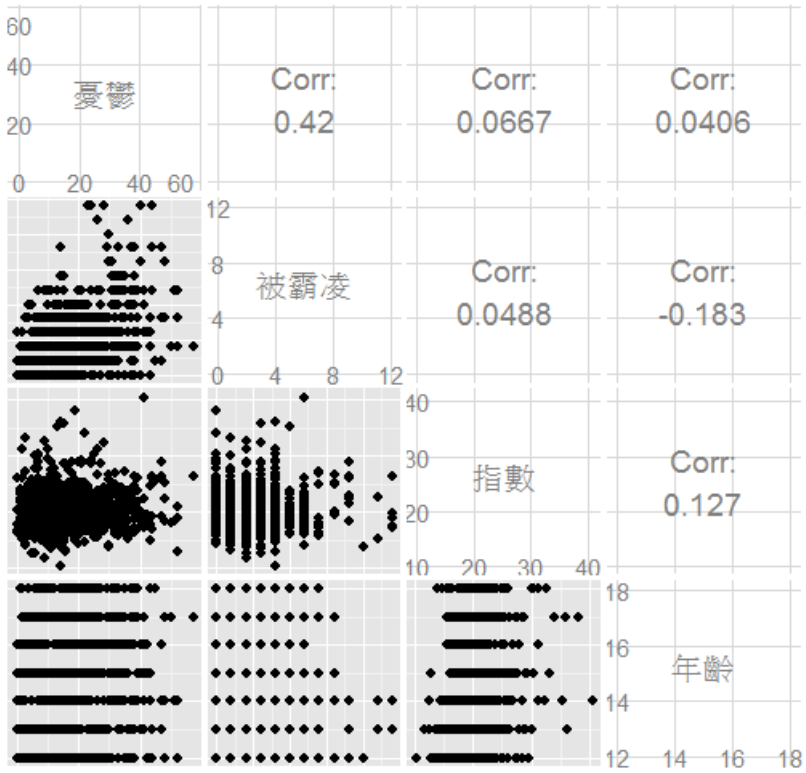
```
> #讀檔案，這是一般的文字檔，可以用 notepad 開啟
> dta <- read.table("bully.txt", header = TRUE)
>
> #看一下資料結構、前六筆、基本統計量
> #程式報表 4.1
> head(dta)
  性別 憂鬱 被霸凌  指數 年齡
1   女   29      3 18.49   17
2   女    4      0 20.17   15
3   女    3      2 15.63   16
4   女   20      1 21.48   18
5   女   25      4 18.43   15
6   女   24      3 16.29   13
> str(dta)
'data.frame':   2000 obs. of  5 variables:
 $ 性別  : Factor w/ 2 levels "女","男": 1 1 1 1 1 1 1 1 1 1 ...
 $ 憂鬱  : int  29 4 3 20 25 24 16 13 10 9 ...
 $ 被霸凌: int  3 0 2 1 4 3 0 3 0 0 ...
 $ 指數  : num  18.5 20.2 15.6 21.5 18.4 ...
 $ 年齡  : int  17 15 16 18 15 13 17 17 17 13 ...
> summary(dta)
 性別           憂鬱            被霸凌
 女:1000   Min.   : 0.00   Min.   : 0.000
 男:1000   1st Qu.: 8.00   1st Qu.: 0.000
           Median :14.00   Median : 2.000
           Mean   :15.73   Mean   : 2.028
           3rd Qu.:21.00   3rd Qu.: 3.000
           Max.   :57.00   Max.   :12.000
      指數            年齡
 Min.   :10.23   Min.   :12.00
 1st Qu.:18.07   1st Qu.:13.00
 Median :19.95   Median :15.00
 Mean   :20.57   Mean   :14.86
 3rd Qu.:22.39   3rd Qu.:16.00
 Max.   :42.98   Max.   :19.00
>
> #選取青少女與青少男資料，分別稱做 dta_f、dta_m
> dta_f <- subset(dta, 性別 == '女')
```

```
> dta_m <- subset(dta, 性別 != '女')
>
> #看一下變項間關聯
> #圖 4.2
> require(GGally)
> windows()
> ggpairs(dta_f[,-1], axisLabels= 'internal')
>
```



```
> #Baron & kenny（1986） 的四步驟，以青少女（dta_f）示範
> #程式報表 4.2
> summary(lm(憂鬱~指數+年齡,data=dta_f))
                Y=X+C

Call:
lm(formula = 憂鬱 ~ 指數 + 年齡, data = dta_f)

Residuals:
    Min      1Q  Median      3Q     Max
-17.314  -7.989  -1.898   5.656  38.675

Coefficients:
            Estimate Std. Error t value
(Intercept) 10.02785    3.16967   3.164
指數         0.19427    0.09897   1.963
年齡         0.18671    0.18191   1.026
            Pr(>|t|)
(Intercept)   0.0016 **
指數          0.0499 *
年齡          0.3050
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 10.43 on 997 degrees of freedom
Multiple R-squared:  0.005495,  Adjusted R-squared:  0.0035
F-statistic: 2.755 on 2 and 997 DF,  p-value: 0.06412

> summary(m2<-lm(被霸凌~指數+年齡,data=dta_f))
                    M=X+C

Call:
lm(formula = 被霸凌 ~ 指數 + 年齡, data = dta_f)

Residuals:
   Min     1Q Median     3Q    Max
-3.122 -1.550 -0.394  1.023  9.776

Coefficients:
```

```
            Estimate Std. Error t value
(Intercept)  4.38104    0.60376   7.256
指數          0.04418    0.01885   2.344
年齡         -0.21343    0.03465  -6.160
            Pr(>|t|)
(Intercept) 7.99e-13 ***
指數          0.0193 *
年齡         1.06e-09 ***
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.987 on 997 degrees of freedom
Multiple R-squared:  0.03896,   Adjusted R-squared:  0.03703
F-statistic: 20.21 on 2 and 997 DF,  p-value: 2.498e-09

> summary(lm(憂鬱~被霸凌+年齡,data=dta_f))
```

Y=M+C

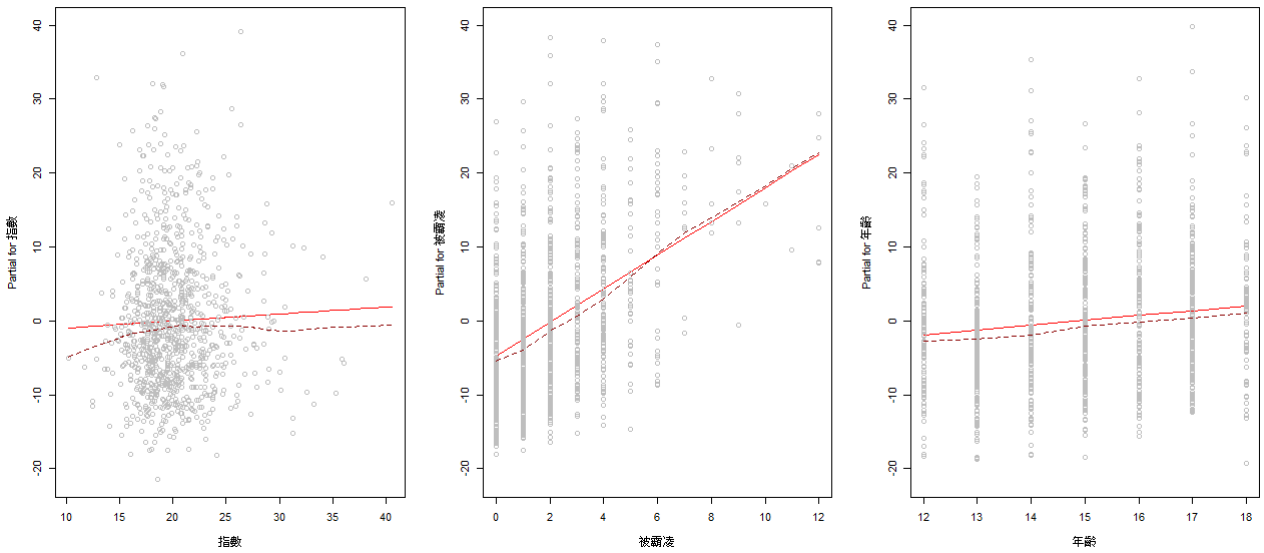
```
Call:
lm(formula = 憂鬱 ~ 被霸凌 + 年齡, data = dta_f)

Residuals:
    Min      1Q  Median      3Q     Max
-21.516  -6.737  -1.313   5.258  39.031

Coefficients:
            Estimate Std. Error t value
(Intercept)   1.5685     2.5636   0.612
被霸凌         2.2839     0.1496  15.271
年齡           0.6960     0.1656   4.204
            Pr(>|t|)
(Intercept)    0.541
被霸凌        < 2e-16 ***
年齡         2.85e-05 ***
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
Residual standard error: 9.408 on 997 degrees of freedom
Multiple R-squared:  0.1909,    Adjusted R-squared:  0.1893
F-statistic: 117.6 on 2 and 997 DF,  p-value: < 2.2e-16

> summary(m4<-lm(憂鬱~指數+被霸凌+年齡,data=dta_f))
```

Y=X+M+C

```
Call:
lm(formula = 憂鬱 ~ 指數 + 被霸凌 + 年齡, data = dta_f)

Residuals:
    Min      1Q  Median      3Q     Max
-21.270  -6.697  -1.322   5.247  38.488

Coefficients:
            Estimate Std. Error t value
(Intercept)  0.07306    2.93335   0.025
指數         0.09388    0.08951   1.049
被霸凌       2.27224    0.14996  15.152
年齡         0.67168    0.16716   4.018
            Pr(>|t|)
(Intercept)    0.980
指數           0.295
被霸凌       < 2e-16 ***
年齡        6.31e-05 ***
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.408 on 996 degrees of freedom
Multiple R-squared:  0.1918,    Adjusted R-squared:  0.1894
F-statistic: 78.79 on 3 and 996 DF,  p-value: < 2.2e-16

>
> #把結果記下來，等一下要用
> res_f <- lapply(list(m2, m4), summary)
> 將模型 2 與 4 的迴歸分析結果存起來，放到 res_f
> #部分殘差圖，先設定一張圖分成三小圖
> #圖 4.3
```

```
> windows()
> par(mfrow = c(1, 3))
> termplot(m4, partial.resid = T, smooth = panel.smooth)
>
```




```
> #Sobel test
> #擷取回迴歸係數與標準誤
> a <- c(Est = res_f[[1]]$coef['指數', 'Estimate'],
+        SE = res_f[[1]]$coef['指數', 'Std. Error' ])
將回歸分析結果的模型 2 的變數  指數  取其  估計值  放到 a 的 Est
                              指數        標準誤  放到 a 的 SE

> b <- c(Est = res_f[[2]]$coef['被霸凌', 'Estimate'],
+        SE = res_f[[2]]$coef['被霸凌', 'Std. Error'])
>
> #計算中介效果與標準誤，並進行檢驗
> ab <- a['Est'] * b['Est']
> abse <- sqrt(a['Est']^2 * b['SE']^2 + b['Est']^2 * a['SE']^2)
> c(ab, z_ab = ab/abse, pz_ab = 2 * (1 - pnorm(abs(ab/abse))))
       Est    z_ab.Est   pz_ab.Est
0.10039345 2.31611999 0.02055172
>
>
```

```
> #利用拔靴法計算中介效果信賴區間
> #先載入 alr3 套件，用來協助拔靴法
> require(alr3)
>
> #記得兩邊的隨機種子要設定成一樣
> set.seed(2014)
> beta4_bt <- bootCase(m4, B = 1001)
                        依據模型 4 的解釋變項與結果變項，從 table 中隨機抽取 1001 筆
> set.seed(2014)
> beta2_bt <- bootCase(m2, B = 1001)
>
> #擷取中介效果
> ab_bt <- beta4_bt[,3] * beta2_bt[,2]
> c("Bootstrap SD" = sd(ab_bt), quantile(ab_bt, c(.025, .975)))
Bootstrap SD         2.5%        97.5%
  0.04900917   0.00839909   0.20318546
>
>
> #如果沒有共變量，可以用 MBESS 套件
> require(MBESS)
> mediation(dv=dta$憂鬱, x=dta$指數, mediator=dta$被霸凌,
+   bootstrap = TRUE, B = 1001)
[1] "Bootstrap resampling has begun. This process may take a considerable amount
of time if the number of replications is large, which is optimal for the
bootstrap procedure."
$Y.on.X
$Y.on.X$Regression.Table
               Estimate Std. Error  t value
Intercept.Y_X 12.312533 1.25466790 9.813380
c (Regressor)  0.166117 0.06002179 2.767611
                   p(>|t|) Low Conf Limit
Intercept.Y_X 3.10760e-22     9.85193892
c (Regressor) 5.69894e-03     0.04840514
              Up Conf Limit
Intercept.Y_X    14.7731279
c (Regressor)     0.2838288
```

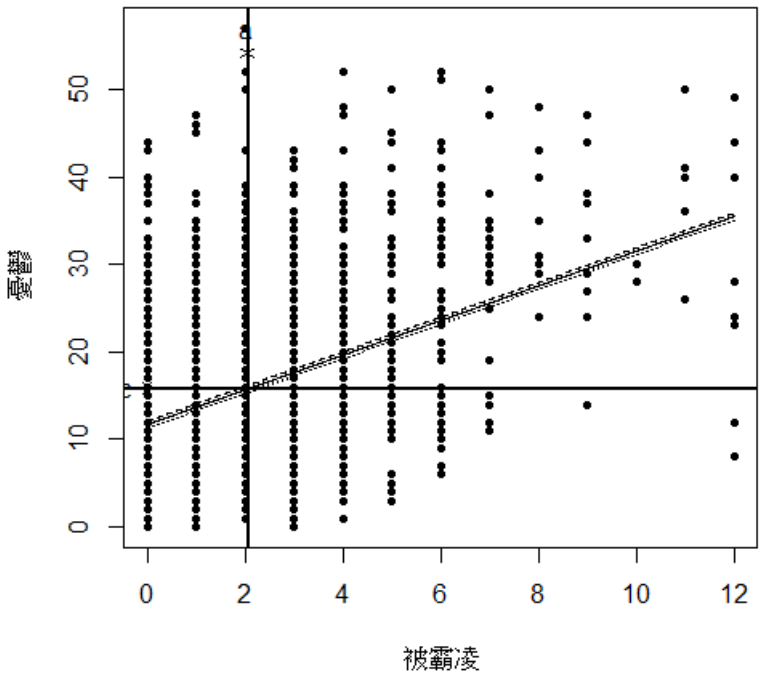
```
$Y.on.X$Model.Fit
       Residual standard error (RMSE)
Values                       9.944107
       numerator df denomenator df F-Statistic
Values            1            1998     7.659673
       p-value (F)          R^2     Adj R^2
Values  0.00569894 0.003819029 0.00332044
       Low Conf Limit Up Conf Limit
Values    0.0003219108     0.01109221


$M.on.X
$M.on.X$Regression.Table
                Estimate Std. Error  t value
Intercept.M_X 1.40505242 0.25286861 5.556452
a (Regressor) 0.03028038 0.01209693 2.503146
                   p(>|t|) Low Conf Limit
Intercept.M_X 3.121650e-08     0.909138628
a (Regressor) 1.238872e-02     0.006556463
              Up Conf Limit
Intercept.M_X    1.90096620
a (Regressor)    0.05400429

$M.on.X$Model.Fit
       Residual standard error (RMSE)
Values                       2.004158
       numerator df denomenator df F-Statistic
Values            1            1998     6.265741
       p-value (F)          R^2      Adj R^2
Values  0.01238872 0.003126202 0.002627267
       Low Conf Limit Up Conf Limit
Values    0.0001347526    0.009895351


$Y.on.X.and.M
$Y.on.X.and.M$Regression.Table
                     Estimate Std. Error
Intercept.Y_XM      9.5328005 1.15976353
```

```
c.prime (Regressor) 0.1062108 0.05514418
b (Mediator)        1.9783837 0.10182325
                      t value      p(>|t|)
Intercept.Y_XM       8.219607 3.629793e-16
c.prime (Regressor)  1.926056 5.423918e-02
b (Mediator)        19.429587 3.689300e-77
                   Low Conf Limit
Intercept.Y_XM         7.258327273
c.prime (Regressor)   -0.001935371
b (Mediator)           1.778692806
                   Up Conf Limit
Intercept.Y_XM         11.8072738
c.prime (Regressor)     0.2143569
b (Mediator)            2.1780747

$Y.on.X.and.M$Model.Fit
      Residual standard error (RMSE)
Values                       9.121718
      numerator df denomenator df F-Statistic
Values            2            1997     193.306
      p-value (F)       R^2   Adj R^2
Values           0 0.1621958 0.1613568
      Low Conf Limit Up Conf Limit
Values      0.1330078     0.1920668


$Bootstrap.Results
                                                        Estimate
Indirect.Effect                                      0.0599062043
Indirect.Effect.Partially.Standardized               0.0060142818
Index.of.Mediation                                   0.0222861092
R2_4.5                                               0.0022626971
R2_4.6                                               0.0004970161
R2_4.7                                               0.0030642962
Maximum.Possible.Mediation.Effect                    2.5236966551
ab.to.Maximum.Possible.Mediation.Effect_kappa.squared 0.0237374821
Ratio.of.Indirect.to.Total.Effect                    0.3606266040
Ratio.of.Indirect.to.Direct.Effect                   0.5640312941
```

Success.of.Surrogate.Endpoint	5.4859617182
Residual.Based_Gamma	0.0009911213
Residual.Based.Standardized_gamma	-0.0007592795
SOS	0.5924796469
	CI.Lower_Percentile
Indirect.Effect	9.000927e-03
Indirect.Effect.Partially.Standardized	8.933514e-04
Index.of.Mediation	3.372740e-03
R2_4.5	1.553956e-05
R2_4.6	1.389828e-05
R2_4.7	9.521230e-05
Maximum.Possible.Mediation.Effect	2.347404e+00
ab.to.Maximum.Possible.Mediation.Effect_kappa.squared	3.940874e-03
Ratio.of.Indirect.to.Total.Effect	6.134400e-02
Ratio.of.Indirect.to.Direct.Effect	-3.517826e+00
Success.of.Surrogate.Endpoint	1.013742e+00
Residual.Based_Gamma	-6.897989e-04
Residual.Based.Standardized_gamma	-3.094809e-03
SOS	5.632845e-02
	CI.Upper_Percentile
Indirect.Effect	0.117003445
Indirect.Effect.Partially.Standardized	0.011683645
Index.of.Mediation	0.042698798
R2_4.5	0.006300371
R2_4.6	0.001818483
R2_4.7	0.010140166
Maximum.Possible.Mediation.Effect	2.671731123
ab.to.Maximum.Possible.Mediation.Effect_kappa.squared	0.045616818
Ratio.of.Indirect.to.Total.Effect	1.279072134
Ratio.of.Indirect.to.Direct.Effect	4.829165174
Success.of.Surrogate.Endpoint	19.569267432
Residual.Based_Gamma	0.004079000
Residual.Based.Standardized_gamma	0.003080666
SOS	0.982422260
	CI.Lower_BCa
Indirect.Effect	NA
Indirect.Effect.Partially.Standardized	NA
Index.of.Mediation	NA

R2_4.5	NA
R2_4.6	NA
R2_4.7	NA
Maximum.Possible.Mediation.Effect	NA
ab.to.Maximum.Possible.Mediation.Effect_kappa.squared	NA
Ratio.of.Indirect.to.Total.Effect	NA
Ratio.of.Indirect.to.Direct.Effect	NA
Success.of.Surrogate.Endpoint	NA
Residual.Based_Gamma	NA
Residual.Based.Standardized_gamma	NA
SOS	NA
	CI.Upper_BCa
Indirect.Effect	NA
Indirect.Effect.Partially.Standardized	NA
Index.of.Mediation	NA
R2_4.5	NA
R2_4.6	NA
R2_4.7	NA
Maximum.Possible.Mediation.Effect	NA
ab.to.Maximum.Possible.Mediation.Effect_kappa.squared	NA
Ratio.of.Indirect.to.Total.Effect	NA
Ratio.of.Indirect.to.Direct.Effect	NA
Success.of.Surrogate.Endpoint	NA
Residual.Based_Gamma	NA
Residual.Based.Standardized_gamma	NA
SOS	NA

```
> #中介效果與總效果圖
> #圖 4.4
> windows()
> mediation.effect.plot(dv=dta$憂鬱, x=dta$指數, mediator=dta$被霸凌,
+                       legend.loc=NA, ylab = '憂鬱', xlab = '被霸凌')
>
>
```

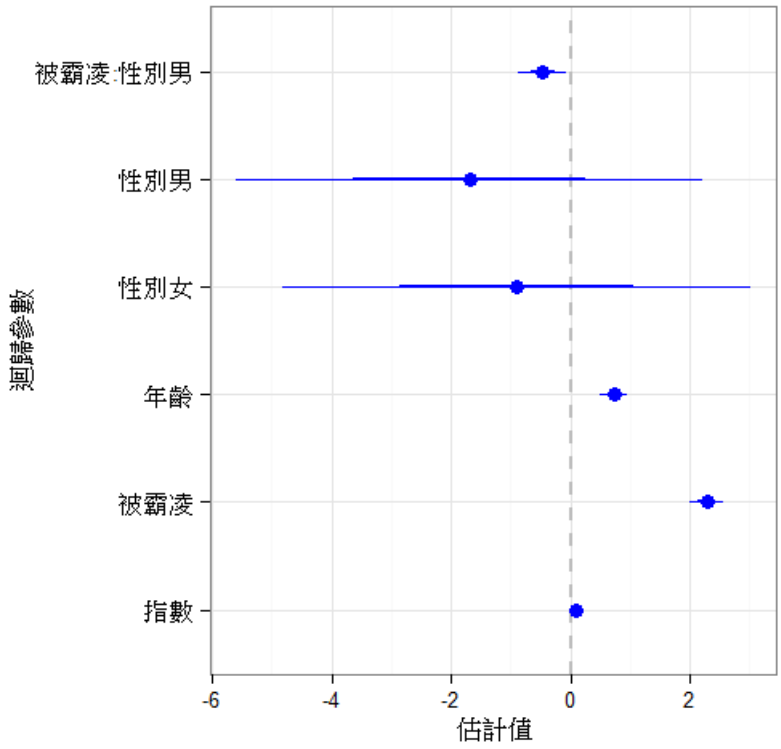



```
> #調節效果
> #驗證性別對指數到被霸凌影響力的調節效果
> ml_fl <- lm(被霸凌 ~ 指數 + 年齡 + 性別 + 指數:性別, data = dta)
> ml_rd <- update(ml_fl, . ~ . - 指數:性別)
> anova(ml_rd, ml_fl)
Analysis of Variance Table

Model 1: 被霸凌 ~ 指數 + 年齡 + 性別
Model 2: 被霸凌 ~ 指數 + 年齡 + 性別 + 指數:性別
  Res.Df    RSS Df Sum of Sq      F Pr(>F)
1   1996 7860.4
2   1995 7860.2  1    0.1127 0.0286 0.8657
```

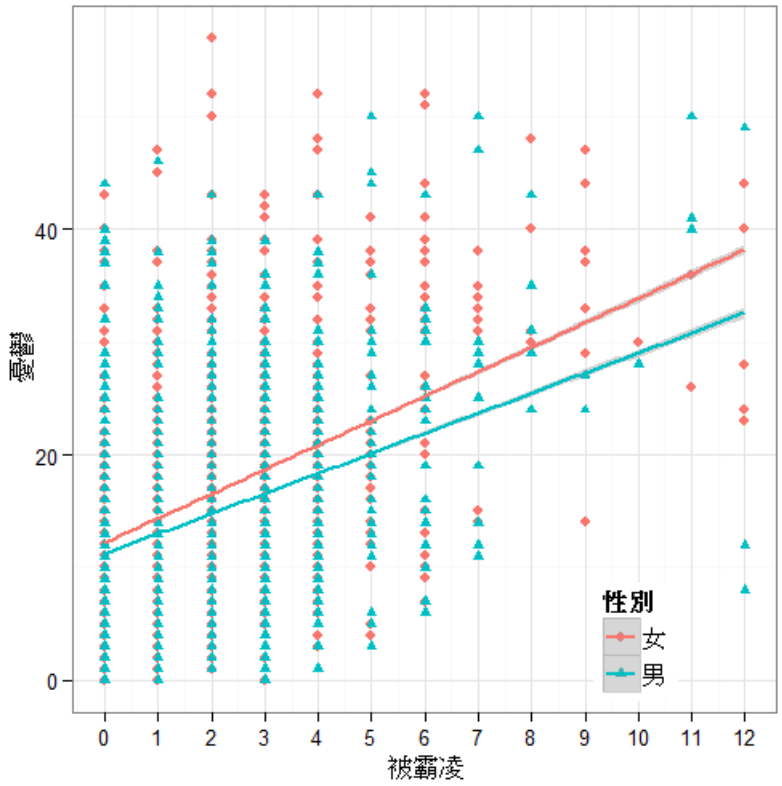
```
> summary(m1_f1)$r.sq - summary(m1_rd)$r.sq
[1] 1.39987e-05
>
> #驗證性別對指數到憂鬱影響力的調節效果
> m4_f1 <-lm(憂鬱 ~ 指數 + 被霸凌 + 年齡 + 性別 + 指數:性別,
+             data = dta)
> m4_rd <- update(m4_f1, . ~ . - 指數:性別)
> anova(m4_rd, m4_f1)
Analysis of Variance Table

Model 1: 憂鬱 ~ 指數 + 被霸凌 + 年齡 + 性別
Model 2: 憂鬱 ~ 指數 + 被霸凌 + 年齡 + 性別 + 指數:性別
  Res.Df    RSS Df Sum of Sq      F Pr(>F)
1   1995 161140
2   1994 161140  1   0.10592 0.0013 0.9711
> summary(m4_f1)$r.sq - summary(m4_rd)$r.sq
[1] 5.340786e-07
>
> #驗證性別對被霸凌到憂鬱影響力的調節效果
> m4_f12 <- update(m4_rd, . ~ . + 被霸凌:性別)
> anova(m4_rd, m4_f12)
Analysis of Variance Table

Model 1: 憂鬱 ~ 指數 + 被霸凌 + 年齡 + 性別
Model 2: 憂鬱 ~ 指數 + 被霸凌 + 年齡 + 性別 + 被霸凌:性別
  Res.Df    RSS Df Sum of Sq      F  Pr(>F)
1   1995 161140
2   1994 160704  1    436.61 5.4174 0.02004 *
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> summary(m4_f12)$r.sq - summary(m4_rd)$r.sq
[1] 0.00220142
>
> #計算相對解釋量差異
> 100*(summary(m4_f12)$r.sq - summary(m4_rd)$r.sq)/summary(m4_f12)$r.sq
[1] 1.160369
>
```

```
> #呈現迴歸結果
> #程式報表 4.3
> summary(m4_fl2)

Call:
lm(formula = 憂鬱 ~ 指數 + 被霸凌 + 年齡 + 性別 + 被霸凌:性別,
    data = dta)

Residuals:
    Min      1Q  Median      3Q     Max
-24.691  -6.475  -1.249   4.854  38.350

Coefficients:
              Estimate Std. Error t value
(Intercept)   -0.89795    1.96227  -0.458
指數           0.09593    0.05532   1.734
被霸凌         2.28217    0.14168  16.108
年齡           0.73259    0.11313   6.476
性別男        -0.79397    0.57505  -1.381
被霸凌:性別男 -0.46674    0.20053  -2.328
              Pr(>|t|)
(Intercept)     0.6473
指數            0.0831 .
被霸凌         < 2e-16 ***
年齡          1.19e-10 ***
性別男          0.1675
被霸凌:性別男   0.0200 *
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 8.977 on 1994 degrees of freedom
Multiple R-squared:  0.1897,    Adjusted R-squared:  0.1877
F-statistic: 93.37 on 5 and 1994 DF,  p-value: < 2.2e-16

>
```

```
> #呈現變項效果，載入 coefplot 套件
> require(coefplot)
>
> #記下設定
> old <- theme_set(theme_bw())
>
> #去除截距、把效果畫出來
> #圖 4.5
> windows()
> coefplot(update(m4_fl2, . ~ . - 1)) +
+  labs(x = '估計值', y = '迴歸參數', title = '')
>
```



```
>
> #利用 fortify 指令把資料加進結果中，方便畫圖
> m4_fy <- fortify(m4_fl2)
>
> #交互作用圖
> #圖 4.6
> windows()
> ggplot(data = m4_fy, aes(x = 被霸凌, y = .fitted, shape = 性別, color = 性
別 )) +
+  geom_point(aes(x = 被霸凌, y = 憂鬱, shape = 性別))+
+  stat_smooth(method = 'lm', size = 1) +
+  scale_x_continuous(breaks = 0:12) +
+  labs(x = '被霸凌', y = '憂鬱') +
+  theme(legend.position = c(.8, .1))
>
```



```
> #回覆色彩主題
> theme_set(old)
>
> #檢驗調節效果
> #此套件不支援中文，把變項換成英文
> require(pequod)
> dtaeng <- dta
> names(dtaeng) <- c('gender','dep','bully','BMI','age')
> dtaeng$gender <- as.numeric(dtaeng$gender=="男")
> summary(rslt <- lmres(dep~BMI+age+bully*gender, data=dtaeng))
Formula:
dep ~ BMI + age + bully + gender + bully.XX.gender
<environment: 0x0000000013ebb8b8>

Models
         R     R^2   Adj. R^2     F     df1
Model1  0.436  0.190     0.188 93.374  5.000
      df2  p.value
Model1 1994  <2e-16 ***
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residuals
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
-24.690  -6.475  -1.249   0.000   4.854  38.350

Coefficients
               Estimate   StdErr  t.value
(Intercept)     -0.89795  1.96227 -0.45761
BMI              0.09593  0.05532  1.73403
age              0.73259  0.11313  6.47550
bully            2.28217  0.14168 16.10766
gender          -0.79397  0.57505 -1.38070
bully.XX.gender -0.46674  0.20053 -2.32753
                   beta p.value
(Intercept)             0.64729
```

```
BMI              0.0357 0.08307 .
age              0.1332 < 2e-16 ***
bully            0.4598 < 2e-16 ***
gender           -0.0399 0.16753
bully.XX.gender -0.0805 0.02004 *
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Collinearity
                  VIF Tolerance
BMI             1.0424    0.9593
age             1.0405    0.9611
bully           2.0052    0.4987
gender          2.0516    0.4874
bully.XX.gender 2.9426    0.3398

> #計算與檢驗簡單斜率
> #程式報表 4.4
> summary(sl<-simpleSlope(rslt,pred="bully",modl="gender",coded="gender"))

** Estimated points of dep  **

                 Low bully (-1 SD)
Low gender ( 0 )           -0.8496
High gender ( 1 )          -1.6534
                 High bully (+1 SD)
Low gender ( 0 )             8.3102
High gender ( 1 )            5.6330



** Simple Slopes analysis ( df= 1994 ) **

                 simple slope standard error
Low gender ( 0 )        2.282          0.142
High gender ( 1 )       1.815          0.143
                 t-value p.value
```

```
Low gender ( 0 )      16.1  <2e-16 ***
High gender ( 1 )     12.7  <2e-16 ***
---
Signif. codes:
0  ‘***’  0.001  ‘**’  0.01  ‘*’  0.05  ‘.’  0.1  ‘ ’  1



** Bauer & Curran 95% CI **

        lower CI upper CI
gender    2.8559   28.354
>
> #也可以畫圖
> #圖 4.7
> windows()
> PlotSlope(sl)
>
```