ggplot2

Much funnier if you speak Mandarin

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Motivation

What is `ggplot2`?

- `ggplot` philosophy
- Simple plots
- Useful techniques
- More complicated plots

What is `ggplot2`?

- Updated version of `ggplot` (older `R` package)
- Implementation of Wilkinson's *grammar of graphics*
- Elements: data, transformations, elements, scale, guide, coordinates
- Describes a layered approach to building graphics beyond formulaic plots (e.g. "boxplot", "scatterplot")
- Zillions of different extensions available here

Philosophy:

- Data input centered around around `data frames`
- Data display centered around `geoms` (geometric objects)
- Columns from data frames are `mapped` into geoms using `aesthetics`
- geoms are displayed according to `themes`

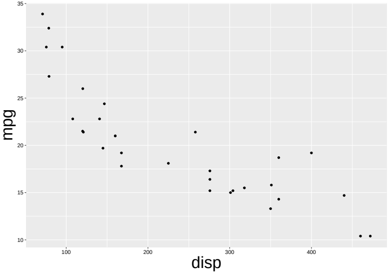
Simple example - scatterplot

```r
data(mtcars) # mtcars dataset (built into R)
head(mtcars,5) # Show first 5 rows
```

```
##                    mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
```

```r
# Load ggplot library
library(ggplot2)

# Top line of code says:
# - data from mtcars dataframe
# - aes = aesthetics from dataframe
# - map disp to x-axis, mpg to y-axis
ggplot(data = mtcars, aes(x = disp, y = mpg))+
  geom_point() # Display data using points
```

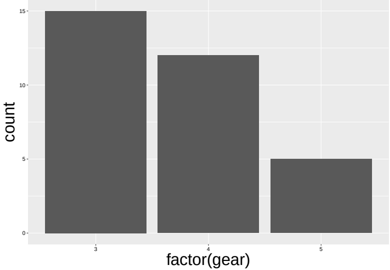


Simple example - bar plot

```r
data(mtcars) # mtcars dataset (built into R)
head(mtcars,5) # Show first 5 rows
```

```
##                    mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
```

```r
# Top line of code says:
# - map gear (number of gears as a factor) to x-axis
ggplot(data = mtcars, aes(x = factor(gear)))+
  geom_bar()
# Display number of data points for each factor level
# Automatically uses stat='count' to group all factors
```

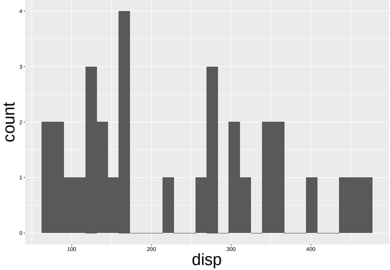


Simple example - histogram

```
data(mtcars) # mtcars dataset (built into R)
head(mtcars,5) # Show first 5 rows
```

```
##                    mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
```

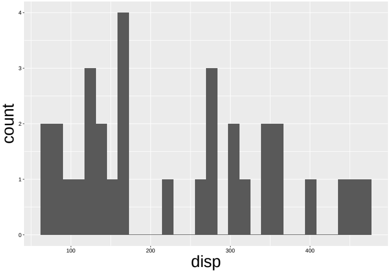
```
# Top line of code says:
# - map disp (displacement) to x-axis
ggplot(data = mtcars, aes(x = disp))+
  # Group disp into bins, and display
  #   count in each bin
  geom_histogram()
```



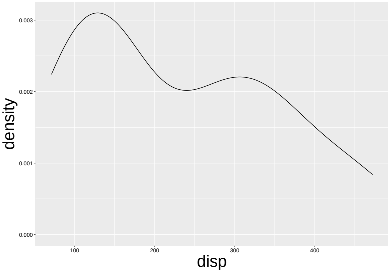
Simple example - histograms and density plots

```r
# Histogram
ggplot(data=mtcars,aes(x=disp))+
  geom_histogram()
```

```r
# Density plot
ggplot(data=mtcars,aes(x=disp))+
  geom_density()
```



Histogram



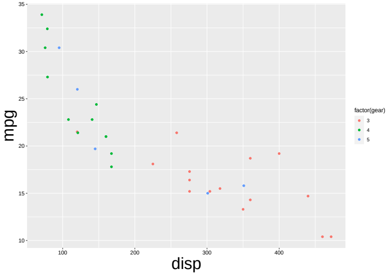
Probability density plot

$\int_{-\infty}^{\infty} x \, dx$

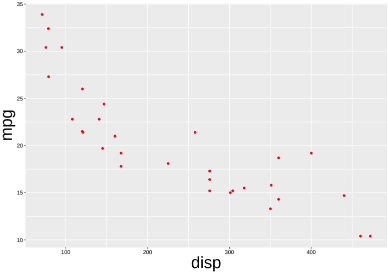
Colours in plots

- Colours can be *mapped* (via aes) or *set* (outside of aes)

```
ggplot(data=mtcars,aes(x=disp,y=mpg))+
  # Maps gear to colour
  geom_point(aes(col=factor(gear)))
```



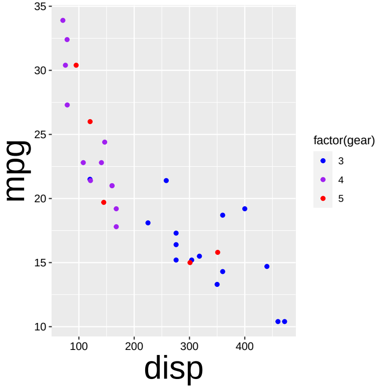
```
ggplot(data=mtcars,aes(x=disp,y=mpg))+
  geom_point(colour='red') #Sets colour
```



- Notice how aes was used twice in Figure 1? If used within the ggplot command, the rest of the geoms will remember it. Used within a geom, it will *update* the aesthetic

What if I want different colours?

- Default colour themes are pretty bad. Change them with `scale_colour_manual`
- Use `scale_fill_manual` for area-based colours (e.g. bar plots, polygons)
- Remember, 10% of males are red-green colourblind!

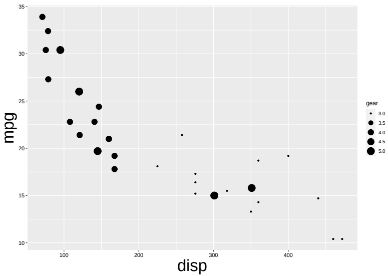


```
ggplot(data=mtcars,aes(x=disp,y=mpg))+
  geom_point(aes(col=factor(gear)))+
  scale_colour_manual(values=c('blue','purple','red'))
```

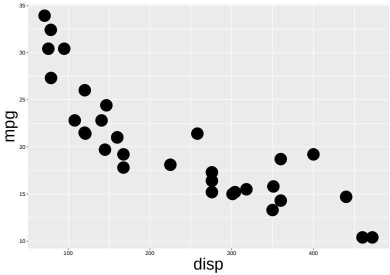
Sizes in plots

- Sizes can also be *mapped* (via aes) or *set* (outside of aes)

```
ggplot(data=mtcars,aes(x=disp,y=mpg))+
  # Maps gear to size
  geom_point(aes(size=gear))
```



```
ggplot(data=mtcars,aes(x=disp,y=mpg))+
  geom_point(size=10) #Sets size
```

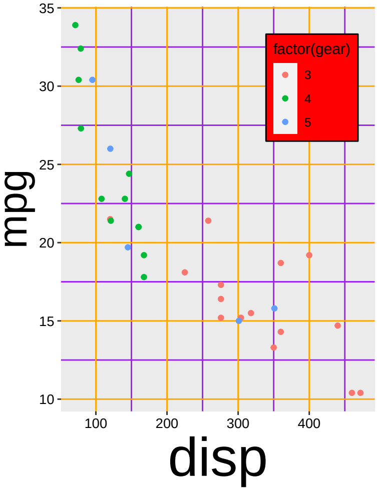


- Similar to colour choices, you can alter mapped sizes using `scale_size`

Change plot `theme`

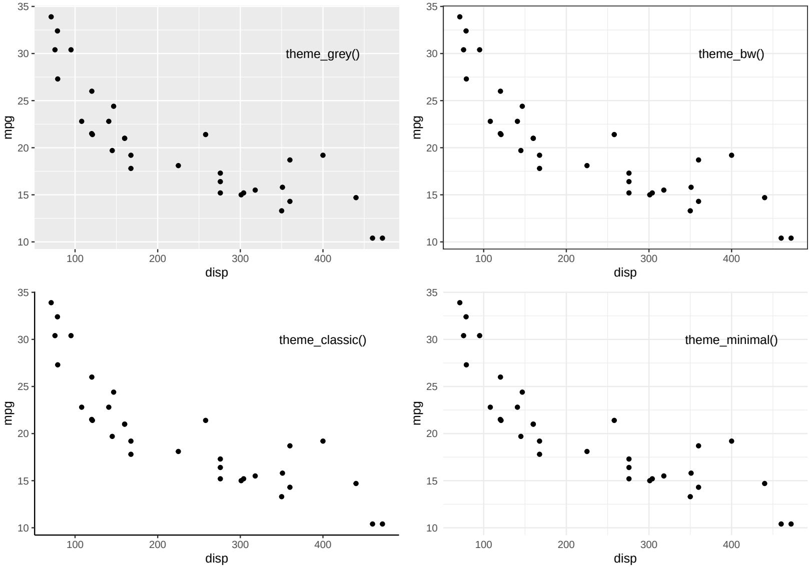
- `theme` controls almost all non-data elements of plots
- Made up of *elements*: `element_line()`, `element_text()`, `element_rect()`
- Let's make some changes:

```
ggplot(data=mtcars,aes(x=disp,y=mpg))+
  # Maps gear to colour
  geom_point(aes(col=factor(gear))) +
  #Changes plot theme
  theme(axis.title.x=element_text(size=40),
    legend.background=element_rect(fill='red'),
    legend.position=c(0.8,0.8),
    panel.grid.minor=element_line(colour='purple'),
    panel.grid.major=element_line(colour='orange'))
```



- This plot is hideous, but it gives you the idea!
- Use `?theme` to see all options

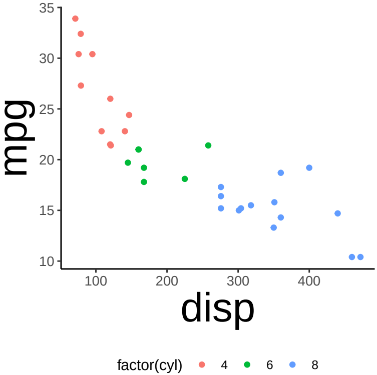
Preset themes



Make your own themes!

- You can modify existing themes in order to create your own
- Try using `theme_set()` at the start of your script to pre-set the theme for the rest of the script

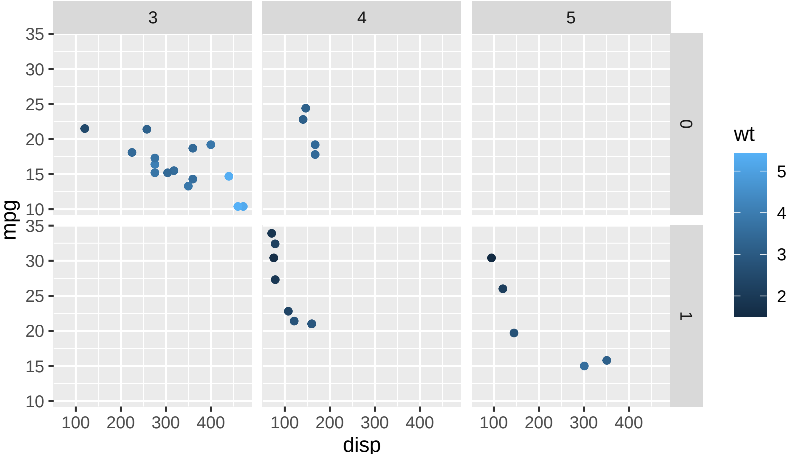
```
myTheme <- theme_classic()+ #Existing theme
  #Makes axis text bigger
  theme(axis.title=element_text(size=30),
        axis.text=element_text(size=10),
        legend.position='bottom')
#Sets up this theme as "default"
theme_set(myTheme)
```



Complex plots - facets

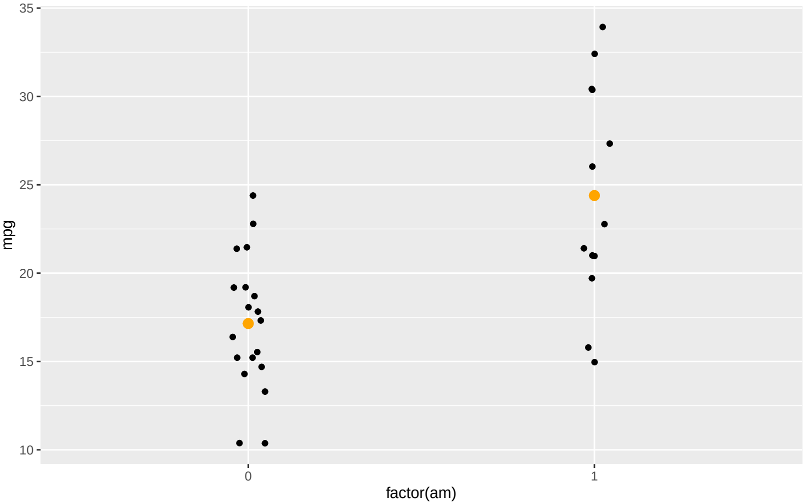
- It is possible to break up the plot into smaller `facets` that are mapped to a given variable
- This can be combined with colour/size mappings

```
ggplot(mtcars,aes(x=disp,y=mpg))+ geom_point(aes(col=wt))+
  facet_grid(factor(am) ~ factor(gear))
```



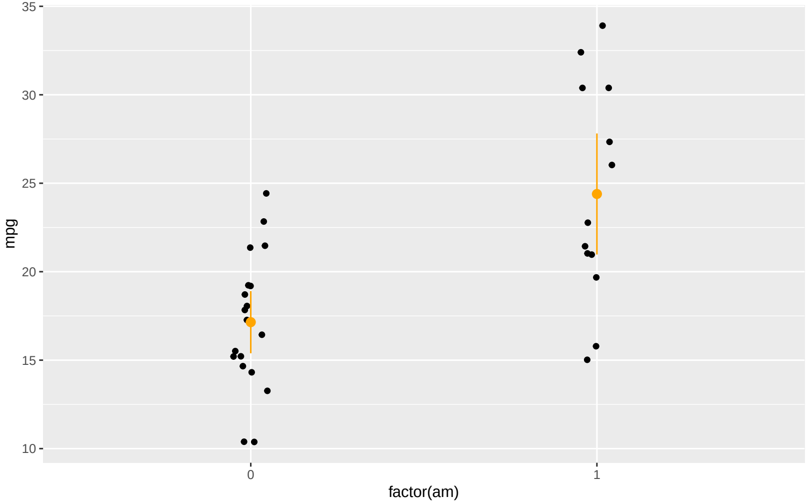
Complex plots - summary statistics (mean)

```
ggplot(mtcars,aes(x=factor(am),y=mpg))+
  geom_point(position=position_jitter(width=0.05))+ #Adds noise to data in x-dimension
  geom_point(stat='summary',fun=mean,col='orange',size=3) #Mean only
```



Complex plots - summary statistics (mean + SD)

```
ggplot(arrange(mtcars,am,disp),aes(x=factor(am),y=mpg))+
  geom_point(position=position_jitter(width=0.05))+
  geom_pointrange(stat='summary',fun.data=mean_se,
                  fun.args = list(mult = 2),col='orange') #Mean + 2 SE
```

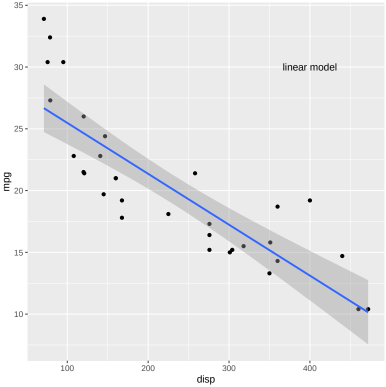


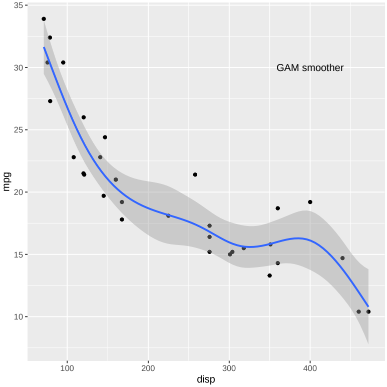
Complex plots - smoothers

- You can add `lm` (or other model) predictions to your plots:

```
ggplot(mtcars,aes(x=disp,y=mpg))+
  geom_point() +
  geom_smooth(method='lm',formula=y~x)
```

```
ggplot(mtcars,aes(x=disp,y=mpg))+
  geom_point() +
  geom_smooth(method='gam',formula=y~s(x))
```



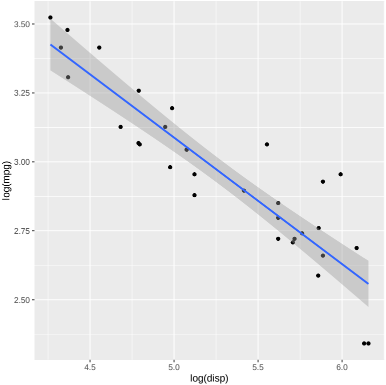


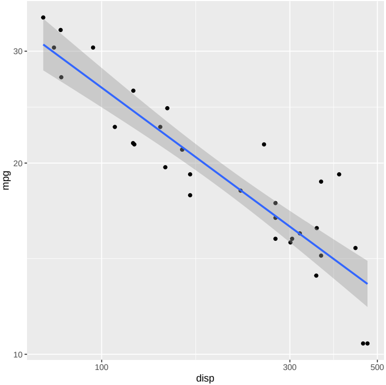
Complex plots - transformations

- You can show transformed data OR you can transform the axes themselves using `scale_*_log10` (x or y axis)

```
ggplot(mtcars,aes(x=log(disp),y=log(mpg)))+
  geom_point() +
  geom_smooth(method='lm',formula=y~x)
# Harder to interpret, because people can't
#     usually do log(x) in their head
```

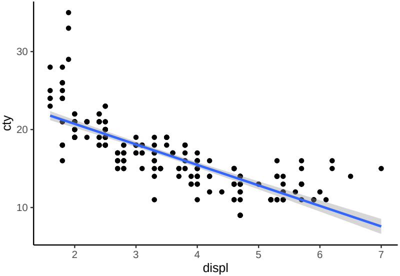
```
ggplot(mtcars,aes(x=disp,y=mpg))+
  geom_point() +
  geom_smooth(method='lm',formula=y~x)+
  scale_x_log10() + scale_y_log10()
# sqrt is also popular
```

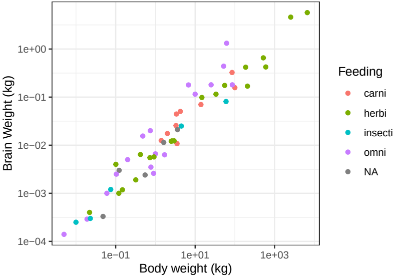


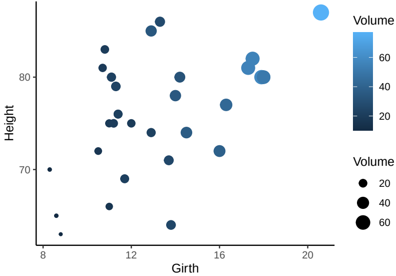


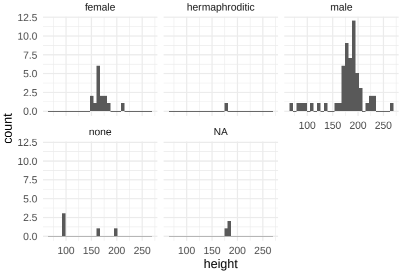
A challenger approaches:

Make these figures! Datasets are found in mpg, msleep, trees, and starwars (built into the ggplot2 and dplyr packages)


cty
displ


1e+00
1e−01
1e−02
1e−03
1e−04
Brain Weight (kg)
1e−01
1e+01
1e+03
Body weight (kg)
Feeding
carni
herbi
insecti
omni
NA


Height
Girth
Volume
Volume


female
hermaphroditic
male
none
NA
count
height