

Crash Course in Meta Analysis - CPA 2019

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Difference between Males and Females in Maladaptive Perfectionism

Effect sizes are reported as Hedge's g (which is almost identical to Cohen's d)

Open Data and Take a Peak

```
dat<-read.csv(file.choose())
```

```
dat
```

```
##      g se_g country
## 1  0.03 0.19      i
## 2  0.15 0.25      i
## 3  1.06 0.34     na
## 4  0.13 0.13      i
## 5  0.94 0.24      i
## 6  3.97 0.19     na
## 7  0.59 0.17      i
## 8  0.90 0.29      i
## 9  1.10 0.35      i
## 10 1.52 0.39     na
## 11 1.18 0.26      i
## 12 0.32 0.20     na
## 13 1.18 0.34      i
## 14 2.01 0.31      i
## 15 -0.01 0.21     i
```

We will use the package “metafor” which has some excellent meta-analysis tools

```
library(metafor)
```

```
## Loading required package: Matrix
```

```
## Loading 'metafor' package (version 2.1-0). For an overview
```

```
## and introduction to the package please type: help(metafor).
```

Fixed Effects Model (method=“FE”)

```
ma1<-rma(data=dat,
         yi=g, sei=se_g,
         method="FE")
summary(ma1)
```

```
##
```

```
## Fixed-Effects Model (k = 15)
```

```
##
##   logLik   deviance      AIC      BIC      AICc
## -179.5037  373.4839  361.0074  361.7155  361.3151
##
## Test for Heterogeneity:
## Q(df = 14) = 373.4839, p-val < .0001
##
## Model Results:
##
## estimate      se      zval      pval      ci.lb      ci.ub
##   0.8446  0.0578  14.6130  <.0001  0.7313  0.9579  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Random Effects Model

Restricted Maximum Likelihood Estimation (method="REML")

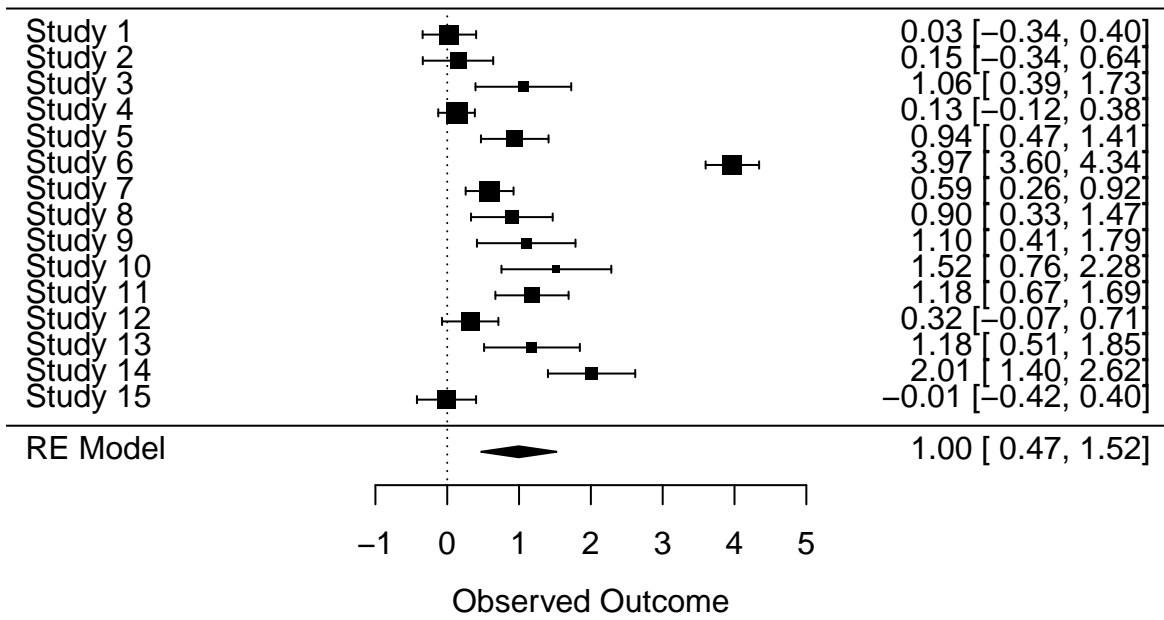
```
ma2<-rma(data=dat,
          yi=g, sei=se_g,
          method="REML")
summary(ma2)
```

```
##
## Random-Effects Model (k = 15; tau^2 estimator: REML)
##
##   logLik deviance      AIC      BIC      AICc
## -20.1858  40.3717  44.3717  45.6498  45.4626
##
## tau^2 (estimated amount of total heterogeneity): 1.0029 (SE = 0.4054)
## tau (square root of estimated tau^2 value):      1.0014
## I^2 (total heterogeneity / total variability):   95.09%
## H^2 (total variability / sampling variability):   20.37
##
## Test for Heterogeneity:
## Q(df = 14) = 373.4839, p-val < .0001
##
## Model Results:
##
## estimate      se      zval      pval      ci.lb      ci.ub
##   0.9966  0.2675  3.7258  0.0002  0.4723  1.5208  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Diagnostics (Random Effects Model)

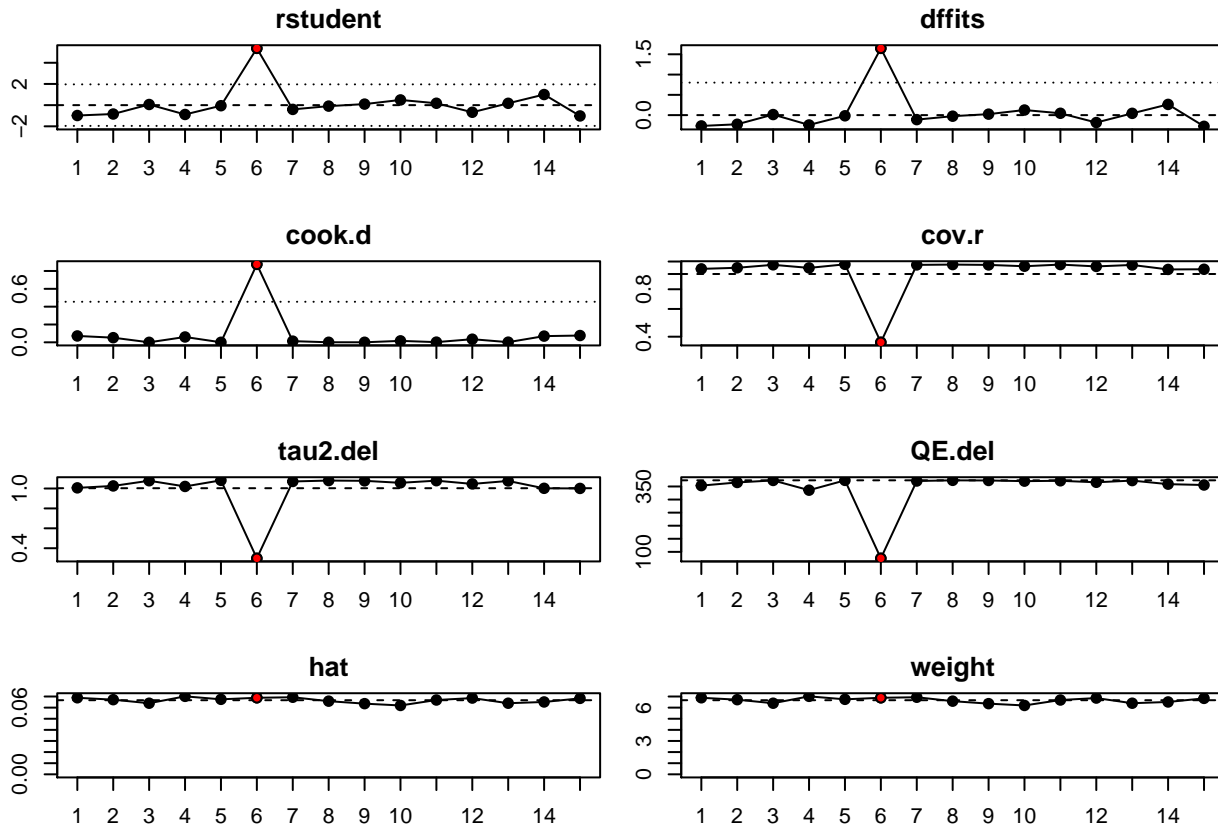
Forest Plot for the Standardized Mean Difference

```
forest(ma2,level=95)
```



###Identify Influential Cases

```
ic<-influence(ma2)
plot(ic)
```



```
(cd_cut<-4/(length(dat$g)))
```

```
## [1] 0.2666667
```

```
ic$inf$cook.d
```

```
## [1] 0.0714604939 0.0522059575 0.0002006071 0.0599027232 0.0003058887
```

```
## [6] 0.8744831272 0.0131973672 0.0007619402 0.0005892664 0.0164281679
```

```
## [11] 0.0022088790 0.0350955282 0.0020220355 0.0696184479 0.0761599048
```

```
which(ic$inf$cook.d > cd_cut)
```

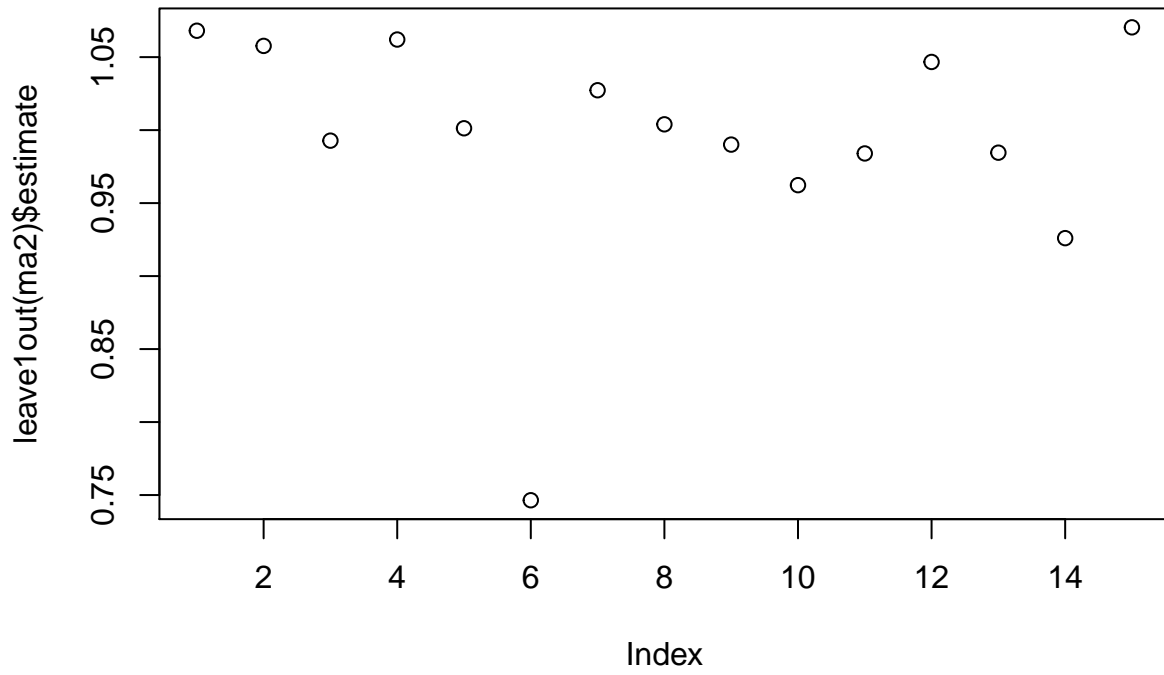
```
## [1] 6
```

Influential Cases

One at a time leave out a study

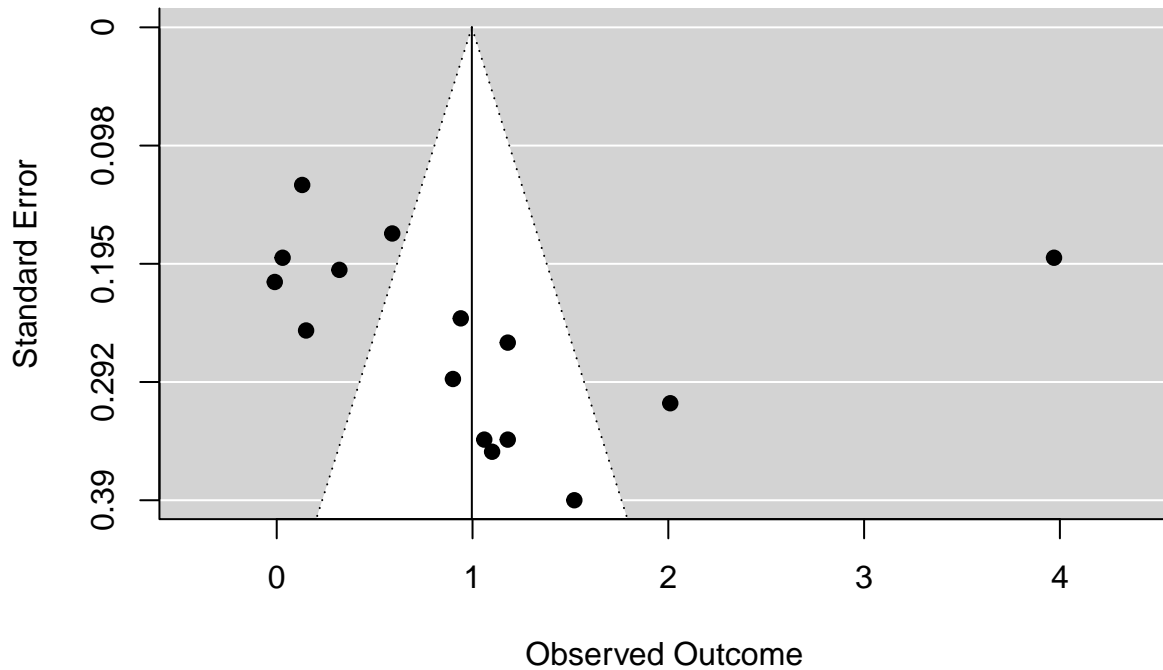
Plot the effect sizes from each analysis

```
plot(leave1out(ma2)$estimate)
```



Publication Bias - Funnel Plot

```
funnel(ma2)
```



```
regtest(ma2)
```

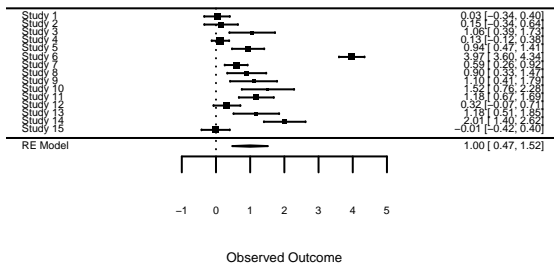
```
##
## Regression Test for Funnel Plot Asymmetry
##
## model:      mixed-effects meta-regression model
## predictor: standard error
##
## test for funnel plot asymmetry: z = 0.8434, p = 0.3990
```

```
#Test for Funnel Plot Asymmetry
```

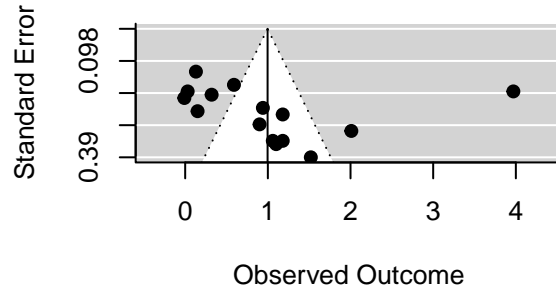
Four helpful plots with one command

```
plot(ma2)
```

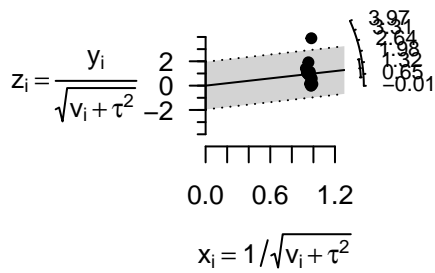
Forest Plot



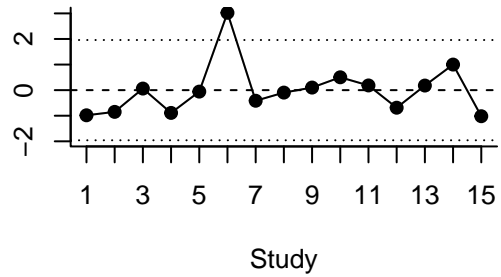
Funnel Plot



Radial Plot

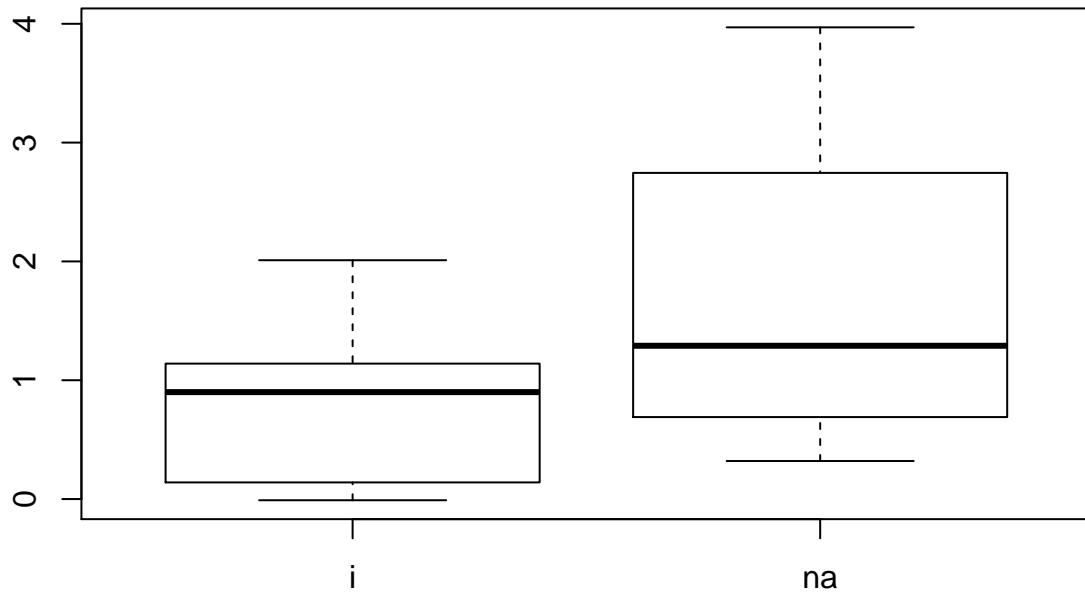


Standardized Residuals



Moderator Analyses

```
library(ggplot2)
#Country as a Moderator of Effect Size
boxplot(dat$g ~ dat$country)
```



Random Effects Model

Restricted Maximum Likelihood Estimation (method="REML")

With moderator "Country"

```
ma4<-rma(data=dat,
          yi=g, sei=se_g,method="REML",
          mods=~country)
summary(ma4)
```

```
##
## Mixed-Effects Model (k = 15; tau^2 estimator: REML)
##
##   logLik  deviance      AIC      BIC     AICc
## -17.7864  35.5727  41.5727  43.2676  44.2394
##
## tau^2 (estimated amount of residual heterogeneity):    0.8516 (SE = 0.3611)
## tau (square root of estimated tau^2 value):           0.9228
## I^2 (residual heterogeneity / unaccounted variability): 94.16%
## H^2 (unaccounted variability / sampling variability):   17.13
## R^2 (amount of heterogeneity accounted for):           15.09%
##
## Test for Residual Heterogeneity:
```



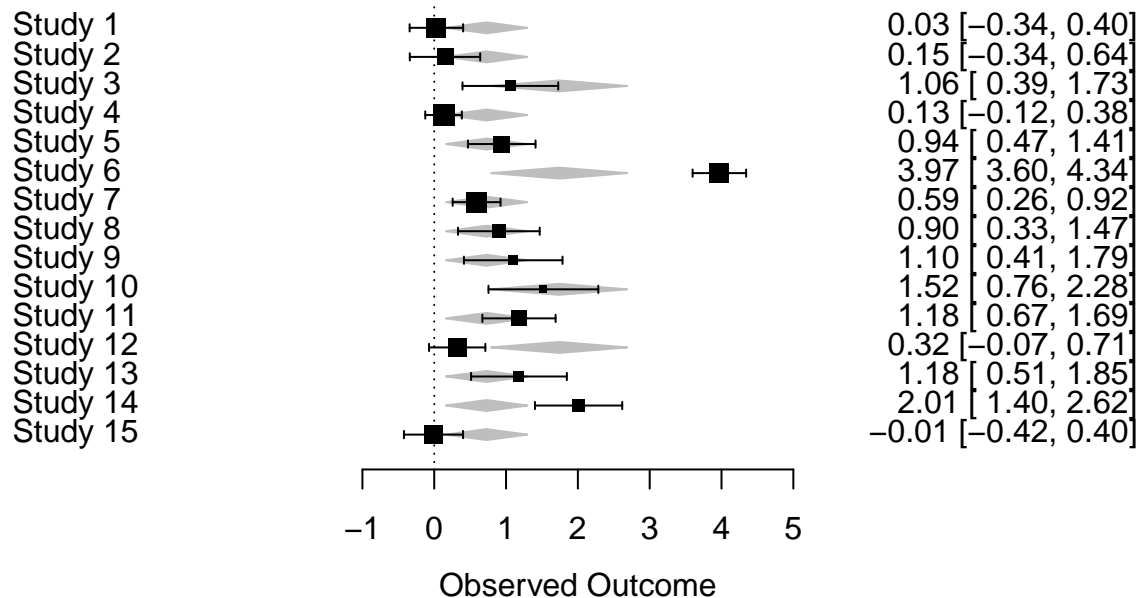
```
## QE(df = 13) = 252.3252, p-val < .0001
##
## Test of Moderators (coefficient 2):
## QM(df = 1) = 3.2134, p-val = 0.0730
##
## Model Results:
##
##          estimate      se    zval    pval    ci.lb    ci.ub
## intrcpt      0.7299  0.2887  2.5281  0.0115   0.1640  1.2958 *
## countryna    1.0094  0.5631  1.7926  0.0730  -0.0942  2.1131 .
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
tapply(dat$g,dat$country,mean)
```

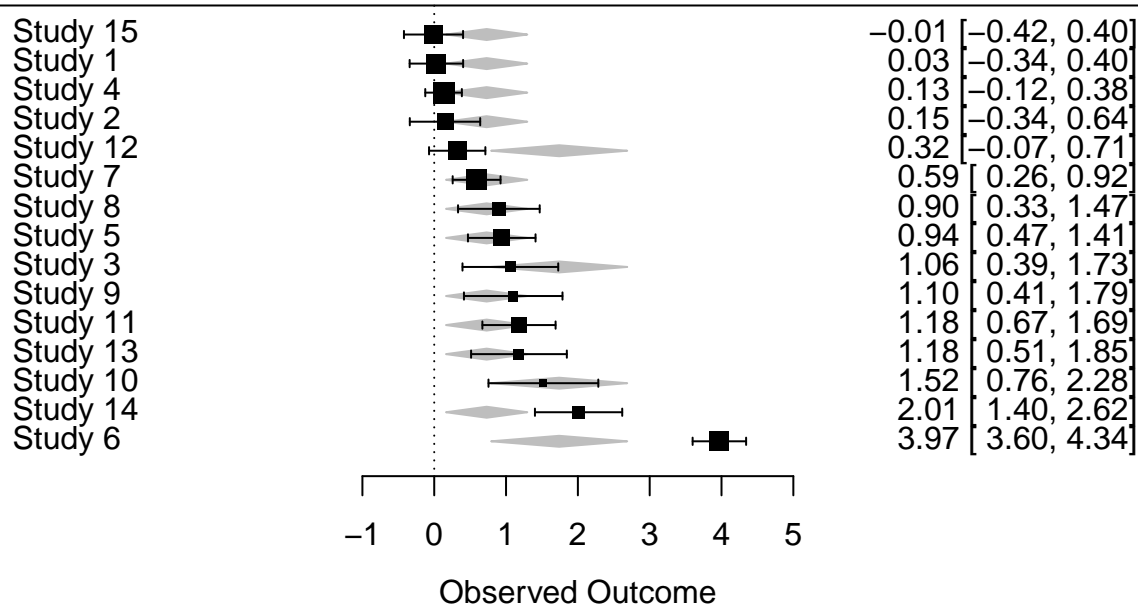
```
##          i          na
## 0.7454545 1.7175000
```

Forest Plot with Fitted Values

```
forest(ma4)
```



```
forest(ma4,order="obs")
```



Let's redo the analysis without Study 6

Recall: Study 6 $g=3.97$

```
dat2<-dat[-6,]
dat2
```

```
##      g se_g country
## 1  0.03 0.19      i
## 2  0.15 0.25      i
## 3  1.06 0.34     na
## 4  0.13 0.13      i
## 5  0.94 0.24      i
## 7  0.59 0.17      i
## 8  0.90 0.29      i
## 9  1.10 0.35      i
## 10 1.52 0.39     na
## 11 1.18 0.26      i
## 12 0.32 0.20     na
## 13 1.18 0.34      i
## 14 2.01 0.31      i
## 15 -0.01 0.21     i
```

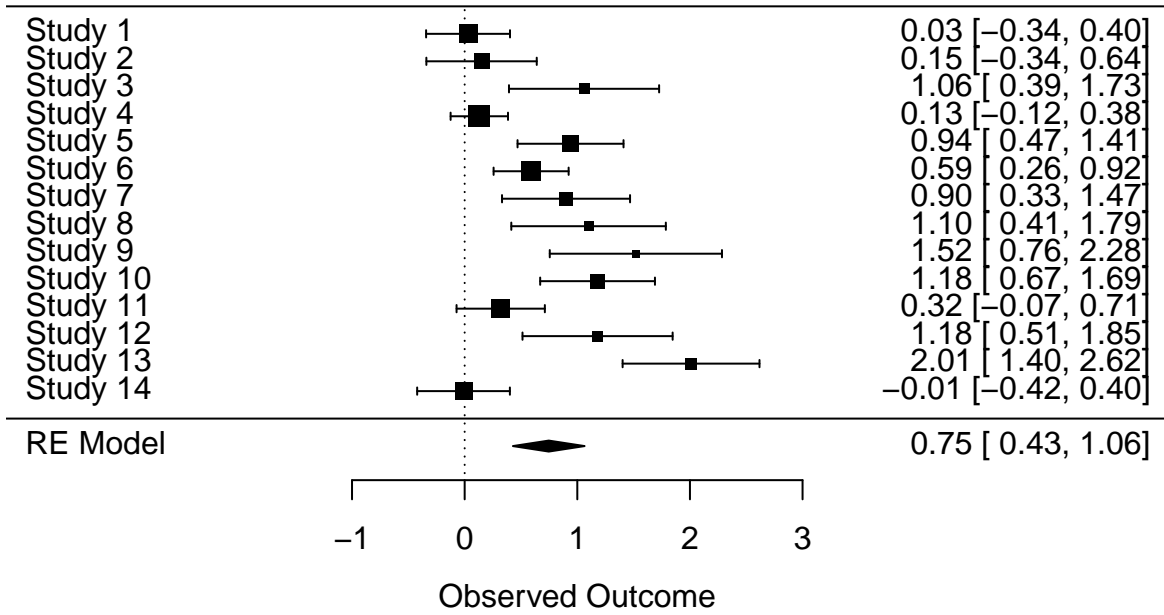
Random Effects Model

```
ma3<-rma(data=dat2,  
          yi=g, sei=se_g, method="REML")  
summary(ma3)
```

```
##  
## Random-Effects Model (k = 14; tau^2 estimator: REML)  
##  
##   logLik deviance      AIC      BIC      AICc  
## -12.0235  24.0469  28.0469  29.1768  29.2469  
##  
## tau^2 (estimated amount of total heterogeneity): 0.2988 (SE = 0.1442)  
## tau (square root of estimated tau^2 value):      0.5467  
## I^2 (total heterogeneity / total variability):   84.79%  
## H^2 (total variability / sampling variability):   6.58  
##  
## Test for Heterogeneity:  
## Q(df = 13) = 75.3078, p-val < .0001  
##  
## Model Results:  
##  
## estimate      se      zval      pval      ci.lb      ci.ub  
##  0.7464  0.1624  4.5974  <.0001  0.4282  1.0647  ***  
##  
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

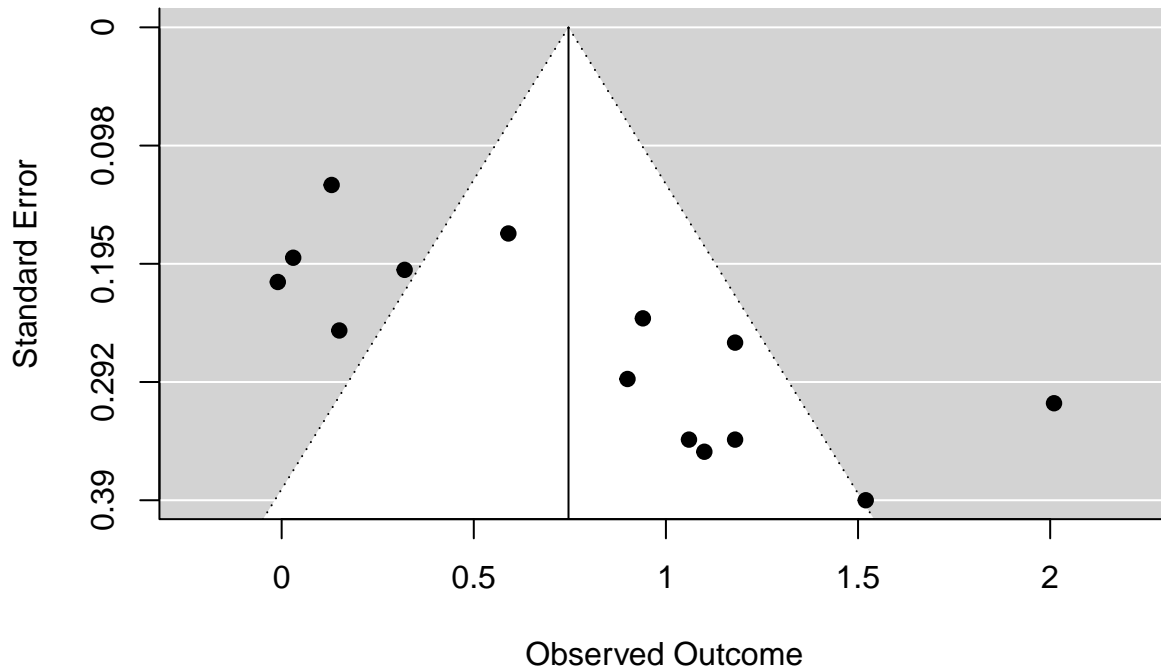
Forest Plot for the Standardized Mean Difference

```
forest(ma3,level=95)
```



###Funnel Plot to Explore Publication Bias

`funnel(ma3)`



```
#Test for Funnel Plot Asymmetry
regtest(ma3)
```

```
##
## Regression Test for Funnel Plot Asymmetry
##
## model:      mixed-effects meta-regression model
## predictor: standard error
##
## test for funnel plot asymmetry: z = 4.0385, p < .0001
```

Explore the Effect of Publication Bias

By Imputing Missing Studies

```
trimfill(ma3, estimator="RO")
```

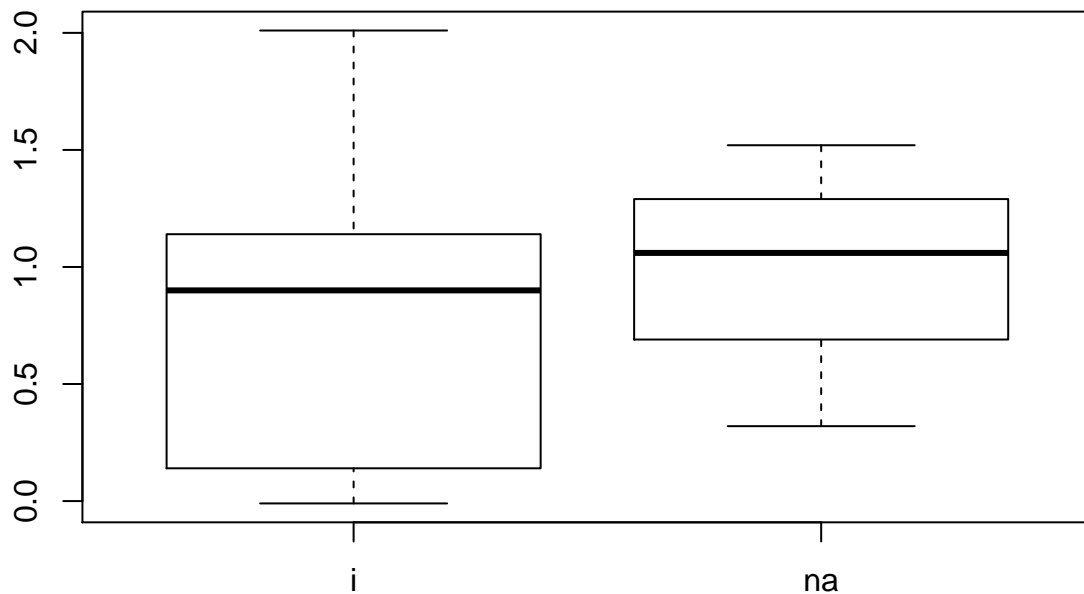
```
##
## Estimated number of missing studies on the left side: 1 (SE = 2.0000)
## Test of H0: no missing studies on the left side:      p-val = 0.2500
##
## Random-Effects Model (k = 15; tau^2 estimator: REML)
##
## tau^2 (estimated amount of total heterogeneity): 0.4016 (SE = 0.1788)
## tau (square root of estimated tau^2 value):      0.6337
## I^2 (total heterogeneity / total variability):   87.92%
## H^2 (total variability / sampling variability):   8.28
```

```
##
## Test for Heterogeneity:
## Q(df = 14) = 91.1298, p-val < .0001
##
## Model Results:
##
## estimate      se      zval      pval      ci.lb      ci.ub      ***
## 0.6619 0.1778 3.7228 0.0002 0.3134 1.0105 ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Moderator Analyses

Country as a Moderator of Effect Size

```
boxplot(dat2$g ~ dat2$country)
```



```
#Random Effects Model
#With moderator "Country"
ma4<-rma(data=dat2,
          yi=g, sei=se_g, method="REML",
          mods=~country)
summary(ma4)
```

```
##
## Mixed-Effects Model (k = 14; tau^2 estimator: REML)
```

```

##
##   logLik  deviance      AIC      BIC      AICc
## -11.4438  22.8877  28.8877  30.3424  31.8877
##
## tau^2 (estimated amount of residual heterogeneity):    0.3227 (SE = 0.1596)
## tau (square root of estimated tau^2 value):           0.5680
## I^2 (residual heterogeneity / unaccounted variability): 85.67%
## H^2 (unaccounted variability / sampling variability):  6.98
## R^2 (amount of heterogeneity accounted for):          0.00%
##
## Test for Residual Heterogeneity:
## QE(df = 12) = 74.2542, p-val < .0001
##
## Test of Moderators (coefficient 2):
## QM(df = 1) = 0.2312, p-val = 0.6306
##
## Model Results:
##
##           estimate      se   zval   pval   ci.lb  ci.ub
## intrcpt      0.7089  0.1874  3.7820  0.0002  0.3415  1.0762 ***
## countryna    0.2012  0.4184  0.4808  0.6306 -0.6189  1.0213
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

tapply(dat2$g,dat2$country,mean)

```

```

##           i           na
## 0.7454545 0.9666667

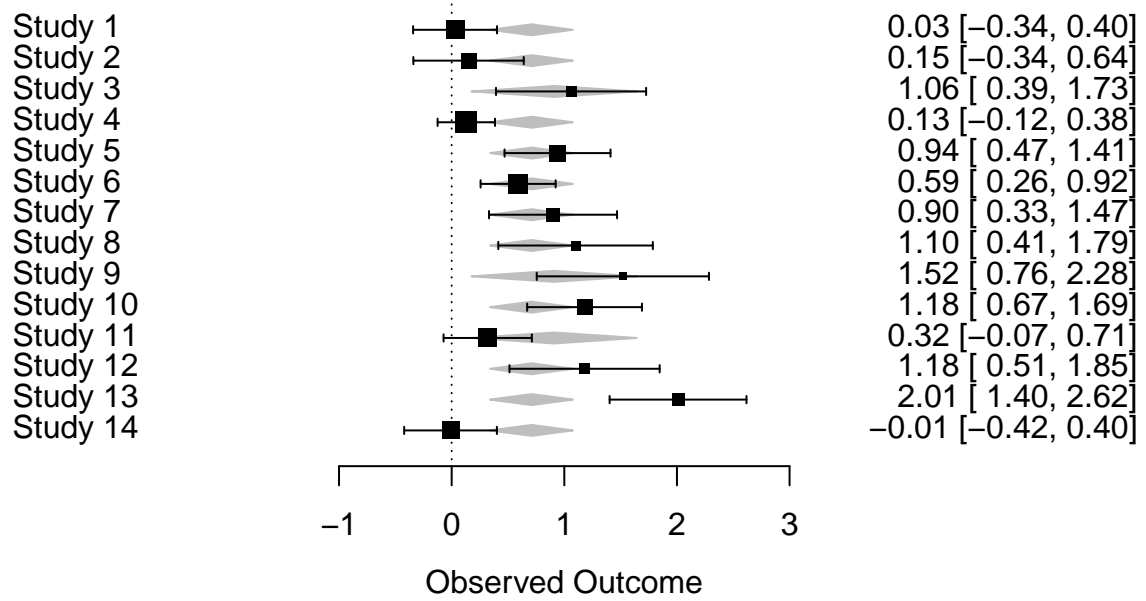
```

Forest Plot with Fitted Values for Each Country

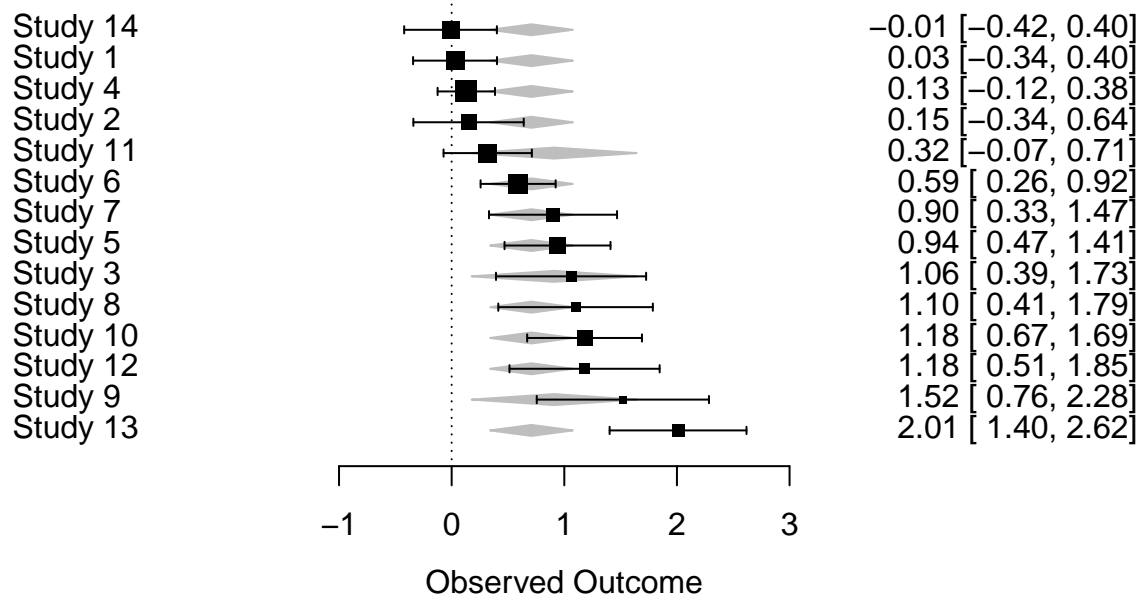
```

forest(ma4)

```

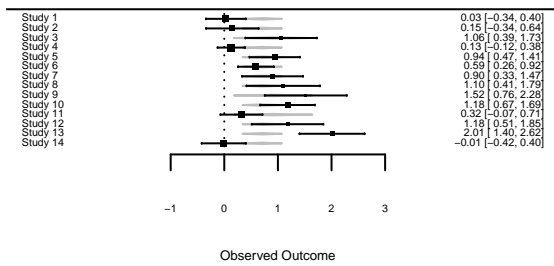


```
forest(ma4, order="obs")
```

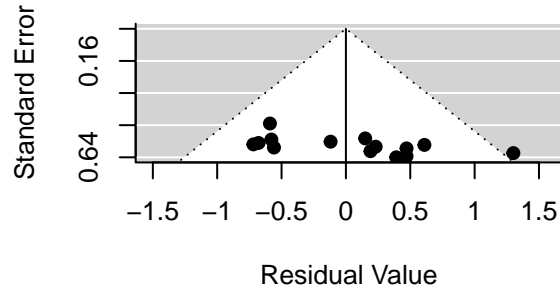



`plot(ma4)`

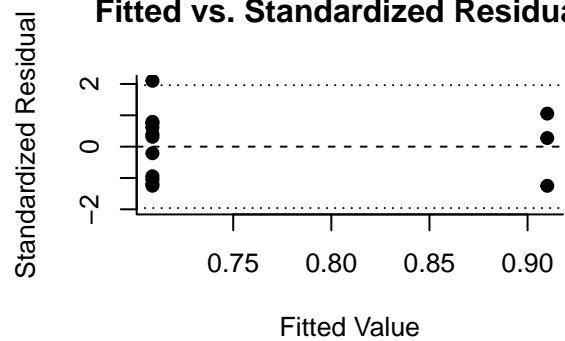
Forest Plot



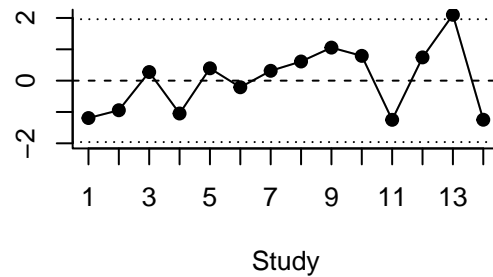
Residual Funnel Plot



Fitted vs. Standardized Residuals



Standardized Residuals



Likelihood Ratio Test for Moderator “Country”

Must use ML, not REML

```
ma5a<-rma(data=dat2,
           yi=g, sei=se_g, method="ML",
           mods=NULL)
ma5b<-rma(data=dat2,
           yi=g, sei=se_g, method="ML",
           mods=~country)
anova(ma5a,ma5b)
```

```
##
##      df      AIC      BIC      AICc  logLik    LRT   pval      QE  tau^2
## Full    3 30.5908 32.5079 32.9908 -12.2954          74.2542 0.2672
## Reduced  2 28.8493 30.1275 29.9403 -12.4247 0.2586 0.6111 75.3078 0.2720
##
##      R^2
## Full
## Reduced 1.7579%
```

The End!