R: Introduction to Graphics

Ting-Shuo Yo

November 18, 2016

關於本課程

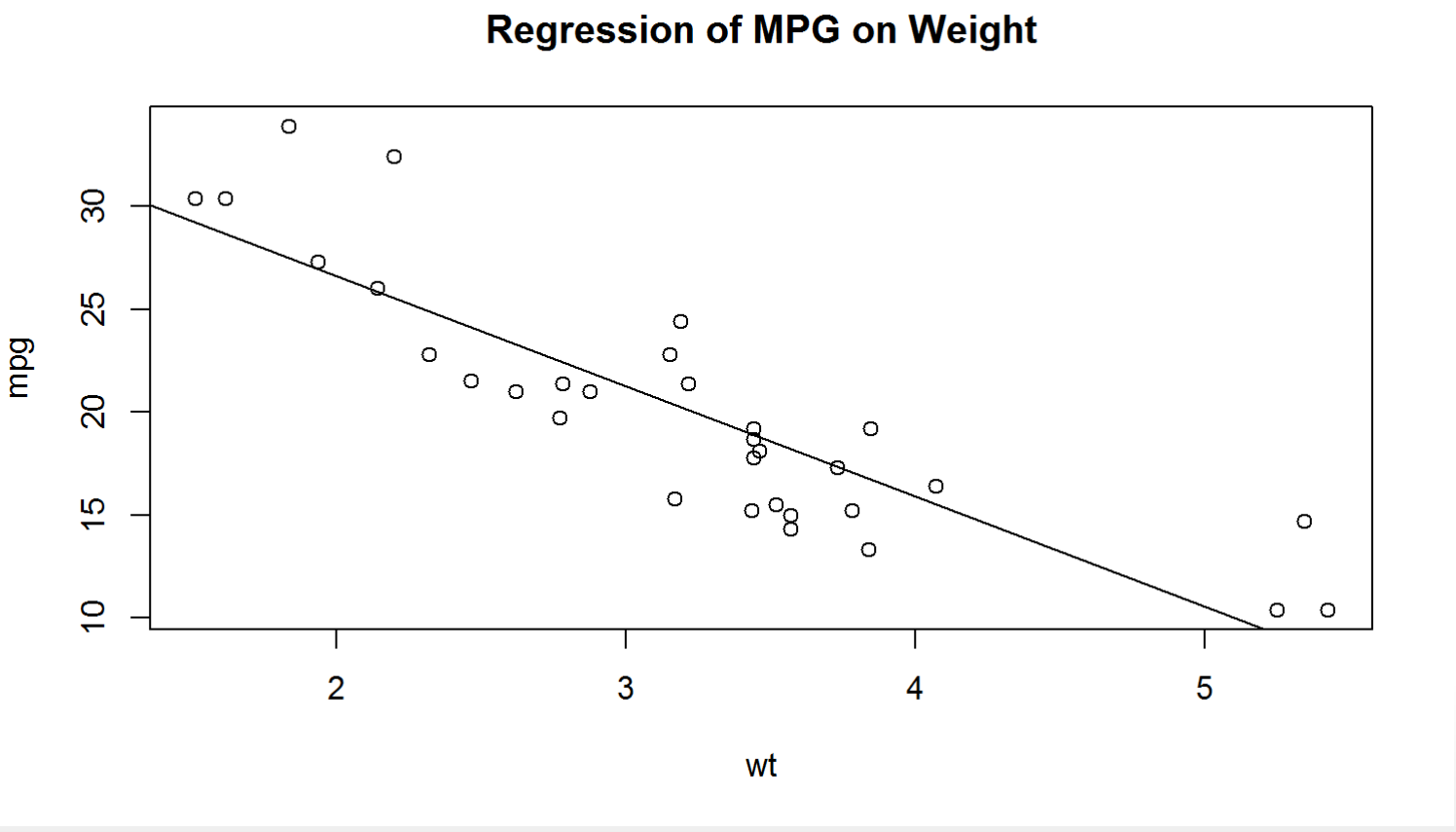
- 這段課程的主題是 **R** 繪圖，包含以下概念：
  - 基本繪圖原理
  - `ggplot2`
  - 實際案例練習

R 的繪圖

- 用範例學習：R Graphics by *Paul Murrell*
  - 著名的參考書，網路版免費
  - 選你想要畫的圖，看程式碼，然後修改
- The R Graph Gallery
  - 更多的範例
- 動手做：
  - Quick-R: Creating a Graph

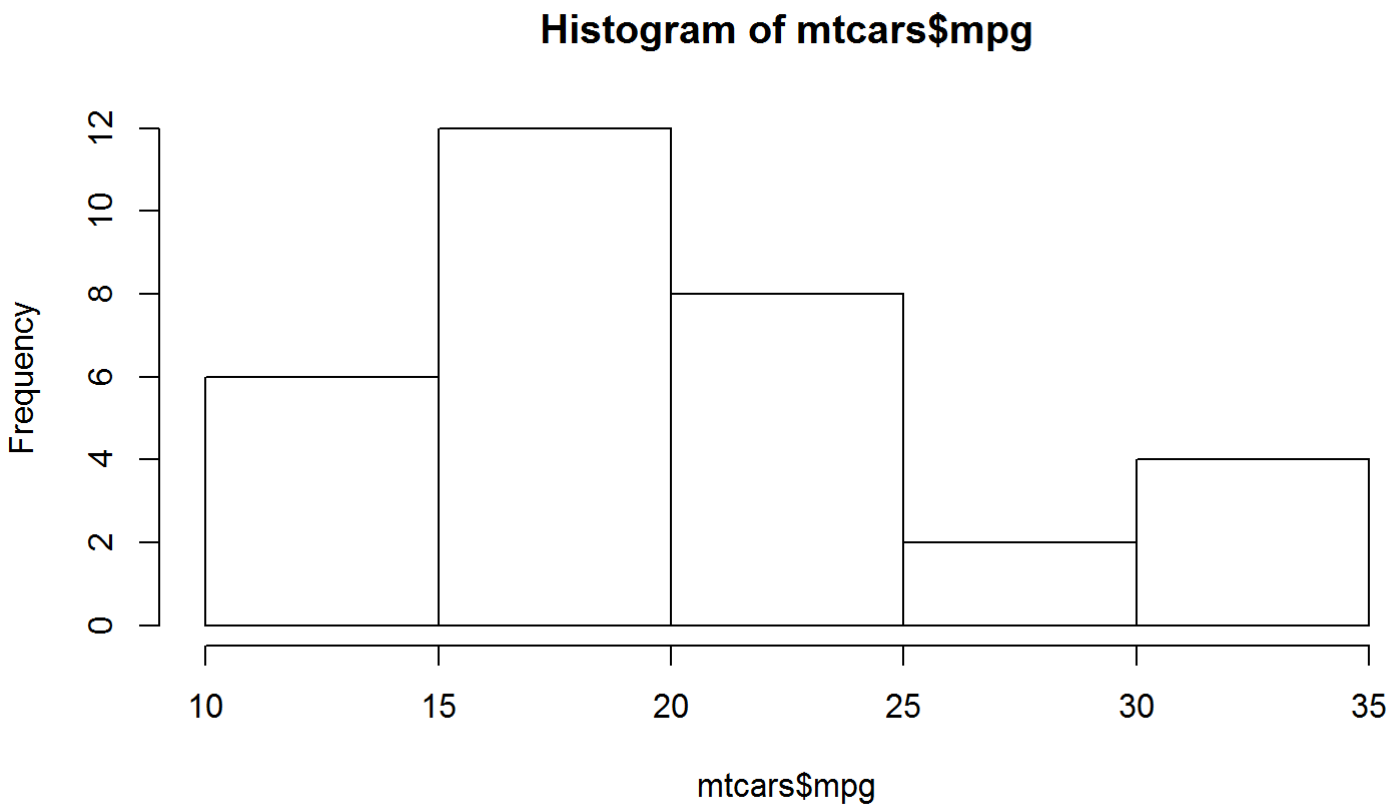
開始動手吧

```
attach(mtcars)
plot(wt, mpg)
abline(lm(mpg~wt))
title("Regression of MPG on Weight")
```



R 繪圖參數

```
hist(mtcars$mpg)
```



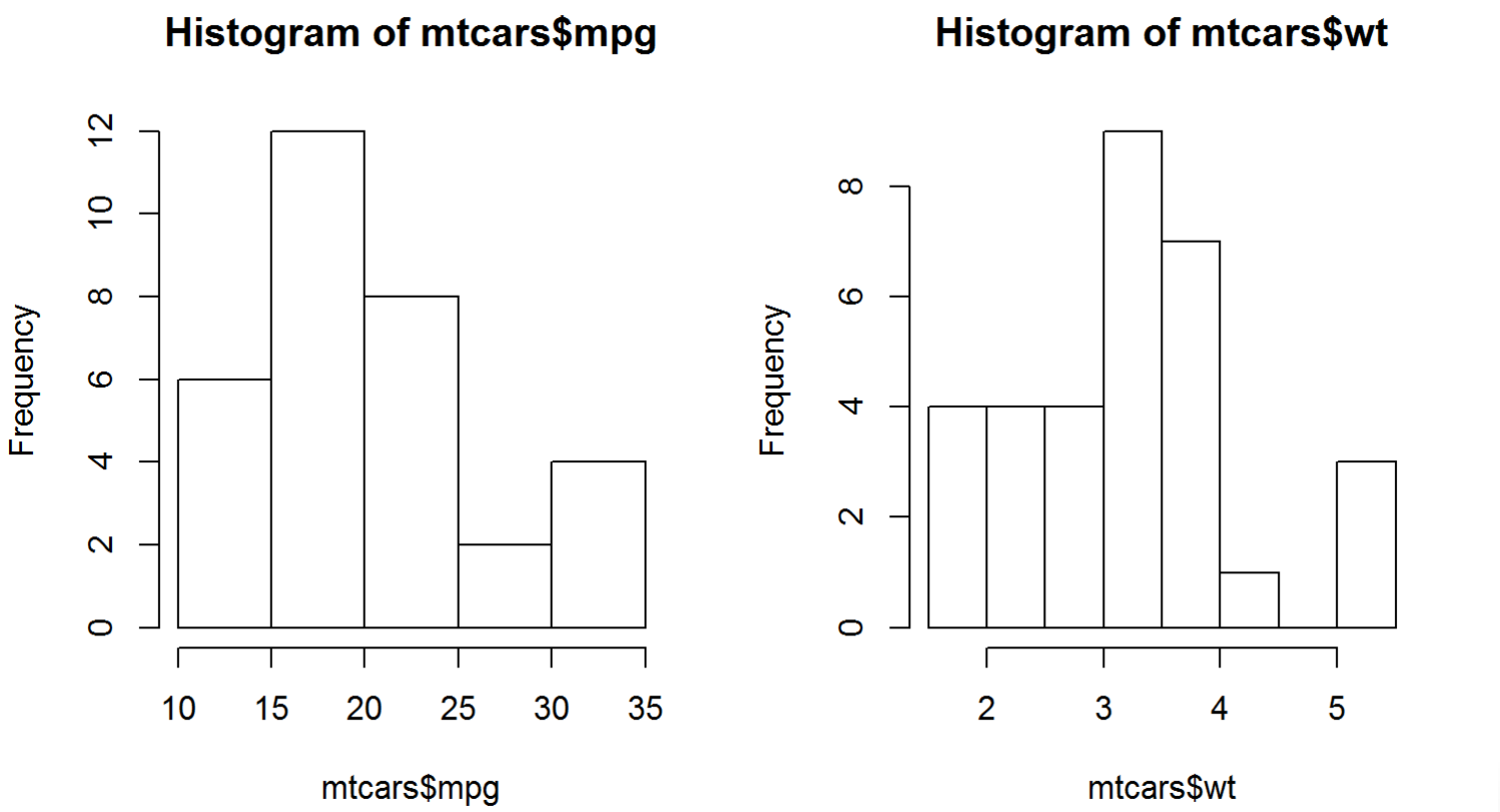
R 繪圖參數 par()

```
# 用 par() 來設定繪圖參數

par()                # 列出現有設定
opar <- par()        # 複製現有設定
par(col.lab="red") # 把座標軸說明改成紅色
hist(mtcars$mpg)   # 用新設定繪圖
par(opar)            # 回復原有設定
```

R 繪圖參數示範：在同一畫面繪製多張圖

```
par(mfrow=c(1,2))  # 把繪圖區分割成 1x2 （一列，兩欄）
hist(mtcars$mpg)
hist(mtcars$wt)
```



R 繪圖參考資料

- 基本繪圖
- 進階繪圖
- 繪圖基本參數
- 繪圖區域與邊界設定

進階繪圖：ggplot2

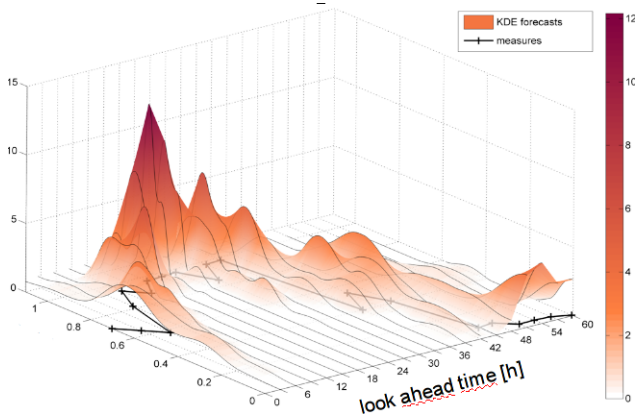
ggplot2簡介

- 設計依據繪圖理論 `grammar of graphics` (Wilkinson, 2005)
- 由 Hadley Wickham 在 Iowa State 讀研究所時開發完成
- 高階語言（用人話叫機器畫圖）
- 高度彈性，可以用 theme system 美化外觀
- R 的第三繪圖系統 (前兩個是 **base** 和 **lattice**)
- 成熟而且完整的繪圖系統（可以透過 CRAN 安裝）
- 網站：http://ggplot2.org (完整的參考文件)
- 很多討論區可以問人

進階繪圖：ggplot2

有些用途，用 ggplot2是不行的

- 3D 圖 (see the rgl package)
- 圖論的圖 (nodes/edges layout; see the igraph package)
- 互動圖 (see the ggvis package)



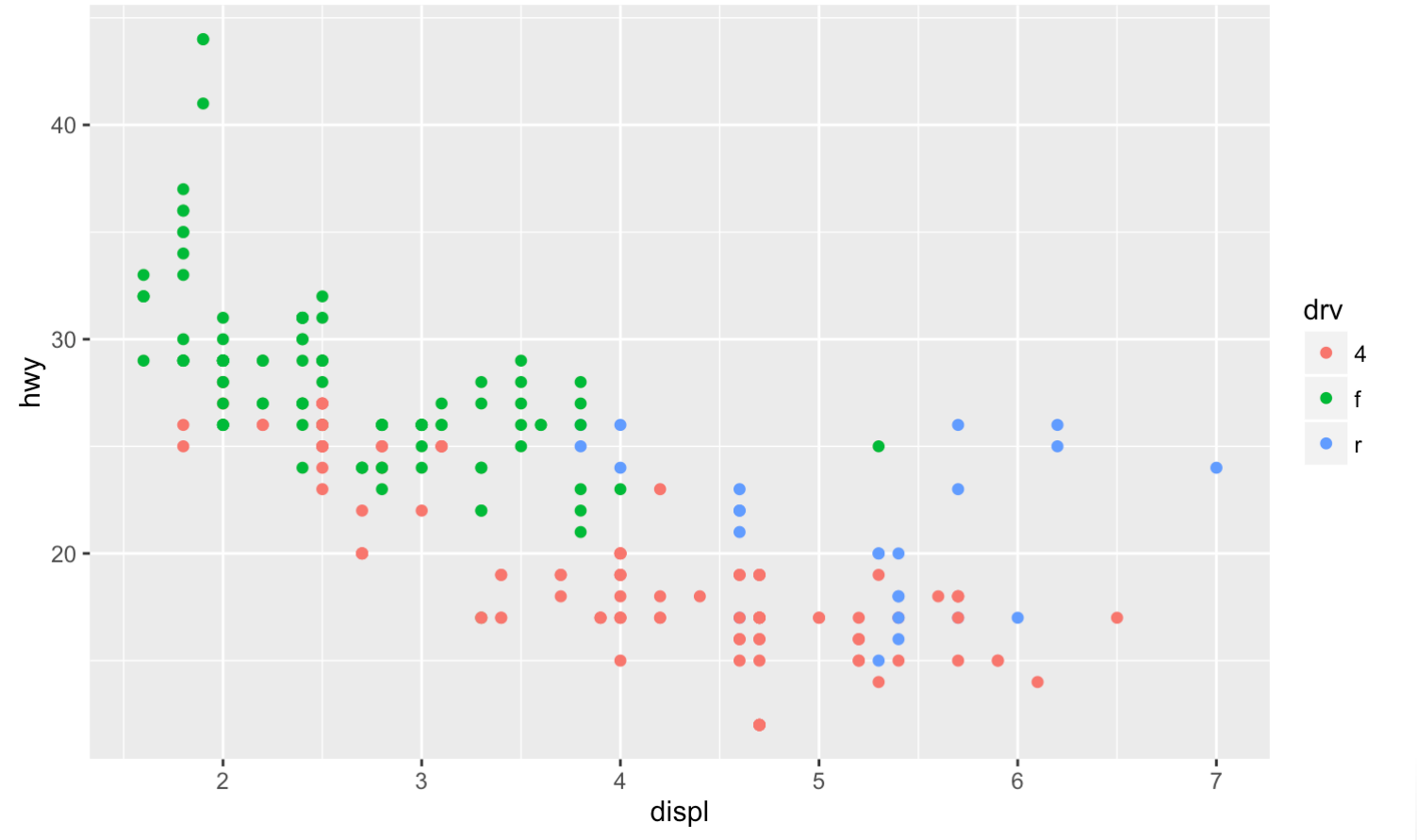
繪圖的文法 grammar of graphics

簡單的說，這個文法將統計繪圖視為一種由 資料 到 幾何物件（點、線、多邊形）和 美學屬性（顏色、形狀、大小）的 映射（mapping）

“In brief, the grammar tells us that a statistical graphic is a **mapping** from data to **aesthetic** attributes (colour, 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” —- from *ggplot2* book

聽起來很有道理，但是那是什麼意思？

```
ggplot(data=mpg) +                      # 資料層
  aes(x=displ, y=hwy, color=drv) +      # 資料和圖形元件的映射
  geom_point()                          # 用「點」畫這張圖
```



繪圖的文法 grammar of graphics

將一張圖分割成各自獨立的元件，類似 XML 的概念，這些元件包括：

- data
- aesthetic mapping
- geometric object
- statistical transformations
- scales
- coordinate system
- position adjustments
- faceting

R 繪圖系統: Base

- “Artist’s palette” model
- 從一張空白的畫布開始
- 用 `plot` 函數 (或相似的函數) 初始化一張畫布
- 用修飾函數 (`text`, `lines`, `points`, `axis`) 來編修畫布
- 方便，直覺的反映資料分析的思維方式
- 繪圖等於一連串的 R 命令，需要先思考妥當再繪圖

R 繪圖系統: Base: Lattice

- 圖形由單一函數來完成 (`xyplot`, `bwplot`, etc.)
- 最適合呈現變項間的關係: 當 y 與 x 改變時， z 的變化情形
- 座標軸等細節由系統自動設定
- 善於一次呈現多個圖
- 只有一個指令來繪圖，不夠方便、直覺

ggplot2 繪圖的基本元件

- A *data frame*：資料
- *aesthetic mappings*: 資料要如何對應到顏色、大小
- *geoms*: 幾何物件，例如 points, lines, shapes.
- *facets*: 條件圖會用到.
- *stats*: 統計轉換，例如 binning, quantiles, smoothing.
- *scales*: 美學映射的設定 (example: male = red, female = blue).
- *coordinate system* ：座標系統

用 ggplot2 繪圖

- ggplot2 像 base 繪圖，像是在一張空白畫布上作畫（qplot 比較像 lattice）
- 一張圖由許多「圖層」組成：
  - 資料的圖形
  - 摘要
  - 描述及註記

範例資料

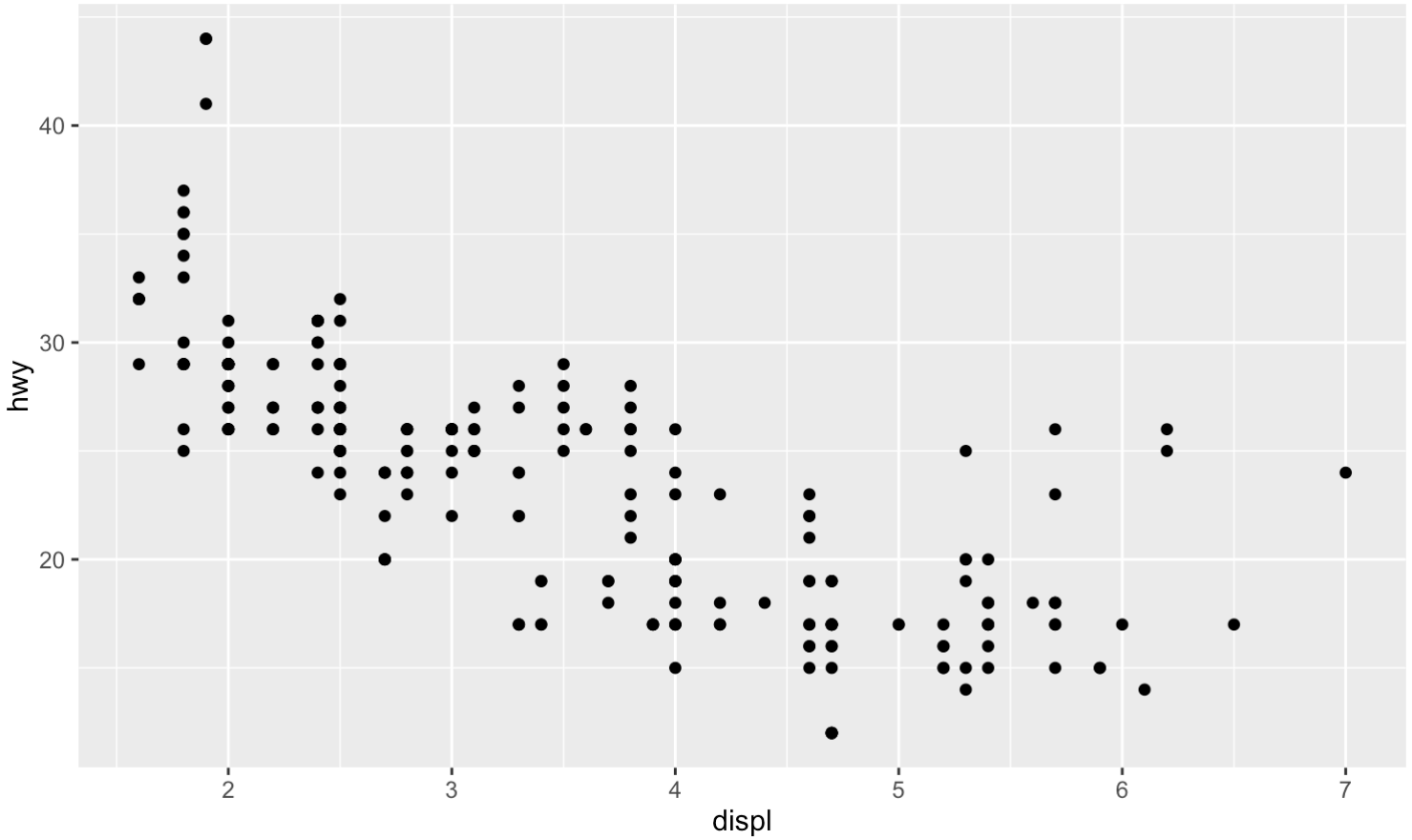
mpg: 1999 - 2008年 38 個車款的燃油效率資料

```
require(ggplot2)
str(mpg)
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame':    234 obs. of  11 variables:
##  $ manufacturer: chr  "audi" "audi" "audi" "audi" ...
##  $ model       : chr  "a4" "a4" "a4" "a4" ...
##  $ displ       : num  1.8 1.8 2 2 2.8 2.8 3.1 1.8 1.8 2 ...
##  $ year        : int  1999 1999 2008 2008 1999 1999 2008 1999 1999 2008 ...
##  $ cyl         : int  4 4 4 4 6 6 6 4 4 4 ...
##  $ trans       : chr  "auto(l5)" "manual(m5)" "manual(m6)" "auto(av)" ...
##  $ drv         : chr  "f" "f" "f" "f" ...
##  $ cty         : int  18 21 20 21 16 18 18 18 16 20 ...
##  $ hwy         : int  29 29 31 30 26 26 27 26 25 28 ...
##  $ fl          : chr  "p" "p" "p" "p" ...
##  $ class       : chr  "compact" "compact" "compact" "compact" ...
```

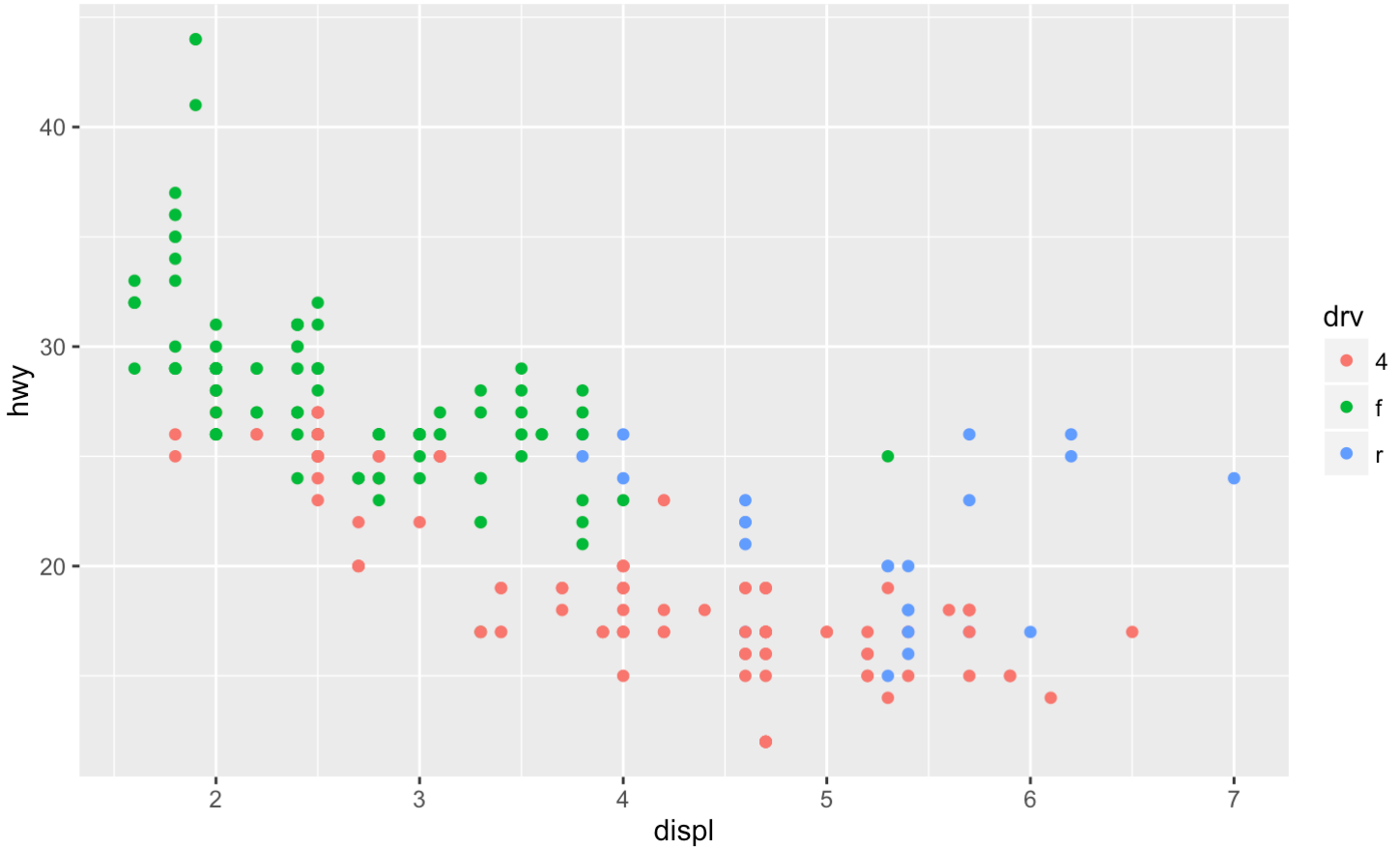
ggplot2 的第一張圖

```
qplot(displ, hwy, data = mpg)
```



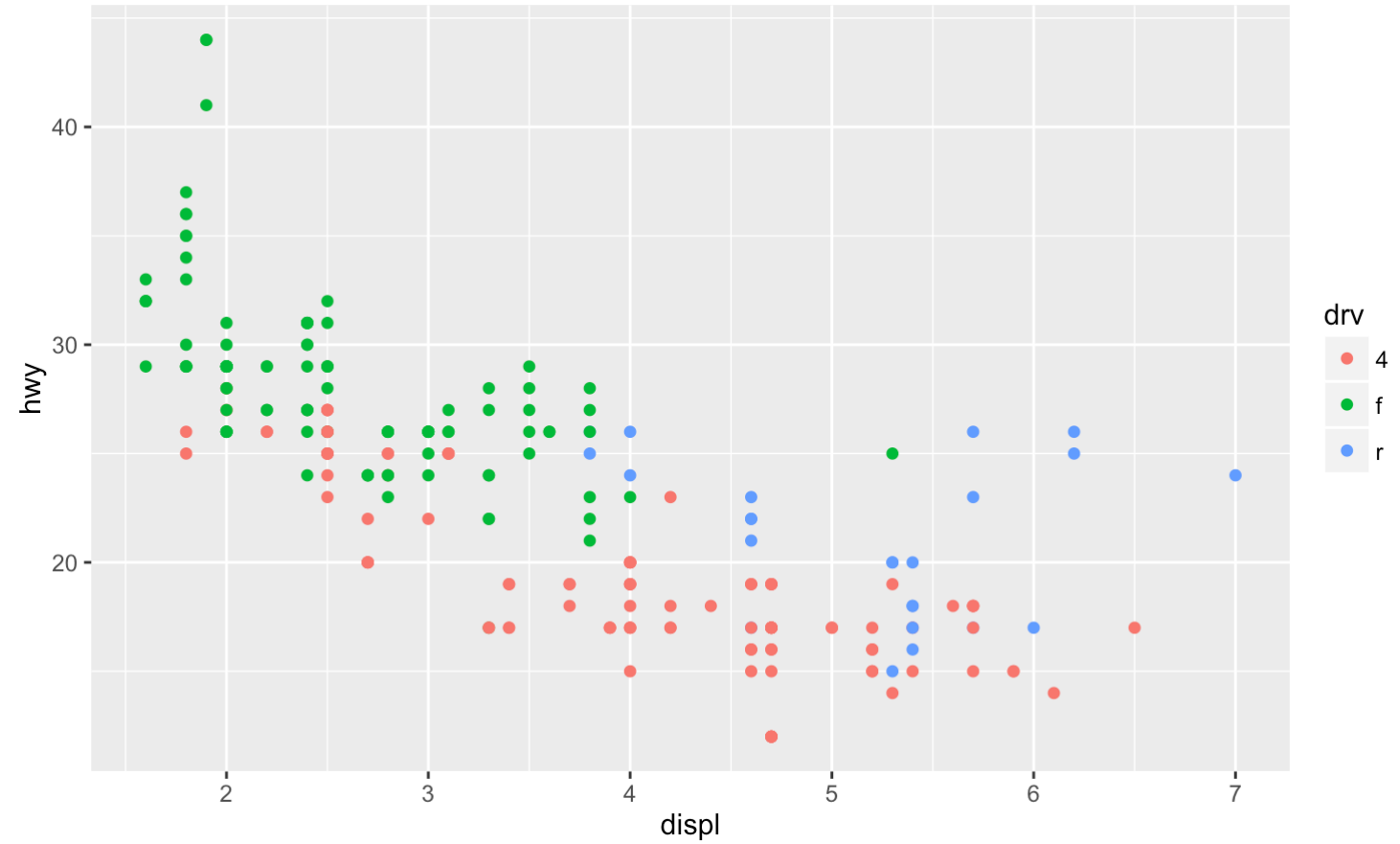
修改美學設定（aes）

```
qplot(displ, hwy, data = mpg, color = drv)
```



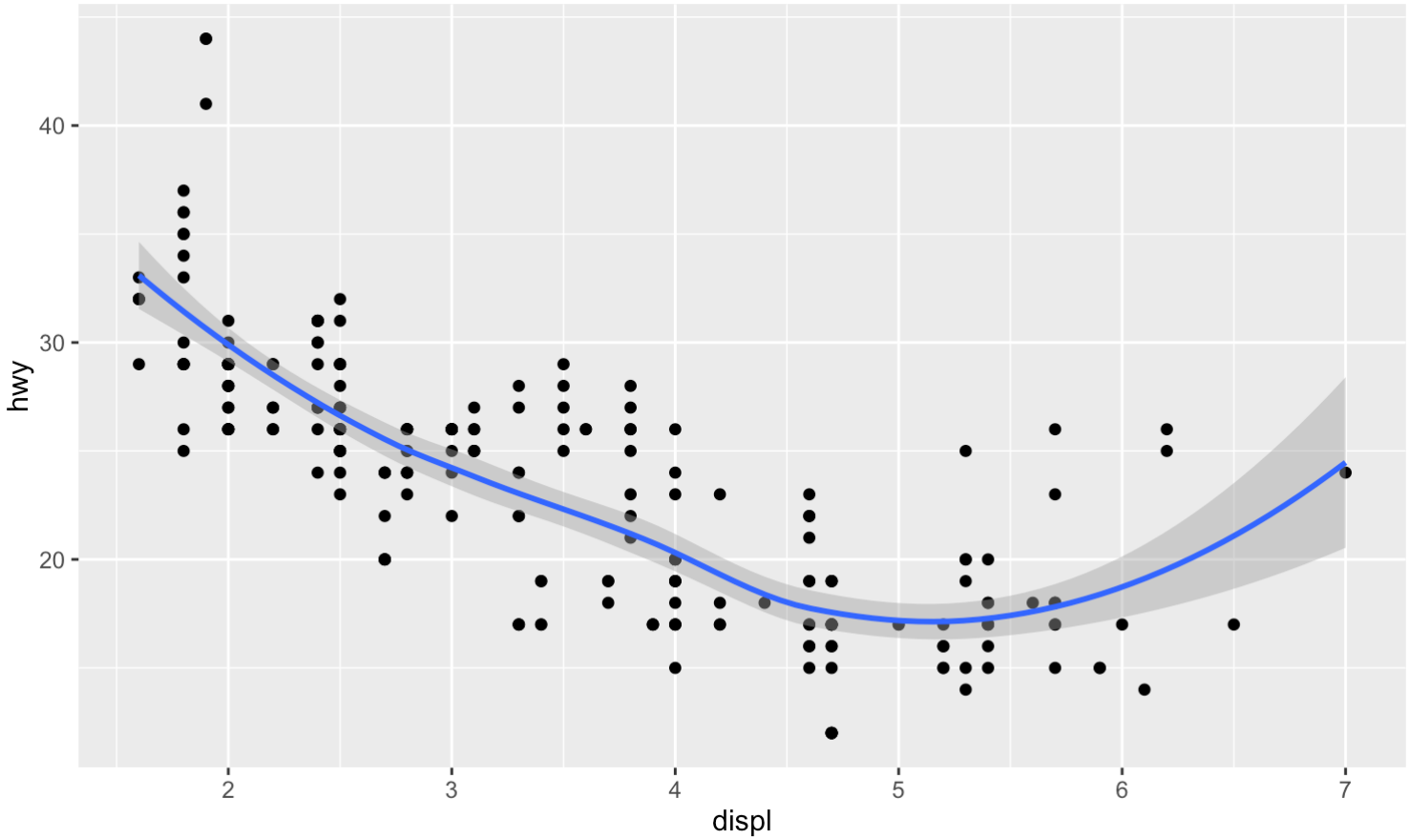
另一種畫法：qplot() vs ggplot()

```
ggplot(data=mpg) +                      # 資料層
  aes(x=displ, y=hwy, color=drv) +      # 資料和圖形元件的映射
  geom_point()                          # 用「點」畫這張圖
```



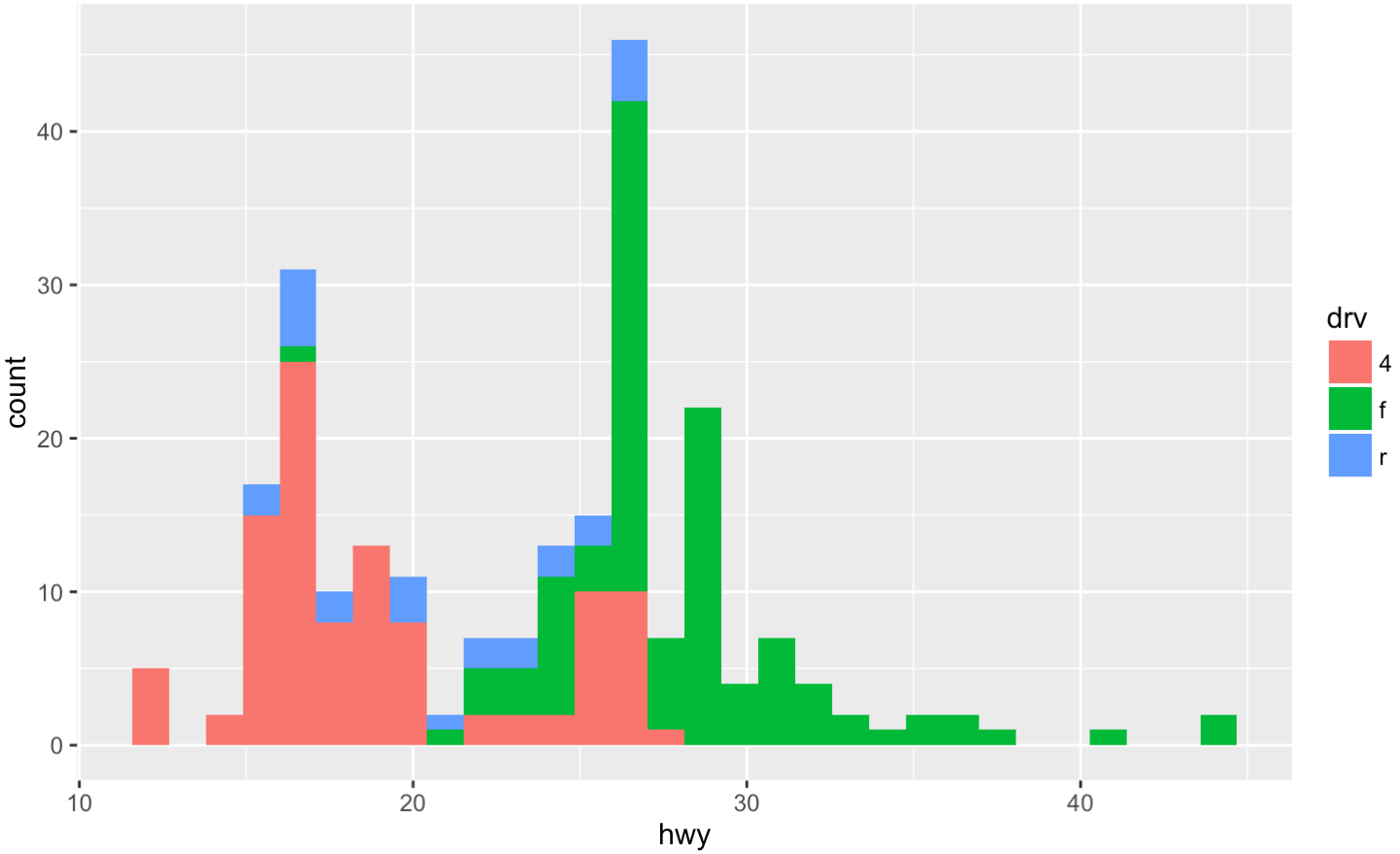
加入新的幾何物件 geom

```
qplot(displ, hwy, data = mpg, geom = c("point", "smooth"))
```



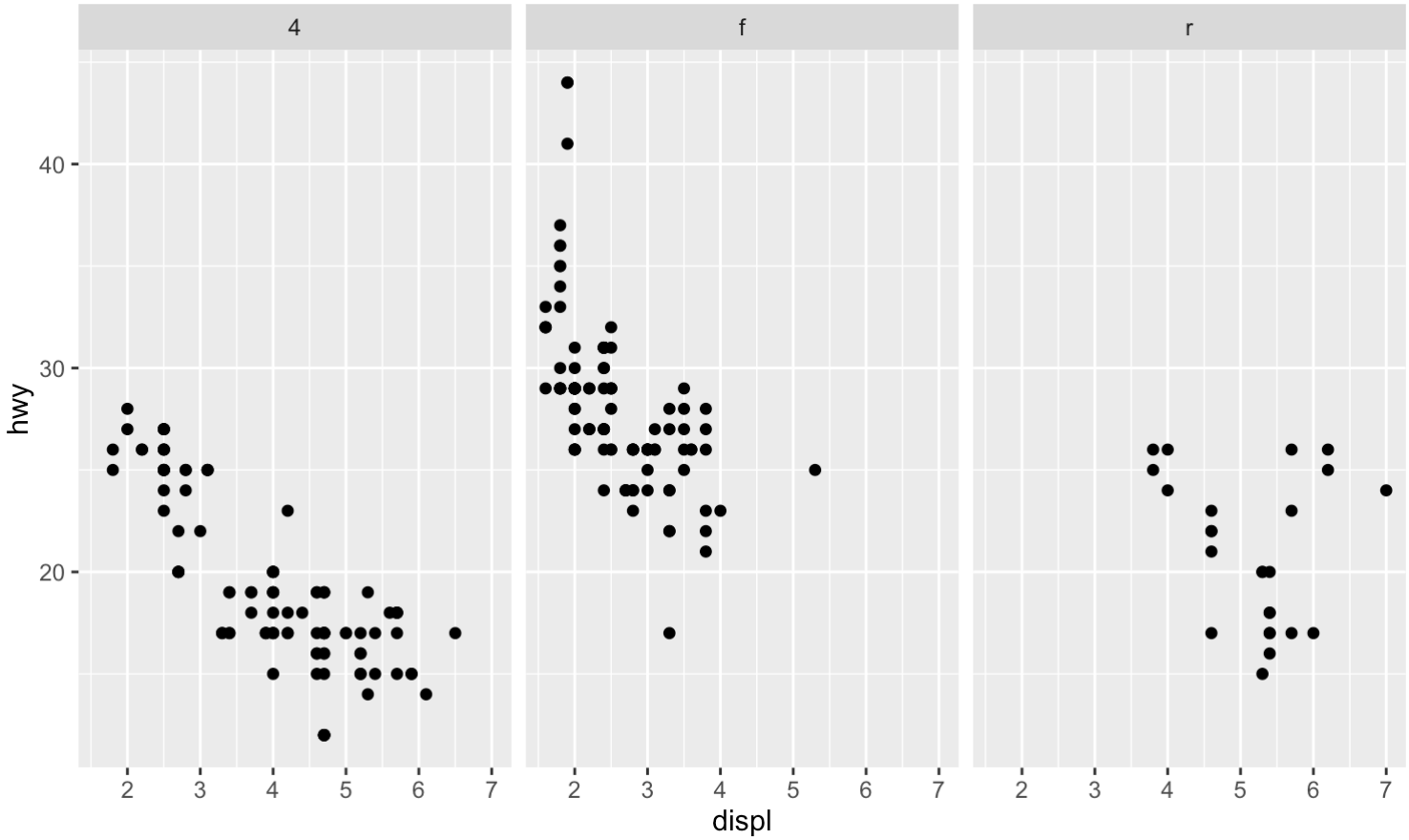
直方圖

```
qplot(hwy, data = mpg, fill = drv)
```



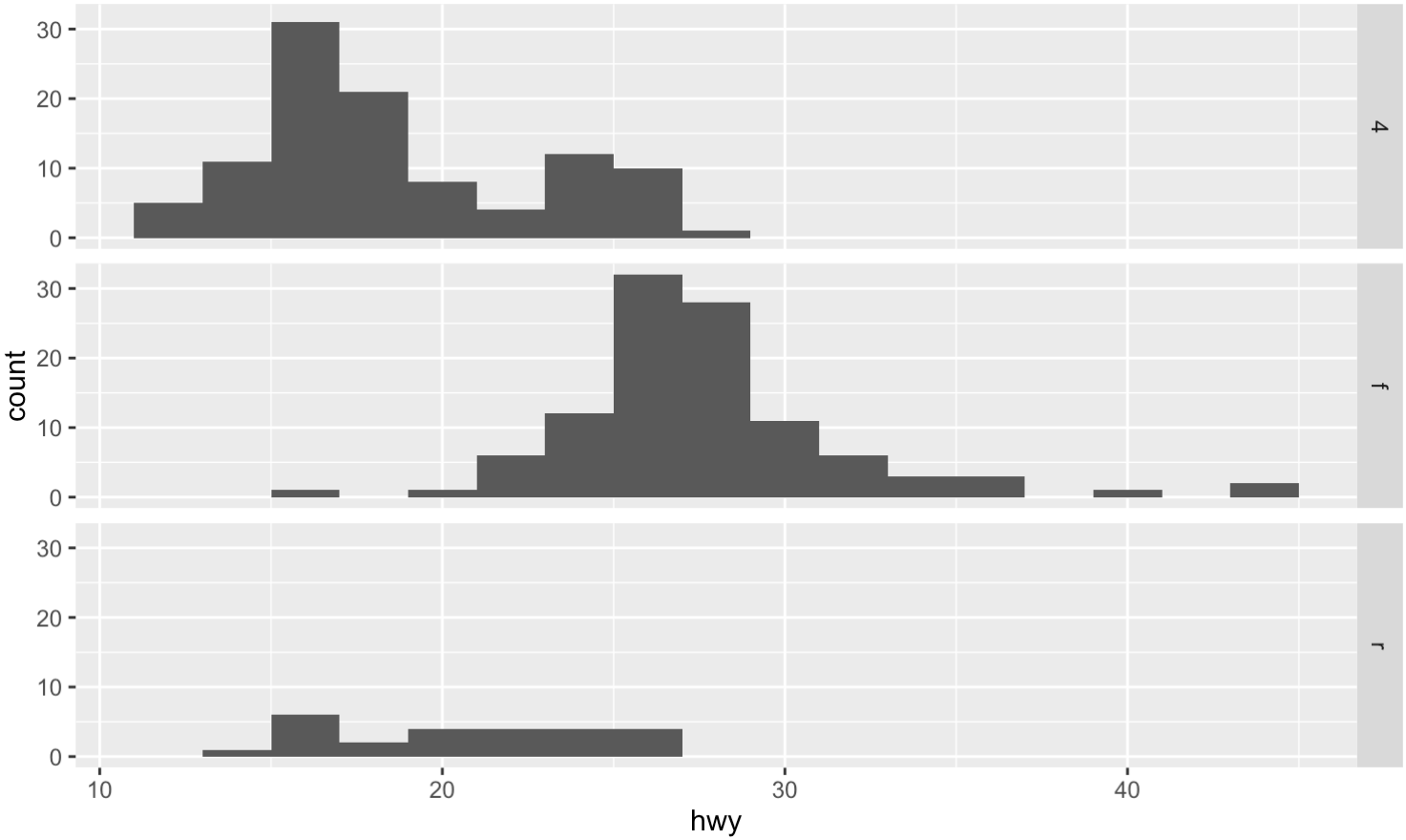
一頁多圖: facets

```
qplot(displ, hwy, data = mpg, facets = . ~ drv)
```



一頁多圖: facets

```
qplot(hwy, data = mpg, facets = drv ~ ., binwidth = 2)
```



範例資料：MAACS

- 過敏原和氣喘的老鼠世代研究（cohort Study）
- Baltimore 兒童 (年齡 5—17)
- 持續氣喘，且在去年惡化
- 氣喘罹患率與室內環境的研究
- 身高體重指數 BMI 是否會影響 $PM_{2.5}$ 與氣喘之間的關聯性？
- 近期研究發表: http://goo.gl/WqE9j8

範例資料：MAACS 概觀

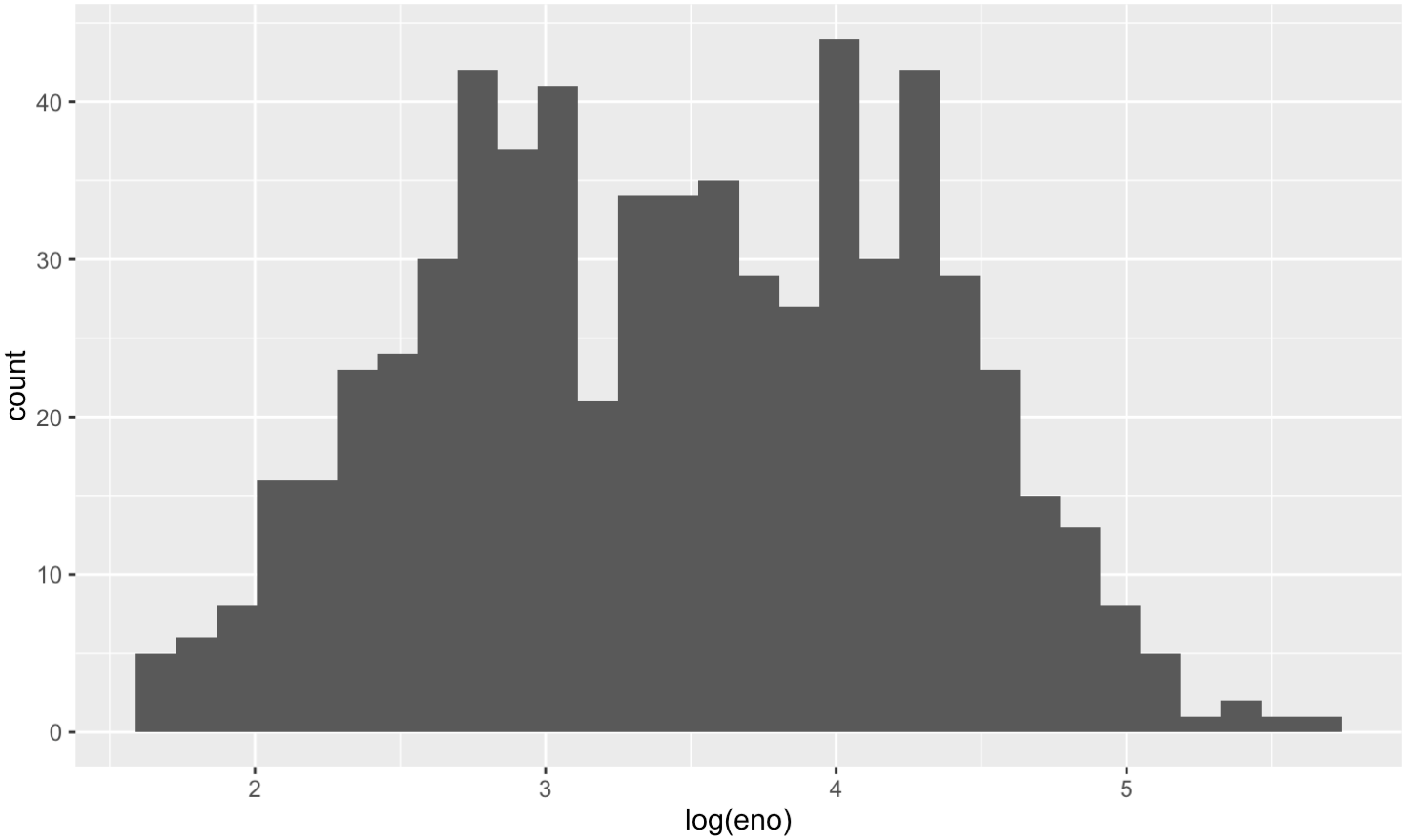
- eno: Exhaled nitric oxide, eNO，測量氣喘的指標
- pm25: 空氣懸浮微粒含量（ppm）
- mopos: 老鼠是否過敏

```
str(maacs)
```

```
## 'data.frame':    750 obs. of  5 variables:
##  $ id       : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ eno      : num  141 124 126 164 99 68 41 50 12 30 ...
##  $ duBedMusM: num  2423 2793 3055 775 1634 ...
##  $ pm25     : num  15.6 34.4 39 33.2 27.1 ...
##  $ mopos    : Factor w/ 2 levels "no","yes": 2 2 2 2 2 2 2 2 2 2 ...
```

Histogram of eNO

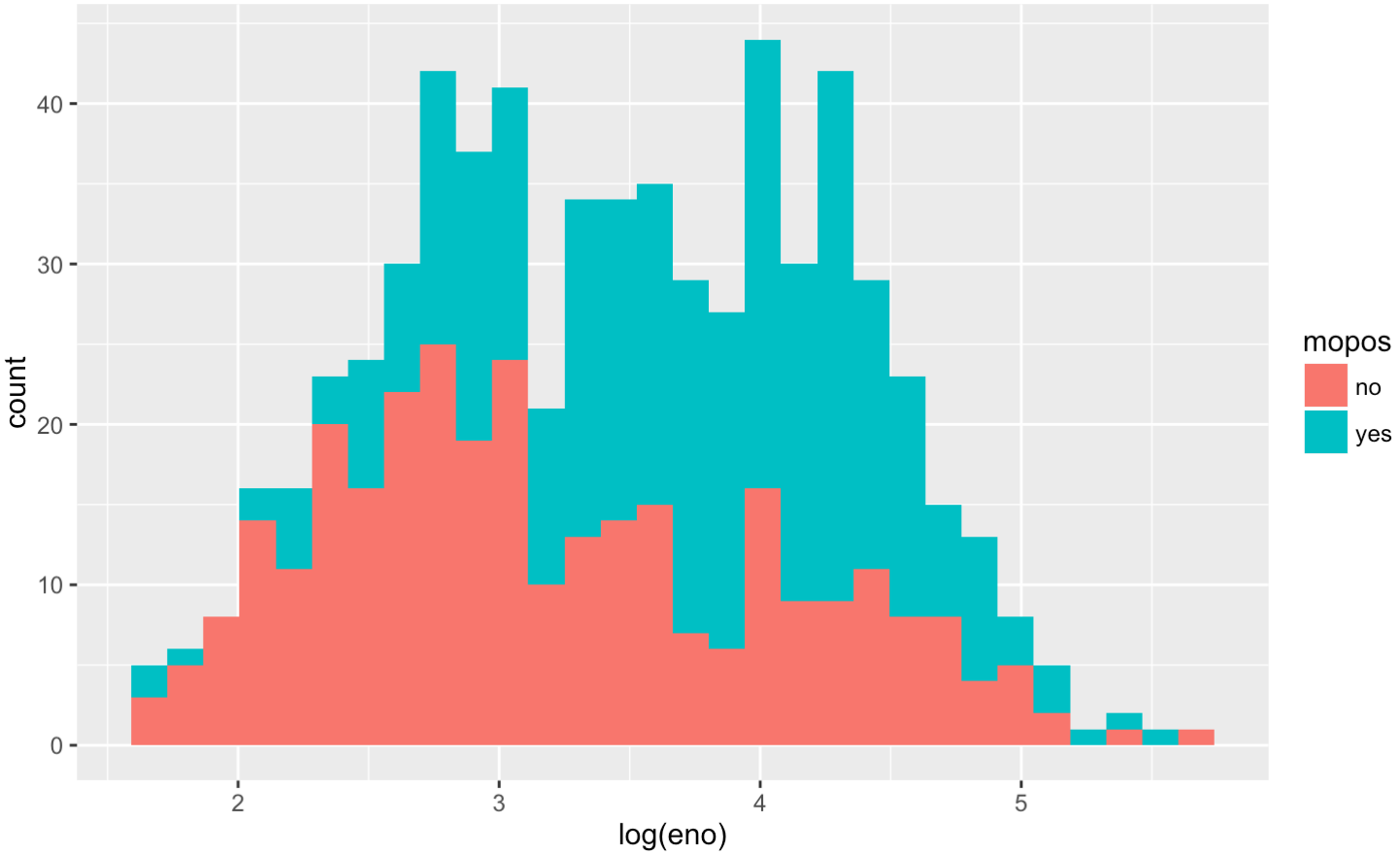
```
ggplot(data = maacs, aes(log(eno))) + geom_histogram()
```




```
# Alternative:
# qplot(log(eno), data = maacs)
```

Histogram by Group

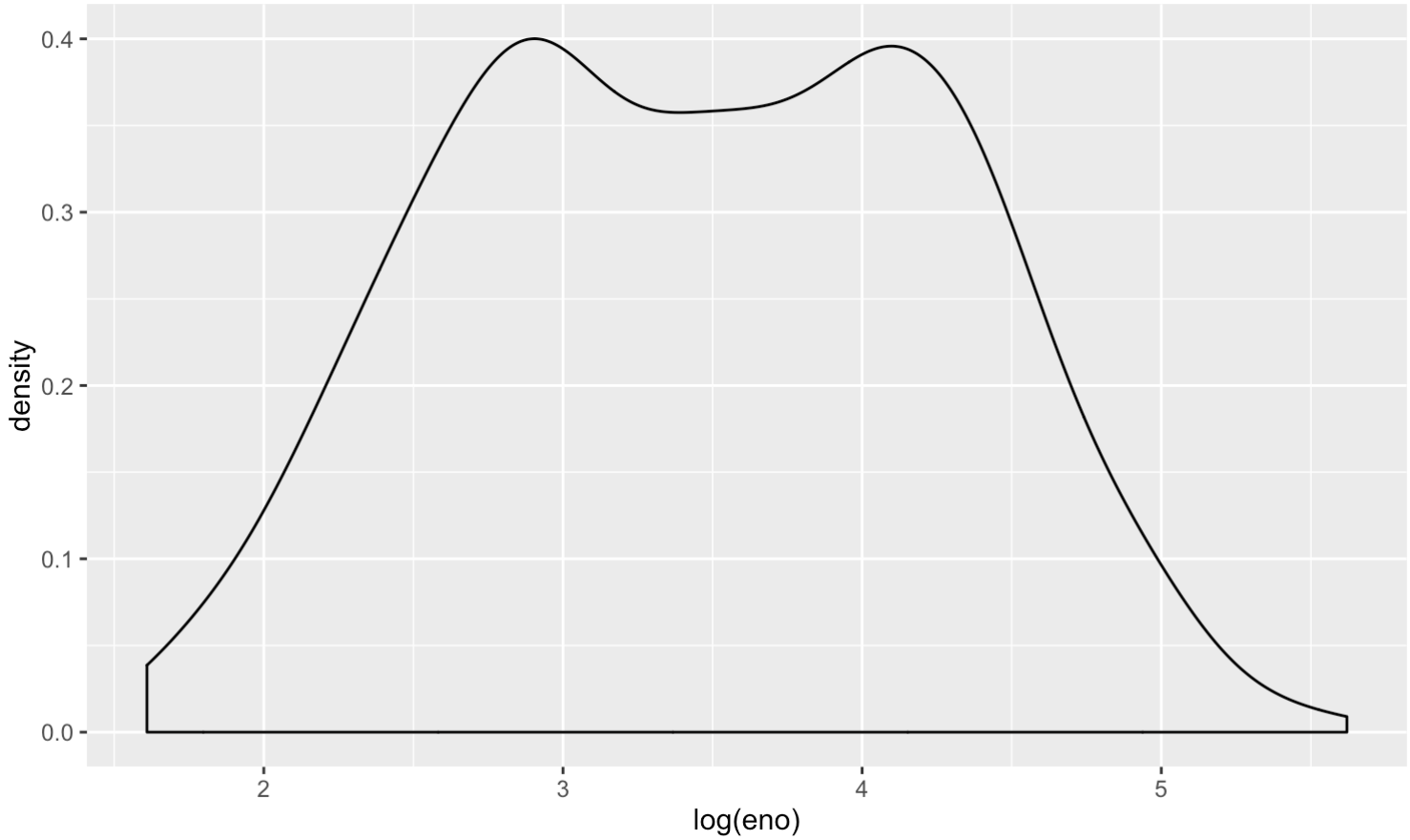
```
ggplot(data = maacs, aes(log(eno), fill=mopos)) + geom_histogram()
```




```
# Alternative:
# qplot(log(eno), data = maacs, fill = mopos)
```

Density Smooth

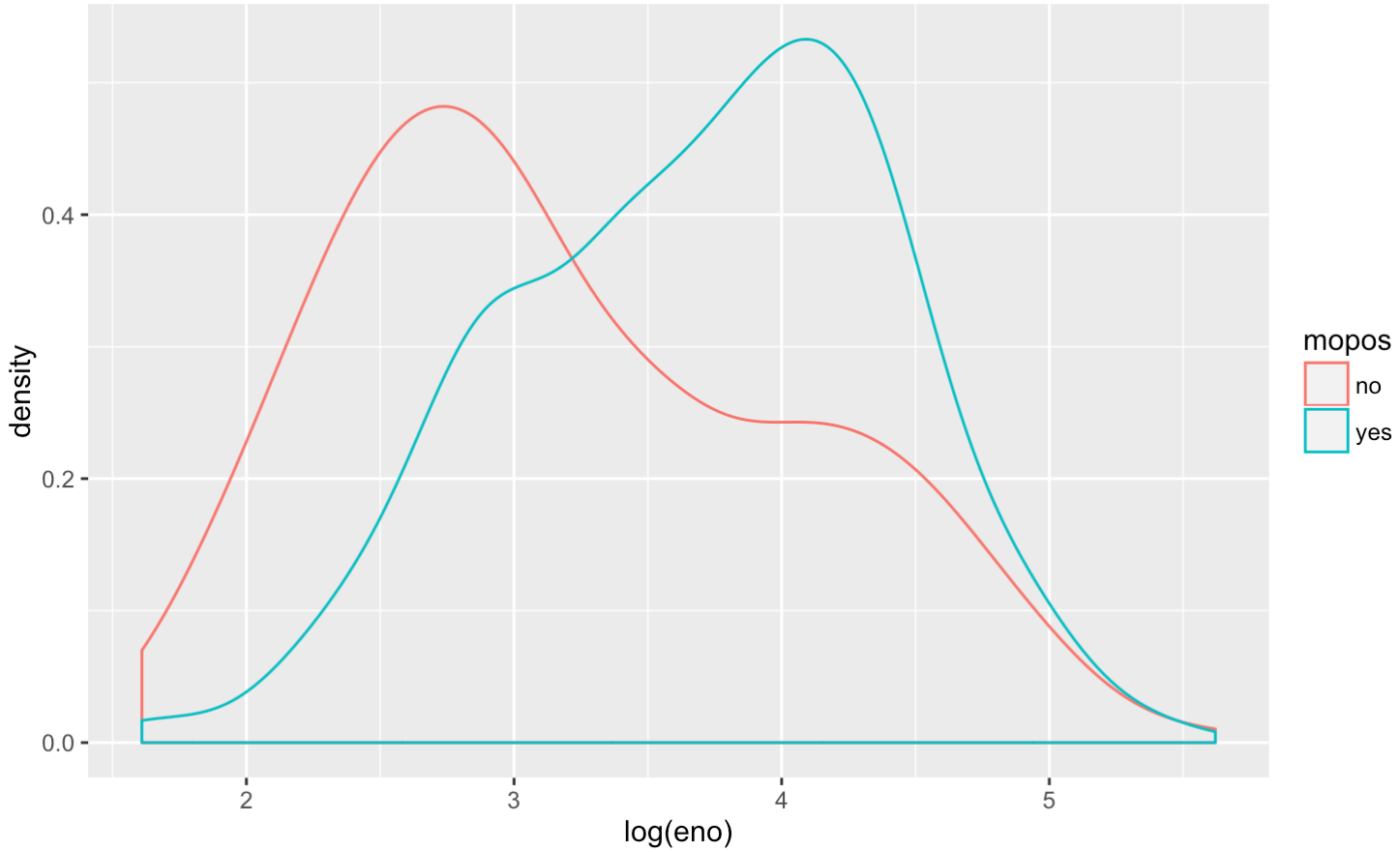
```
ggplot(data = maacs, aes(log(eno))) + geom_density()
```




```
# Alternative:
# qplot(log(eno), data = maacs, geom = "density")
```

Density Smooth by Group

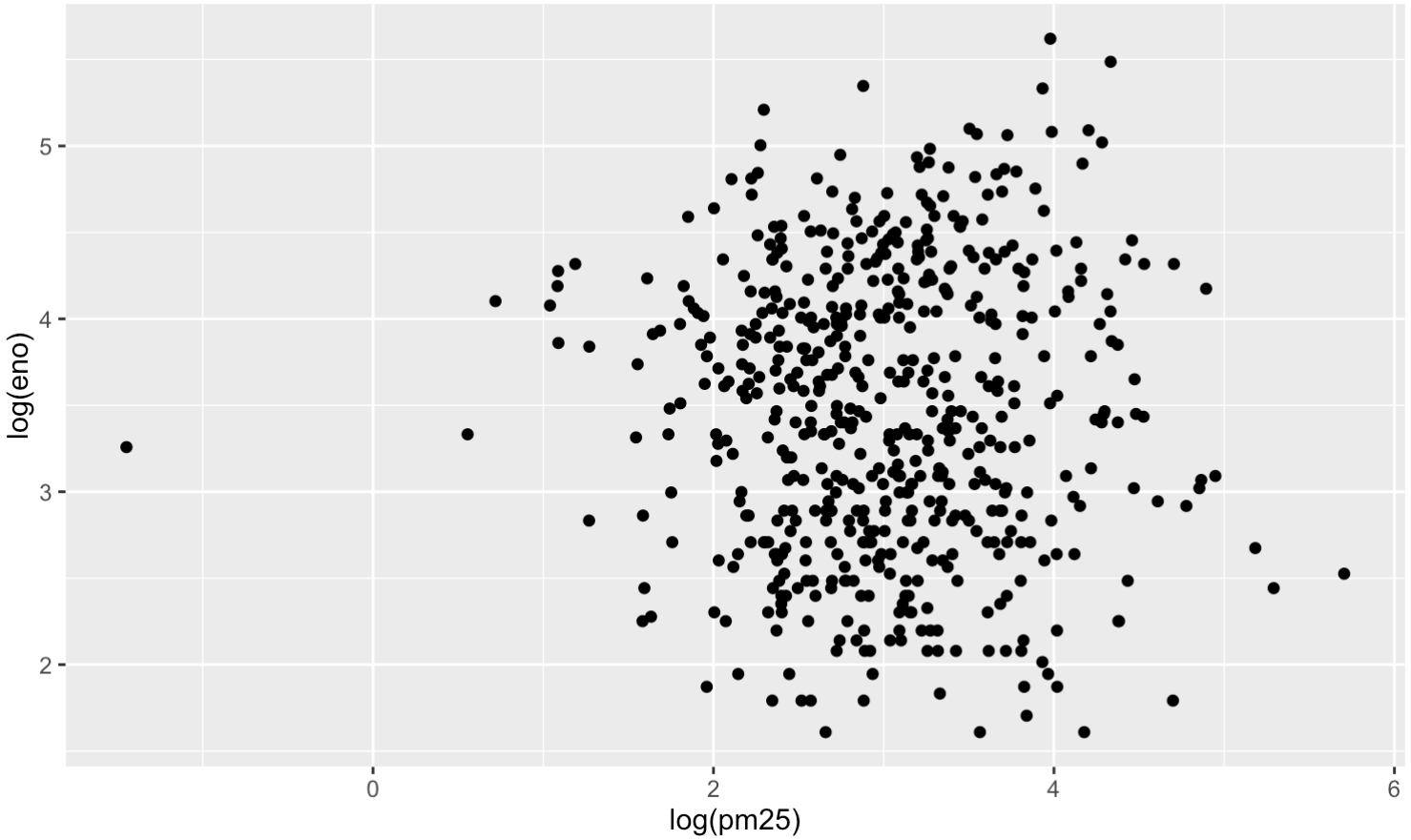
```
ggplot(data = maacs, aes(log(eno), color=mopos)) + geom_density()
```




```
# Alternative:
# qplot(log(eno), data = maacs, geom = "density", color = mopos)
```

Scatterplots: eNO vs. $PM_{2.5}$

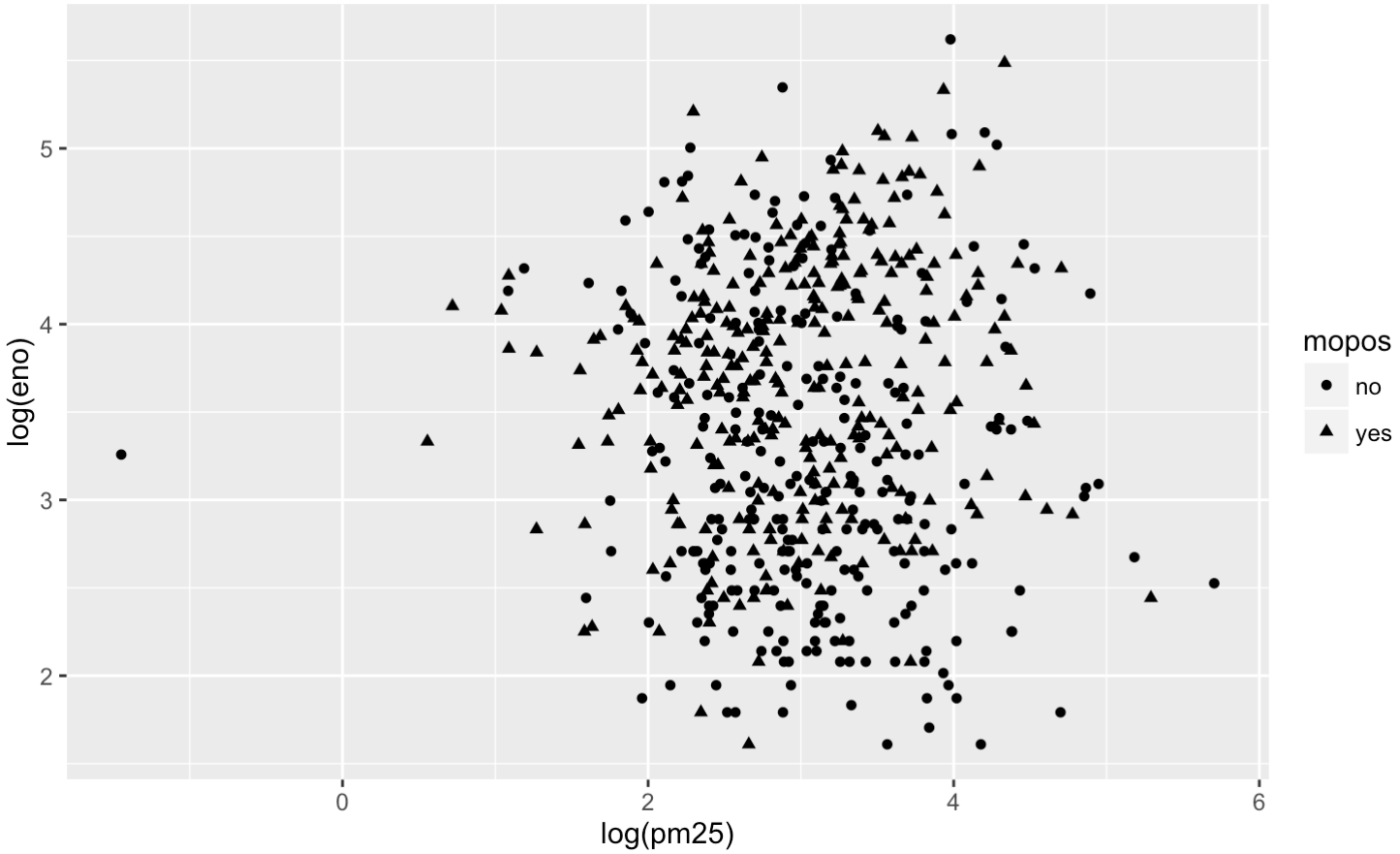
```
ggplot(data=maacs, aes(x=log(pm25), y=log(eno))) + geom_point()
```




```
#qplot(log(pm25), log(eno), data = maacs)
```

Scatterplots: eNO vs. $PM_{2.5}$

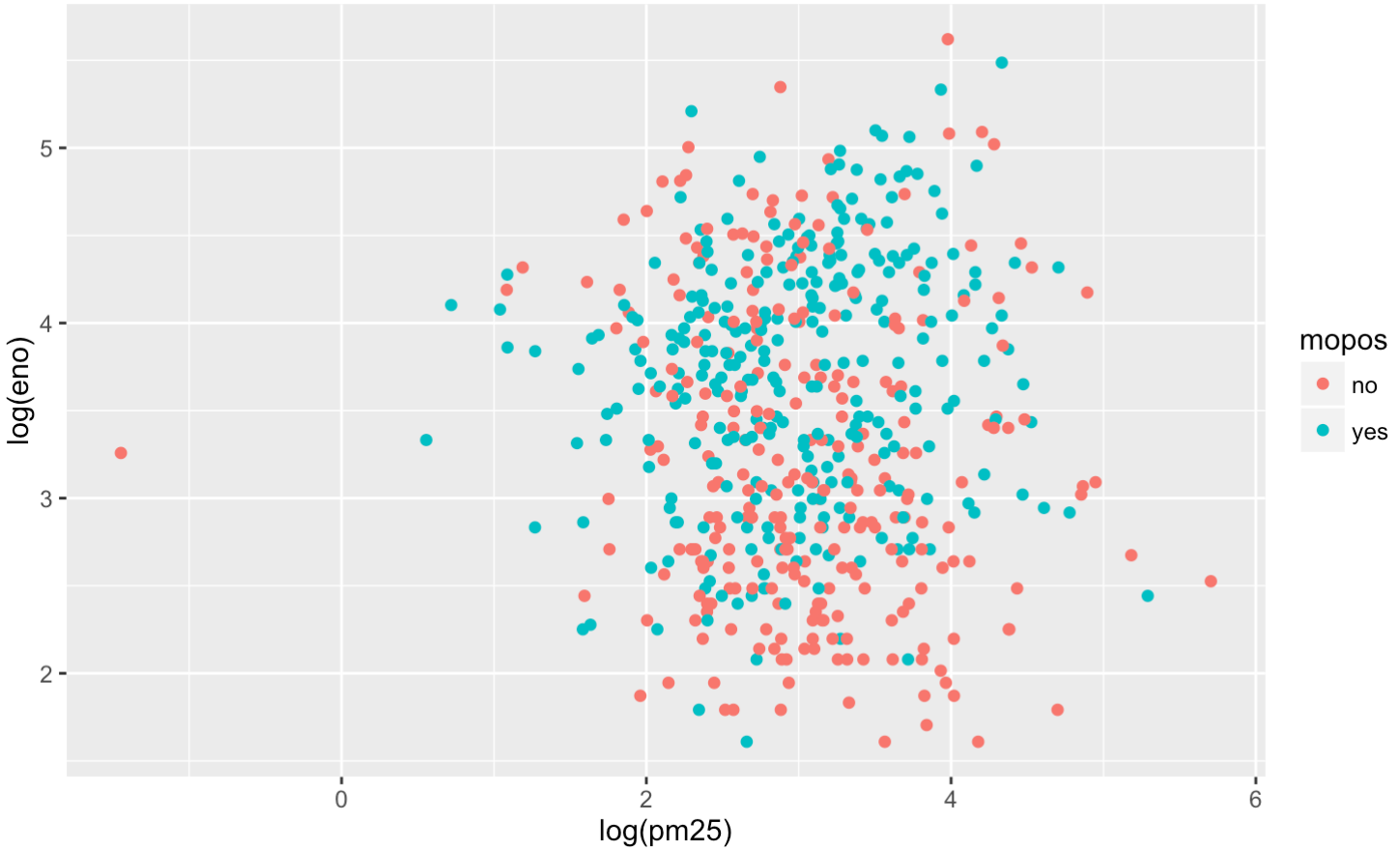
```
ggplot(data=maacs, aes(x=log(pm25), y=log(eno))) + geom_point(aes(shape=mopos))
```




```
#qplot(log(pm25), log(eno), data = maacs, shape = mopos)
```

Scatterplots: eNO vs. $PM_{2.5}$

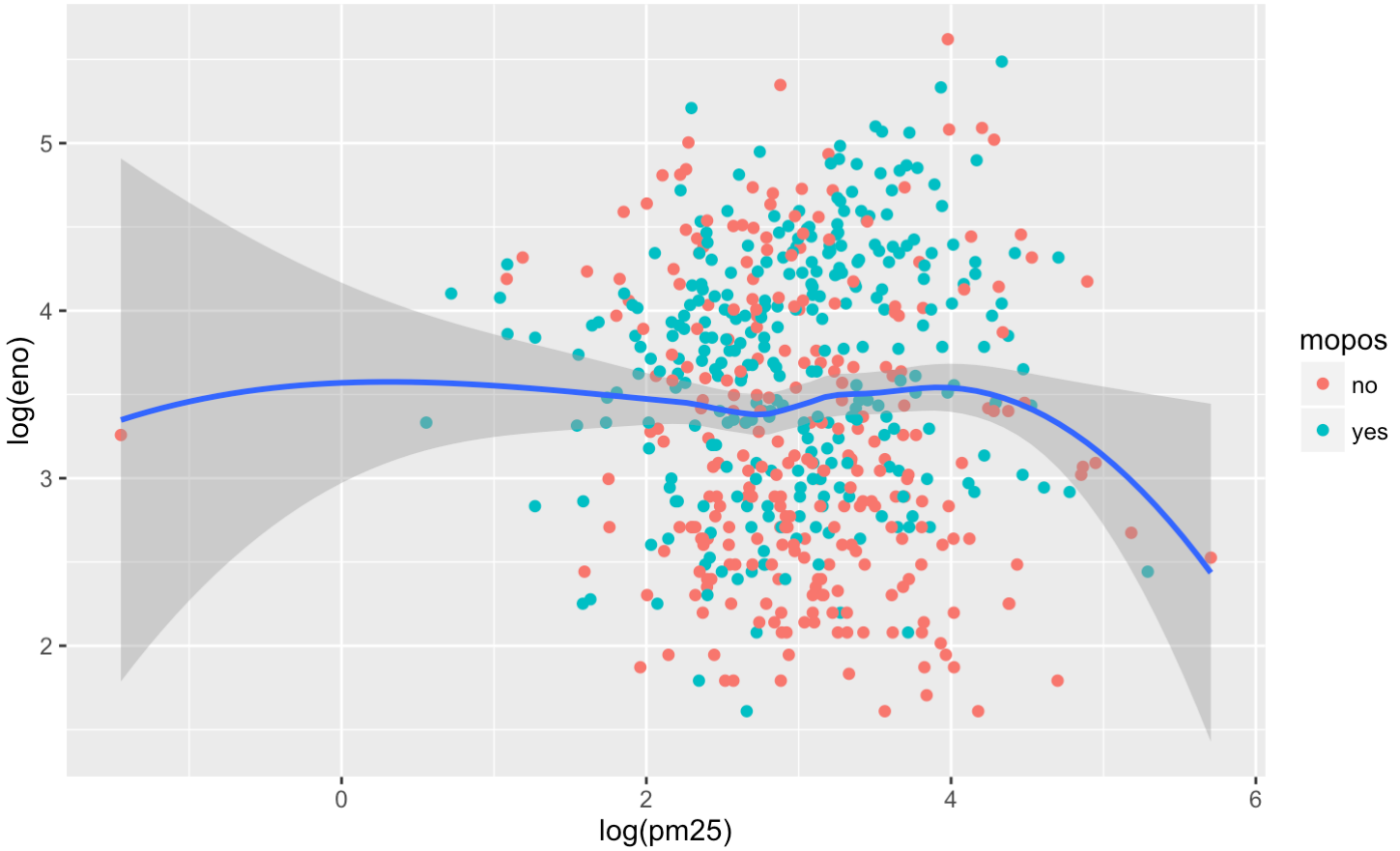
```
ggplot(data=maacs, aes(x=log(pm25), y=log(eno))) + geom_point(aes(colour=mopos))
```




```
#qplot(log(pm25), log(eno), data = maacs, color = mopos)
```

Scatterplots: eNO vs. $PM_{2.5}$

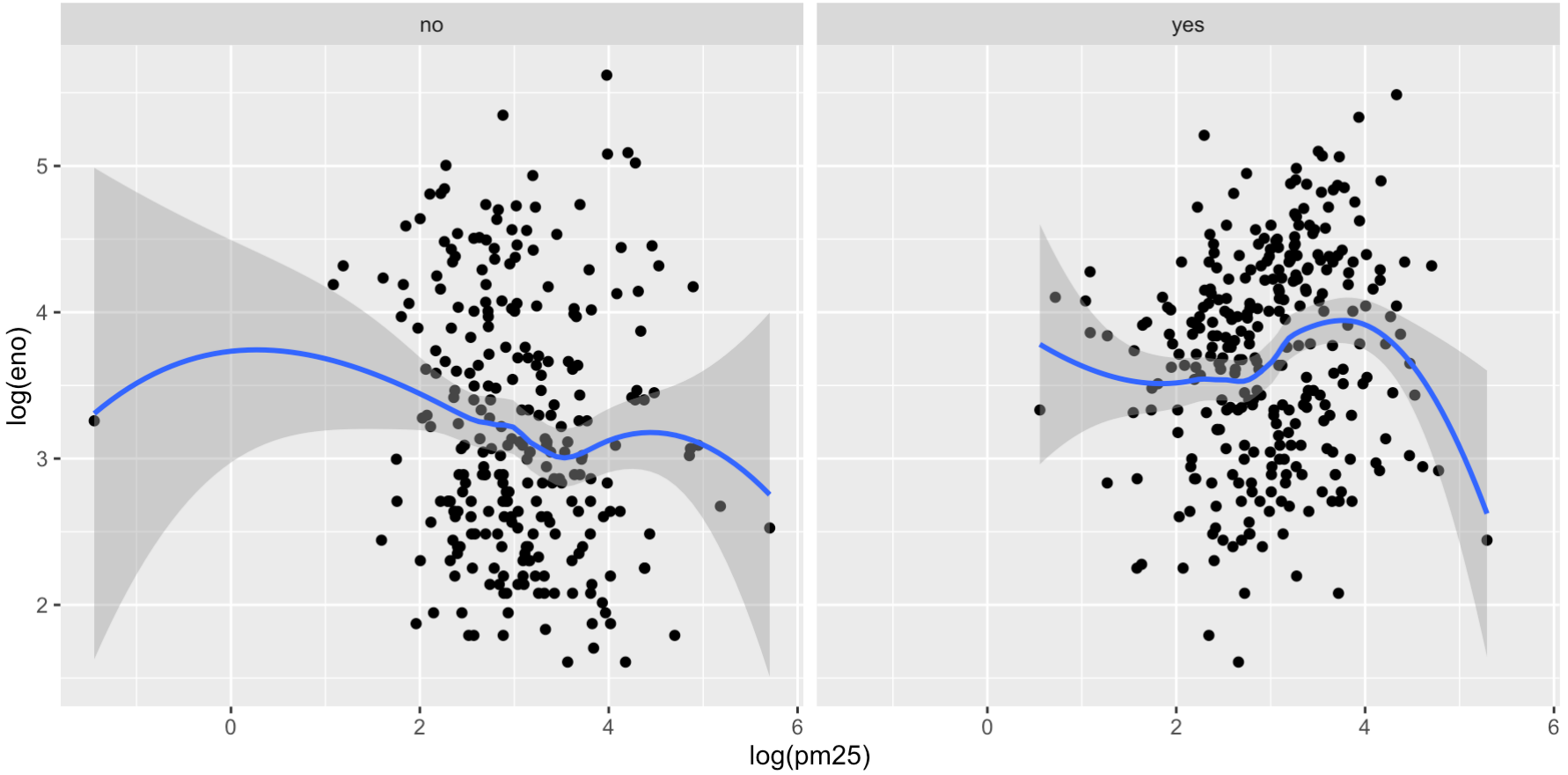
```
ggplot(data=maacs, aes(log(pm25), log(eno))) + geom_point(aes(colour=mopos)) + geom_smooth()
```




```
#qplot(log(pm25), log(eno), data = maacs, color = mopos, geom = c("point", "smooth"))
```

Scatterplots: eNO vs. $PM_{2.5}$

```
ggplot(data=maacs, aes(log(pm25), log(eno))) + geom_point() +
  geom_smooth() + facet_grid(.~mopos)
```

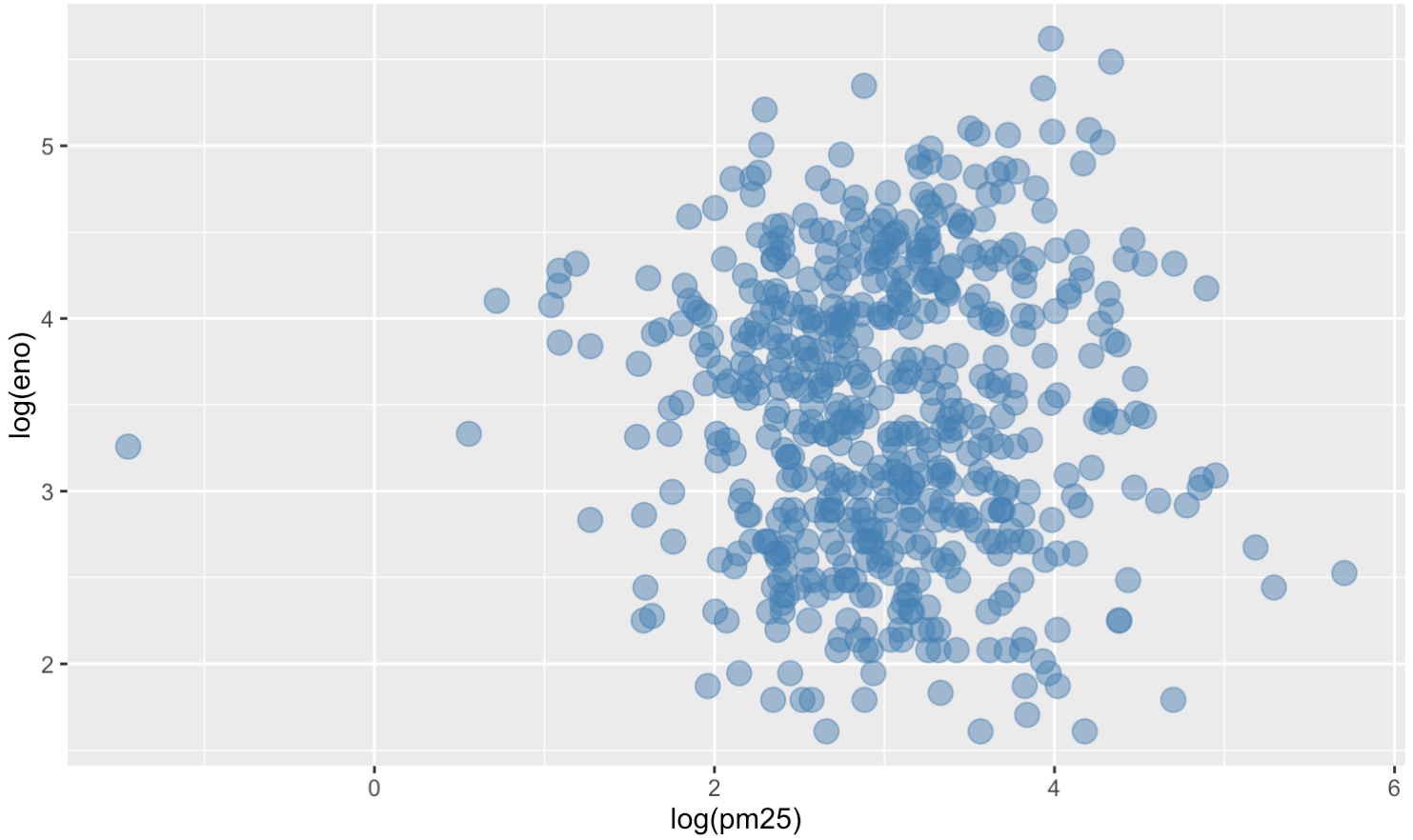


註解層

- 標籤(Labels): `xlab()`, `ylab()`, `labs()`, `ggtitle()`
- 每個幾何物件 (“geom_xxx”) 都有參數可以修改
- 整張圖的屬性修改，可以使用 `theme()`
  - Example: `theme(legend.position = "none")`
- ggplot2 內建兩套「主題」
  - `theme_gray()`: 預設主題 (灰底)
  - `theme_bw()`: 黑白主題，較乾淨

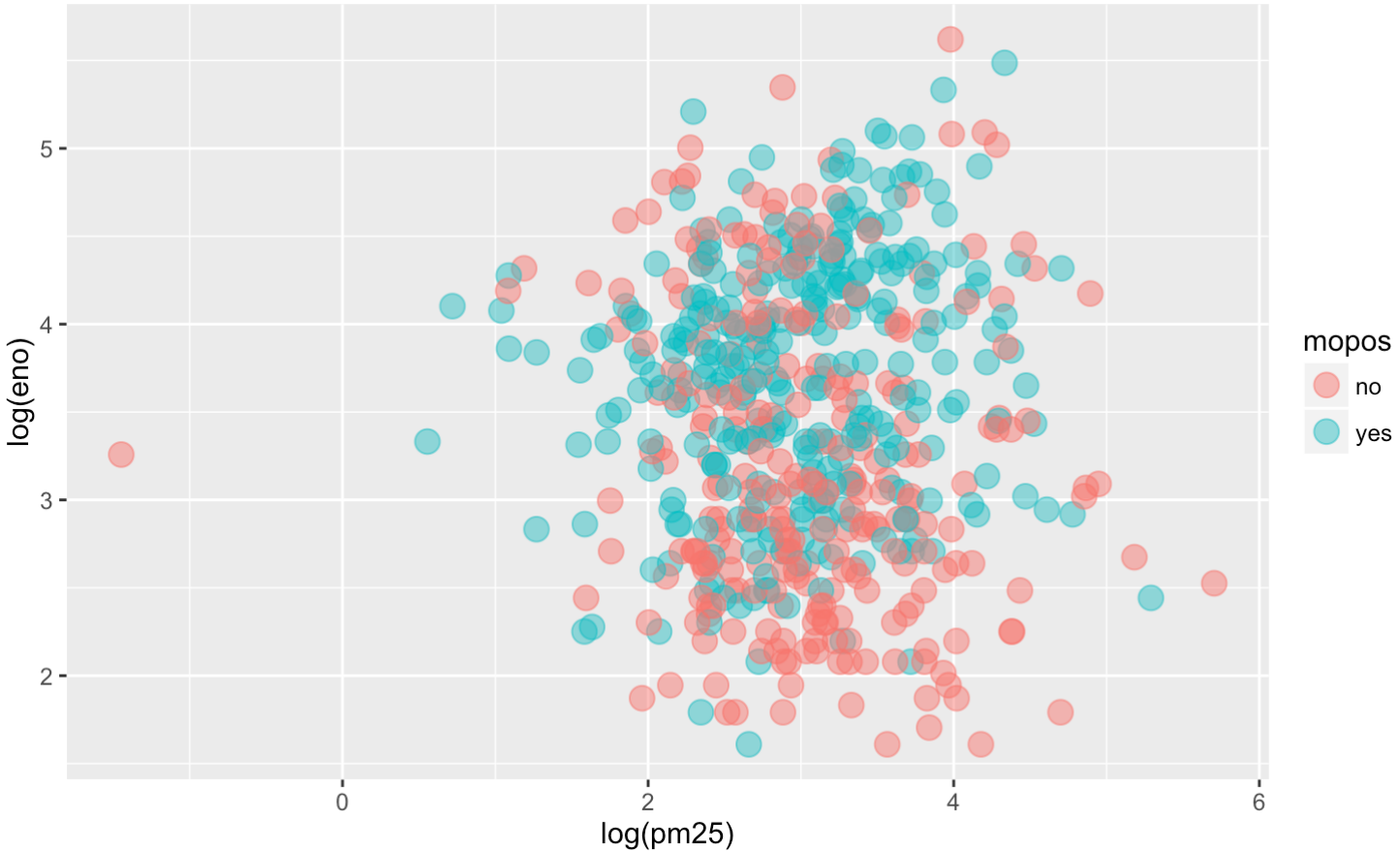
修改美學設定（aes）

```
g <- ggplot(maacs, aes(log(pm25), log(eno)))
g + geom_point(color = "steelblue", size = 4, alpha = 1/2)
```



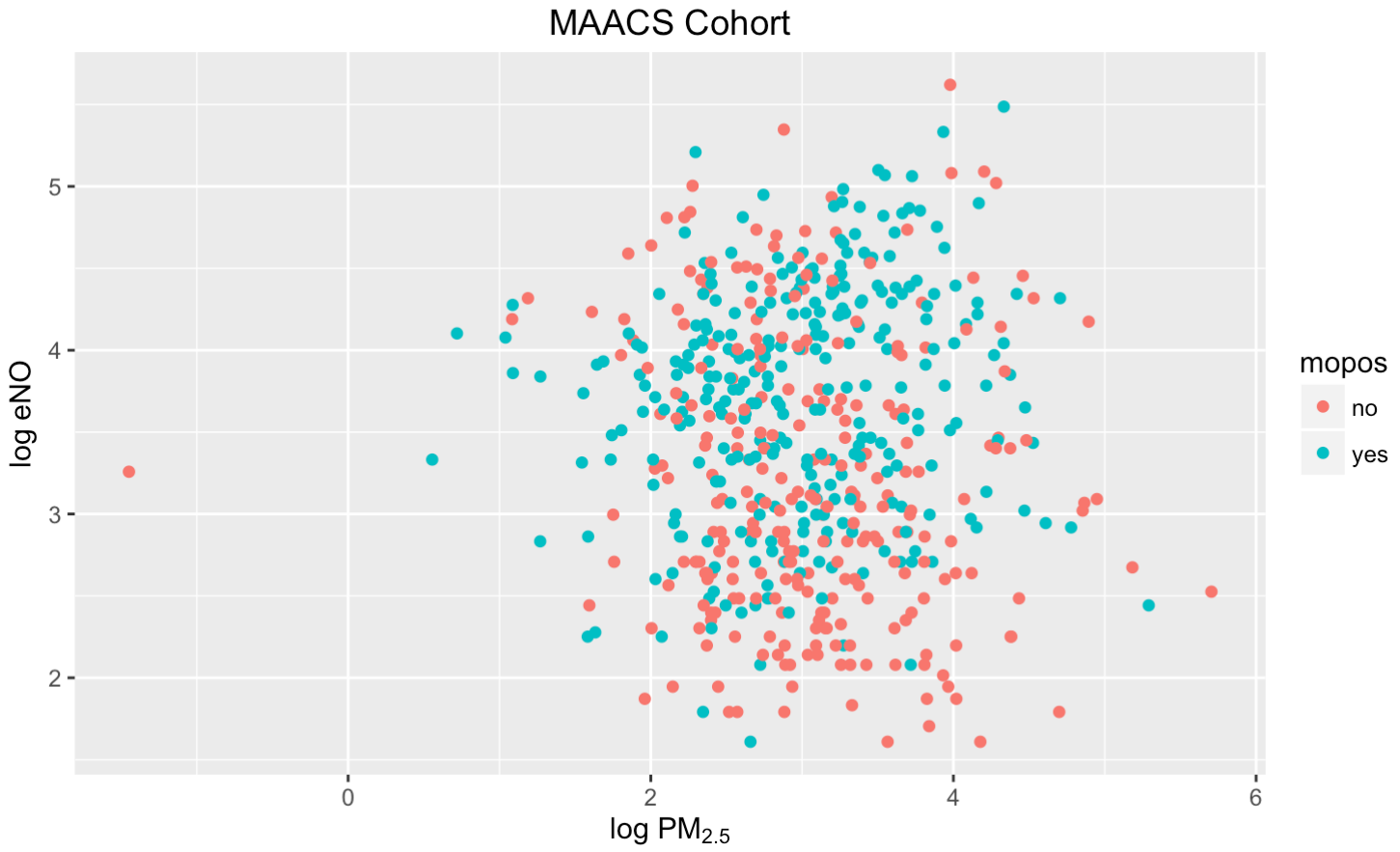
修改美學設定（aes）

```
g + geom_point(aes(color = mopos), size = 4, alpha = 1/2)
```



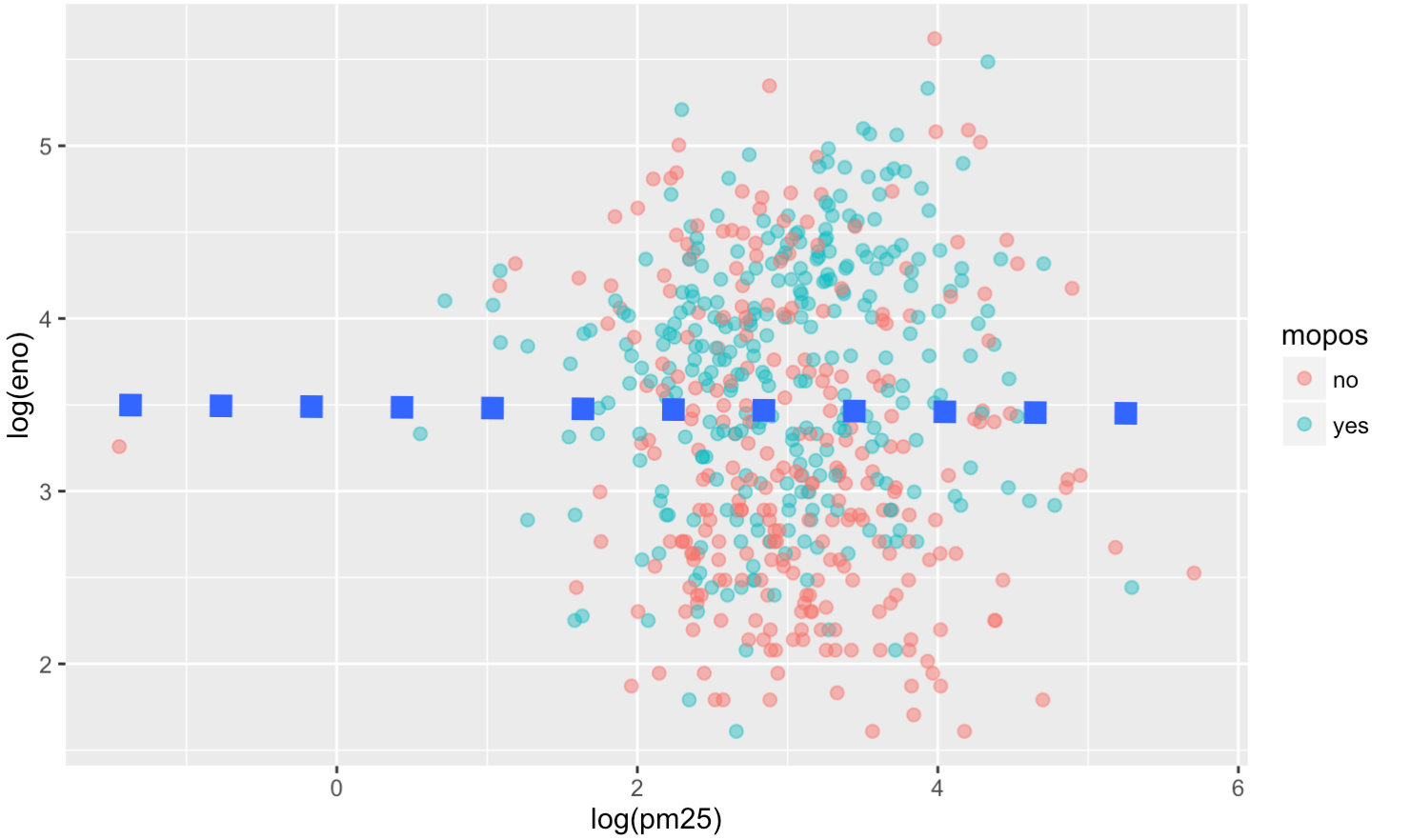
修改標籤設定

```
g + geom_point(aes(color = mopos)) + labs(title = "MAACS Cohort") +
    labs(x = expression("log " * PM[2.5]), y = expression("log " * eNO))
```



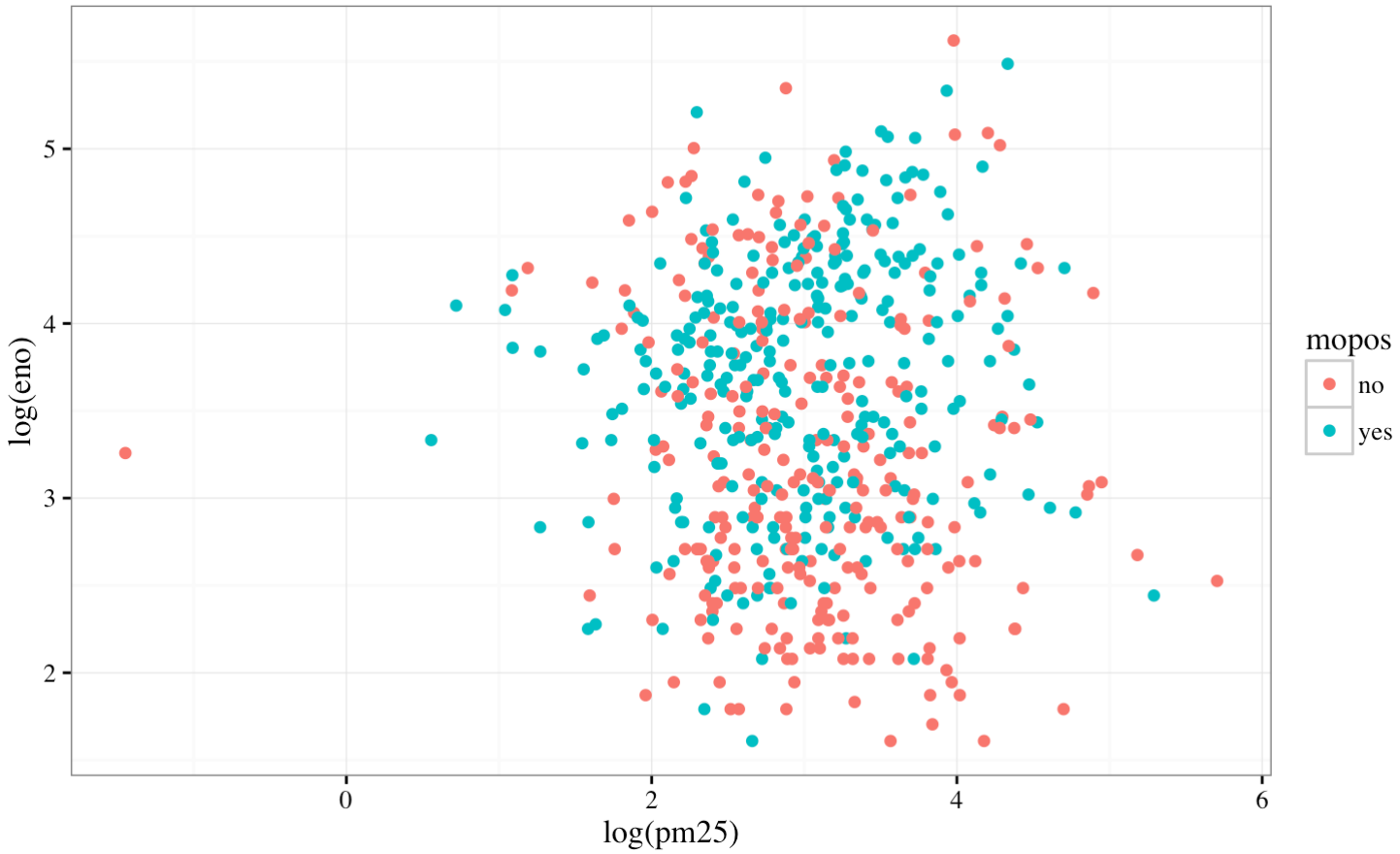
自定 smooth 設定

```
g + geom_point(aes(color = mopos), size = 2, alpha = 1/2) +
    geom_smooth(size = 4, linetype = 3, method = "lm", se = FALSE)
```



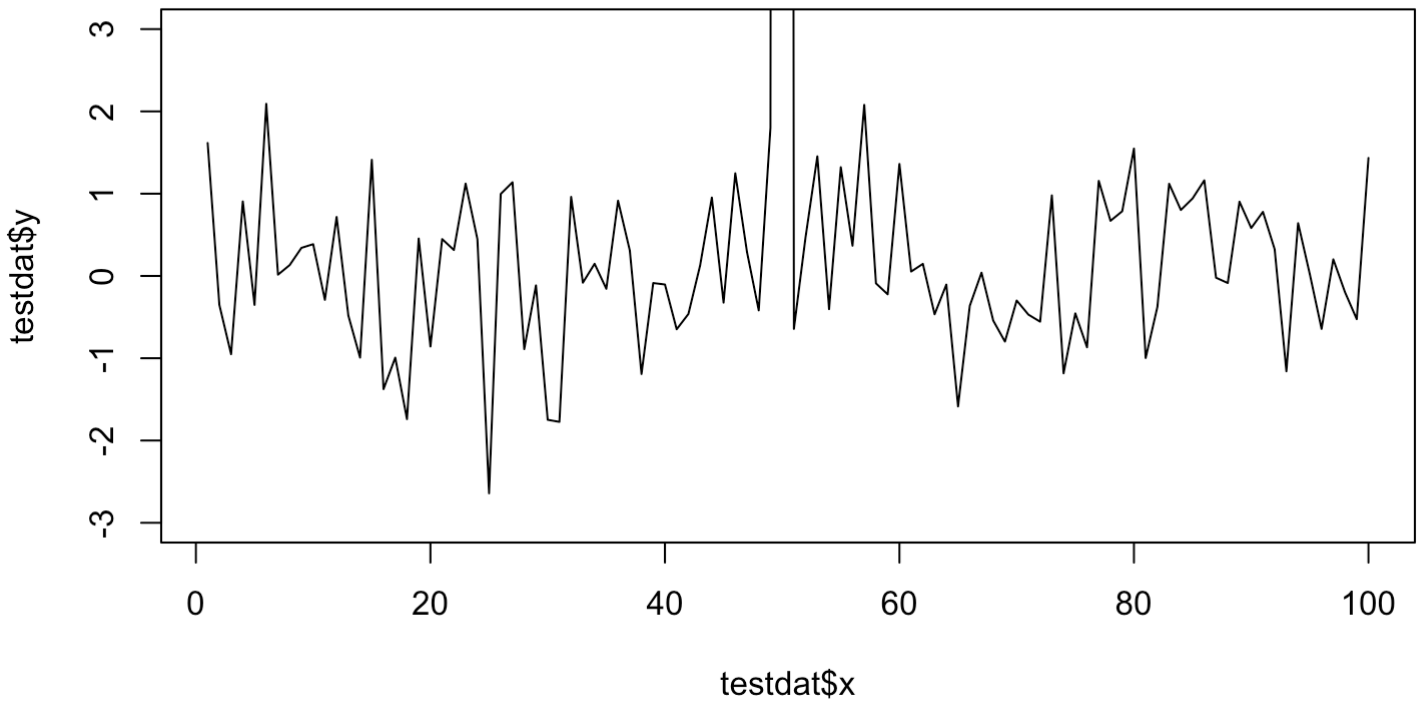
更改主題

```
g + geom_point(aes(color = mopos)) + theme_bw(base_family = "Times")
```



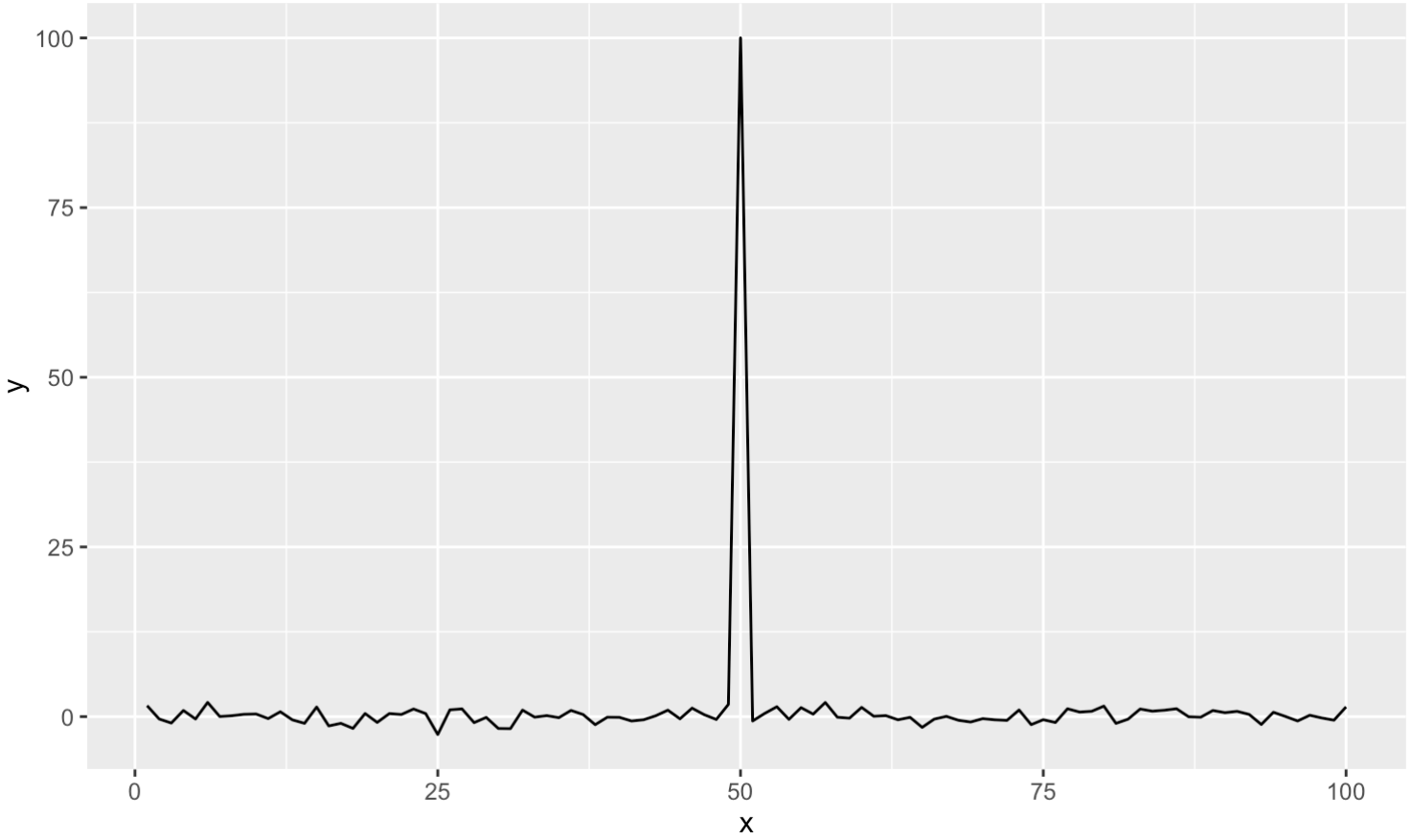
座標軸範圍

```
testdat <- data.frame(x = 1:100, y = rnorm(100))
testdat[50,2] <- 100  ## Outlier!
plot(testdat$x, testdat$y, type = "l", ylim = c(-3,3))
```



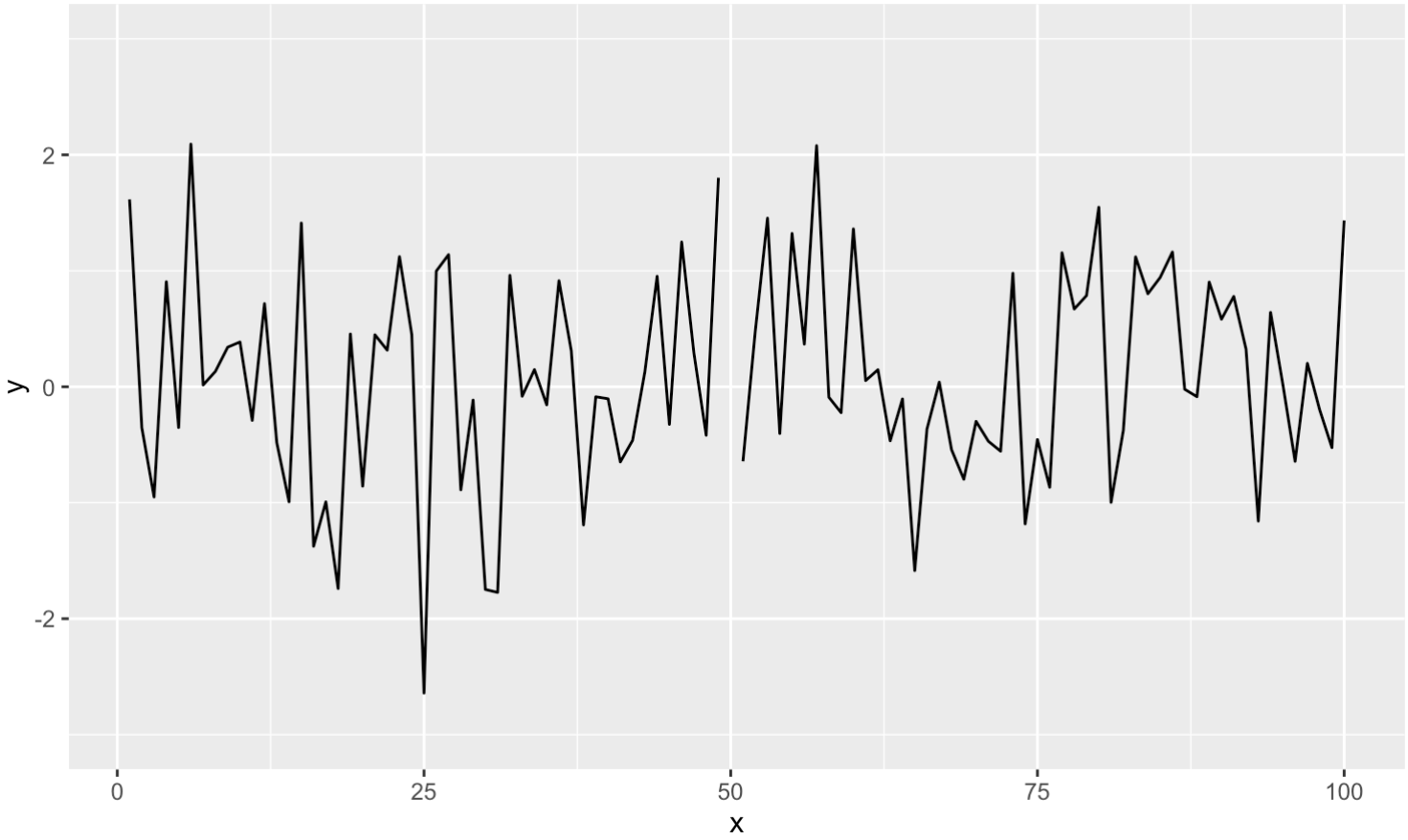
座標軸範圍

```
g <- ggplot(testdat, aes(x = x, y = y))
g + geom_line()
```



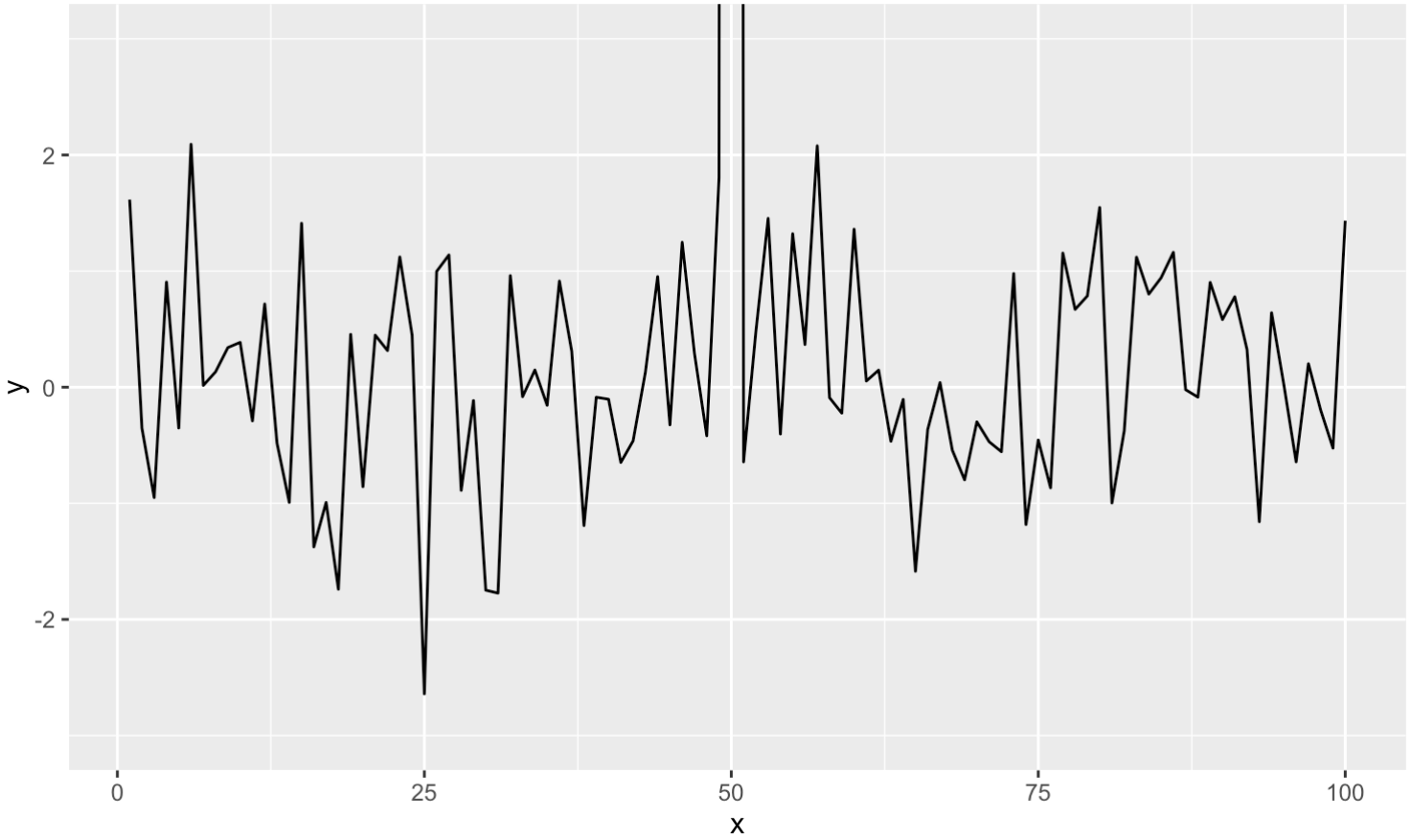
座標軸範圍

```
g + geom_line() + ylim(-3, 3)
```



座標軸範圍

```
g + geom_line() + coord_cartesian(ylim = c(-3, 3))
```



小結

- ggplot2 是非常強大的繪圖工具
  - Hadley Wickham 的 *ggplot2* 參考書
  - Winston Chang 的 *R Graphics Cookbook* 參考書
  - ggplot2 網站 (http://ggplot2.org)
  - ggplot2 論壇 (http://goo.gl/OdW3uB)（開發者為主）
- 有些圖需要使用 ggplot2 以外的套件
- 用範例學習：選你想要畫的圖，看程式碼，然後修改
  - R Graphics by *Paul Murrell*
  - The R Graph Gallery