615            373615            373615
#> 5 Slam             1009819           1087521           1087521
#> 6 Mississippi Mermaid 24551            2624551            2624551
#> # ... with 3,195 more rows, and 12 more variables:
#> #   Production_Budget <int>, Release_Date <chr>,
#> #   MPAA_Rating <chr>, Running_Time_min <int>,
#> #   Distributor <chr>, Source <chr>, Major_Genre <chr>,
#> #   Creative_Type <chr>, Director <chr>,
#> #   Rotten_Tomatoes_Rating <int>, IMDB_Rating <dbl>,
#> #   IMDB_Votes <int>
```

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case study

- import

- skin

```

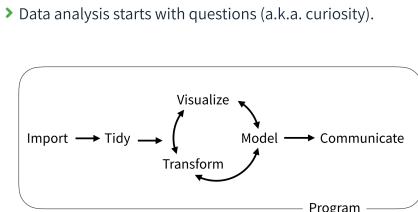
skimr:::skim(movies)

#> Data Summary -----
#> #> Name          movies
#> #> Number of rows 3201
#> #> Number of columns 16
#> #> Column type frequency:
#> #>   character      8
#> #>   numeric        8
#> #>
#> #> Group variables None
#>
#> Variable type: character
#> #>   skim_variable n_missing complete_rate min max    empty n_unique whitespace
#> #>  1 Release_date       1           1.00     1  66    0 3176      0
#> #>  2 Release_date       7           0.998    8  11    0 1603      0
#> #>  3 MPAA_Rating       605          0.811    1  9     0    7      0
#> #>  4 Distributor       232           0.928    3  33    0 174      0
#> #>  5 Source          365           0.866    6  29    0 18      0
#> #>  6 Major_Genre       275           0.914    5  19    0 12      0
#> #>  7 Creative_Type     446           0.863    7  23    0 9       0
#> #>  8 Director         1331          0.984    7  27    0 559      0
#>
#> Variable type: numeric
#> #>   skim_variable n_missing complete_rate mean sd
#> #>  1 US_Gross          0           0.998 44902085. 62555311. 44 / 5
#> #>  2 Worldwide_Gross     7           0.998 85343400. 149947343. 0

```

case study

- import
- skim
- vis



➤ Data analysis starts with questions (a.k.a. curiosity).

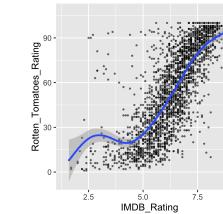
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case study

- import
- skim
- vis

② Are movies ratings consistent b/t IMDB & Rotten Tomatoes

```
ggplot(movies, aes(x = IMDB_Rating, y = Rotten_Tomatoes_Rating)) +  
  geom_point(size = 0.5, alpha = 0.5) +  
  geom_smooth(method = "gam") +  
  theme(aspect.ratio = 1)
```



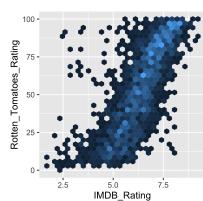
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case study

- import
- skim
- vis

② Are movies ratings consistent b/t IMDB & Rotten Tomatoes

```
ggplot(movies, aes(x = IMDB_Rating, y = Rotten_Tomatoes_Rating)) +  
  geom_hex() +  
  theme(aspect.ratio = 1)
```



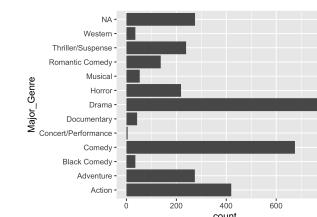
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case study

- import
- skim
- vis

② The popularity of major genre

```
ggplot(movies, aes(y = Major_Genre)) +  
  geom_bar()
```



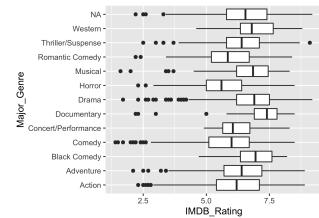
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case study

- import
- skim
- vis

② The likeness of major genre

```
ggplot(movies) +  
  geom_boxplot(aes(x = IMDB_Rating, y = Major_Genre))
```



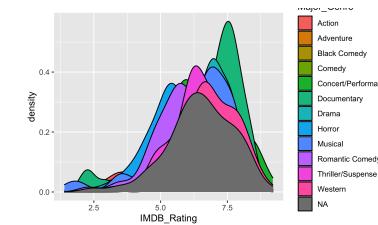
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case study

- import
- skim
- vis

② The likeness of major genre

```
ggplot(movies) +  
  geom_density(aes(x = IMDB_Rating, fill = Major_Genre))
```

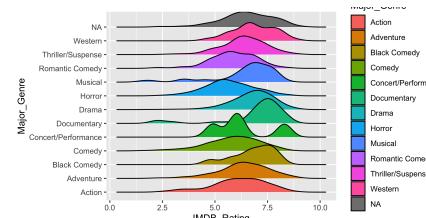


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case study

- import
- skim
- vis

```
library(agridges)  
ggplot(movies, aes(x = IMDB_Rating, y = Major_Genre)) +  
  geom_density_ridges(aes(fill = Major_Genre))
```



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{ggplot2}-ext

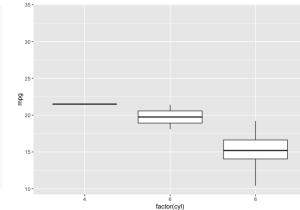
{ggplot2} now has an official extension mechanism. This means that others can now easily create their own stats, geoms and positions, and provide them in other packages. This should allow the ggplot2 community to flourish, even as less development work happens in ggplot2 itself.

 <https://exts.ggplot2.tidyverse.org/gallery/>

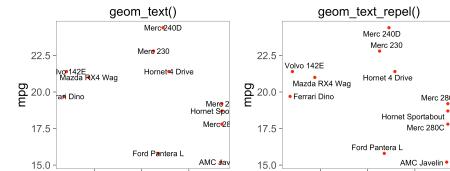
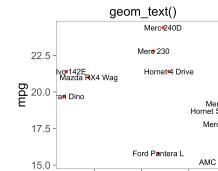
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```
library(gganimate)
ggplot(mtcars, aes(factor(cyl), mpg)) +
  geom_boxplot() +
  # Here comes the gganimate code
  transition_states(
    gear,
    transition_length = 2,
    state_length = 1
  ) +
  enter_fade() +
  exit_shrink() +
  ease_aes("sine-in-out")
```

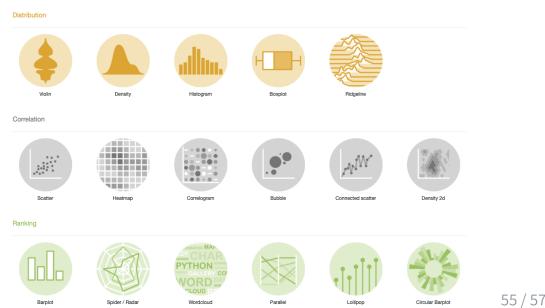


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The R Graph Gallery



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To be continued

...

John Burn-Murdoch @jburnmurdoch

NEW: the Thursday 19 March update of our coronavirus mortality trajectories tracker

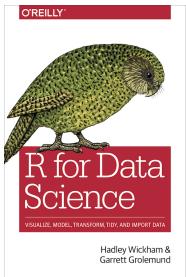
- Italy now has more Covid-19 deaths than China's total
- UK remains on a steeper mortality curve than Italy, while Britain remains far from lockdown

Live version here: ft.com/content/a26fbf...

8:34 AM - Mar 20, 2020

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Reading



- [Data visualisation](#)
- [\[ggplot2\] cheatsheet](#)