First look analysis of Sisks et al. 2018

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To do

- The effect size measure is the correlation coefficient. It is unclear if in the paper they transformed it or not.
- Question: When we use Fisher's Z transform in metafor, is the output reporting the correlation as Pearson correlation or as Z?
- In 3-level we assume that outcomes are nested within studies. However, a more accurate data structure would be: outcomes nested within samples nested within studies. This would correspond to a 4-level model. Is it possible to implement this and compare it to a 3-level model?

Notes:

- Benningfield (2013) - S2, S3, S4 was: "sample overlaps with Hendricks (2012)".
- Hendricks, J. (2012). The effect of gender and implicit theories of math ability on math interest and achievement. Unpublished specialist project, Western Kentucky University, Bowling Green, Kentucky.
  - The sample consisted of a total of 1802 students, which included 934 males and 868 females. There were 332 second grade students, 363 third grade students, 406 fourth grade students, 390 fifth grade students, and 311 sixth grade students.
- Benningfield, S. (2013). The effects of gender and implicit theories on science achievement and interest in elementary-aged students. Unpublished specialist project, Western Kentucky University.
  - The sample consisted of a total of 1,910 students. There were 369 second grade students, 382 third grade students, 354 fourth grade students, 409 fifth grade students, and 396 sixth grade students. Of the total number of students, 986 were female and 924 were male.
  - Decision: We have 3 difference samples (S2, S3, S4: 3rd, 4th, 5th) grade. It is unclear if they are the same sample in Hendricks, as written in the excel or not, because when quickly comparing the two papers, the samples sizes are different (see above). For the moment, I decided to code them as separate samples with the codes: 163, 164, 165 (colum Sample#)

Analysis: Meta-analysis 1

r not transformed

```
library(readxl)
library(metafor)
```

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

```
##
```

```
## Loading the 'metafor' package (version 3.0-2). For an
## introduction to the package please type: help(metafor)
```

```
# Import data
df1 <- read_excel('data/mindset.xlsx', sheet = 'Meta-analysis 1')
str(df1)
```

```
## tibble [273 x 35] (S3: tbl_df/tbl/data.frame)
##  $ Document #                        : num [1:273] 1 2 2 2 3 3 3 3 4 5 ...
##  $ Study #                           : num [1:273] 1 2 2 2 3 3 3 3 4 5 ...
##  $ Sample #                          : num [1:273] 1 2 3 4 5 163 164 165 6 7 ...
##  $ Sample Country                    : chr [1:273] "Indonesia" "USA" "USA" "USA" ...
##  $ ES #                              : num [1:273] 1 2 3 4 5 6 7 8 9 10 ...
##  $ Reference                         : chr [1:273] "Adatitomo (2015)" "Bagley (2016) - S1" "Bagley (20
##  $ N                                 : num [1:273] 123 400 1019 710 250 ...
##  $ Adjusted N                        : num [1:273] 123 400 1019 710 250 ...
##  $ Student Description               : chr [1:273] "second semester university students enrolled in ar
##  $ School Level                      : chr [1:273] "post-secondary" "post-secondary" "post-secondary"
##  $ Development Stage                 : chr [1:273] "Adults" "Adults" "Adults" "Adults" ...
##  $ Risk status                       : chr [1:273] "low" "moderate" "moderate" "moderate" ...
##  $ SES                               : chr [1:273] "not reported" "not reported" "not reported" "not r
##  $ MS Measure                        : chr [1:273] "Mindset about intelligence" "Dweck's Mindset asses
##  $ MS Measure Description            : chr [1:273] "6 items, 3 growth and 3 fixed from Dweck (2006); M
##  $ Mindset Type                      : chr [1:273] "Intelligence" "Personal attributes" "Personal attr
##  $ Achievement Measure Description   : chr [1:273] "Statistics final exam grade" "Developmental math c
##  $ Academic Achievement Measure Type: chr [1:273] "Course exam" "Course grade" "Course grade" "Course
##  $ Lab-based                         : chr [1:273] "no" "no" "no" "no" ...
##  $ Published                         : chr [1:273] "yes" "no" "no" "no" ...
##  $ ES type                           : chr [1:273] "continuous" "continuous" "continuous" "continuous"
##  $ Calculation                       : chr [1:273] "Pearson's r" "sqrt of bivariate R^2 (i.e., Pearson
##  $ Variance                          : num [1:273] 0.007943 0.002419 0.000907 0.001382 0.003919 ...
##  $ Adjusted Variance                 : num [1:273] 0.007943 0.002419 0.000907 0.001382 0.003919 ...
##  $ Significant?                      : chr [1:273] "N" "Y" "Y" "Y" ...
##  $ r                                 : num [1:273] -0.125 0.133 0.197 0.101 0.11 ...
##  $ Growth M                          : num [1:273] NA NA NA NA NA NA NA NA NA NA ...
##  $ Growth SD                         : num [1:273] NA NA NA NA NA NA NA NA NA NA ...
##  $ Other M                           : num [1:273] NA NA NA NA NA NA NA NA NA NA ...
##  $ Other SD                          : num [1:273] NA NA NA NA NA NA NA NA NA NA ...
##  $ Cohen's d                         : num [1:273] NA NA NA NA NA NA NA NA NA NA ...
##  $ rpb                               : num [1:273] NA NA NA NA NA NA NA NA NA NA ...
##  $ rb                                : num [1:273] NA NA NA NA NA NA NA NA NA NA ...
##  $ Calculated r                      : num [1:273] NA NA NA NA NA NA NA NA NA NA ...
##  $ Notes                             : chr [1:273] "the authors of the study also measured the correla
```

```
# Inspect column names
names(df1)
```

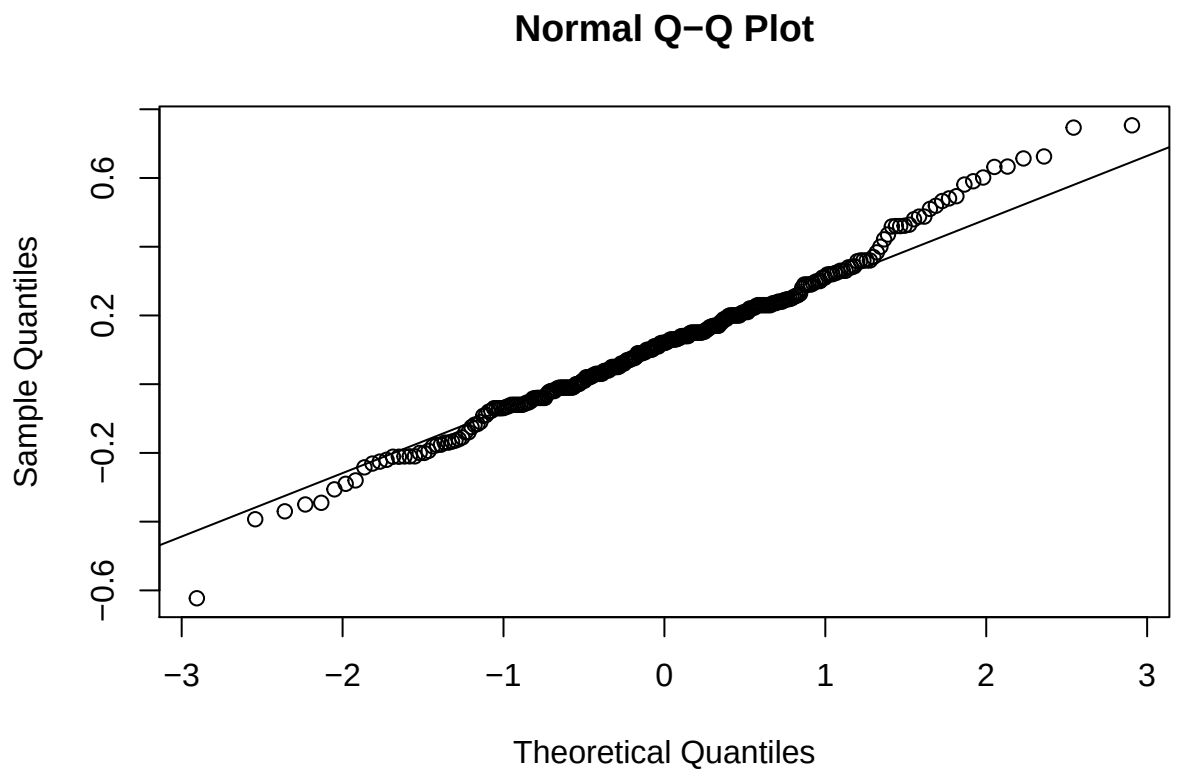
```
##  [1] "Document #"                        "Study #"
##  [3] "Sample #"                          "Sample Country"
##  [5] "ES #"                              "Reference"
##  [7] "N"                                 "Adjusted N"
##  [9] "Student Description"               "School Level"
## [11] "Development Stage"                 "Risk status"
## [13] "SES"                               "MS Measure"
## [15] "MS Measure Description"            "Mindset Type"
## [17] "Achievement Measure Description"   "Academic Achievement Measure Type"
```

```
## [19] "Lab-based"                          "Published"
## [21] "ES type"                            "Calculation"
## [23] "Variance"                           "Adjusted Variance"
## [25] "Significant?"                       "r"
## [27] "Growth M"                           "Growth SD"
## [29] "Other M"                            "Other SD"
## [31] "Cohen's d"                          "rpb"
## [33] "rb"                                 "Calculated r"
## [35] "Notes"
```

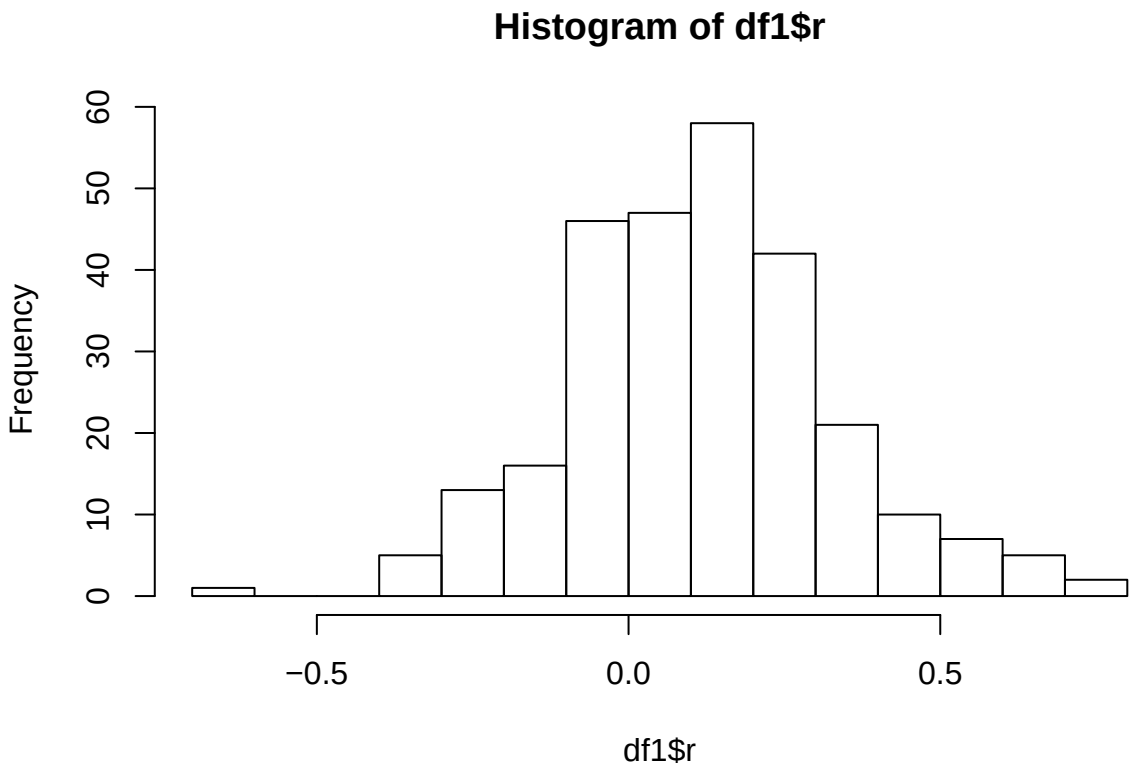
```
# Rename columns: Document #, Study #, Sample #, ES #
names(df1)[names(df1)=="Document #"] <- "DocumentID"
names(df1)[names(df1)=="Study #"] <- "StudyID"
names(df1)[names(df1)=="Sample #"] <- "SampleID"
names(df1)[names(df1)=="ES #"] <- "ESID"

# Inspect column names
names(df1)
```

```
##  [1] "DocumentID"                          "StudyID"
##  [3] "SampleID"                            "Sample Country"
##  [5] "ESID"                                "Reference"
##  [7] "N"                                   "Adjusted N"
##  [9] "Student Description"                 "School Level"
## [11] "Development Stage"                   "Risk status"
## [13] "SES"                                 "MS Measure"
## [15] "MS Measure Description"              "Mindset Type"
## [17] "Achievement Measure Description"     "Academic Achievement Measure Type"
## [19] "Lab-based"                           "Published"
## [21] "ES type"                             "Calculation"
## [23] "Variance"                            "Adjusted Variance"
## [25] "Significant?"                        "r"
## [27] "Growth M"                            "Growth SD"
## [29] "Other M"                             "Other SD"
## [31] "Cohen's d"                           "rpb"
## [33] "rb"                                  "Calculated r"
## [35] "Notes"
```

```
# Look at distribution of r
qqnorm(df1$r)
qqline(df1$r)
```




```
hist(df1$r)
```




```
shapiro.test(df1$r)
```

```
##
##  Shapiro-Wilk normality test
```

```
##
## data:  df1$r
## W = 0.9898, p-value = 0.0527
```

```
ks.test(df1$r, 'pnorm')
```

```
## Warning in ks.test(df1$r, "pnorm"): ties should not be present for the
## Kolmogorov-Smirnov test
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
## data:  df1$r
## D = 0.37569, p-value < 2.2e-16
## alternative hypothesis: two-sided
```

```
# FEM
FEM <- rma(yi=r, vi=Variance, data=df1, method='FE')
summary(FEM)
```

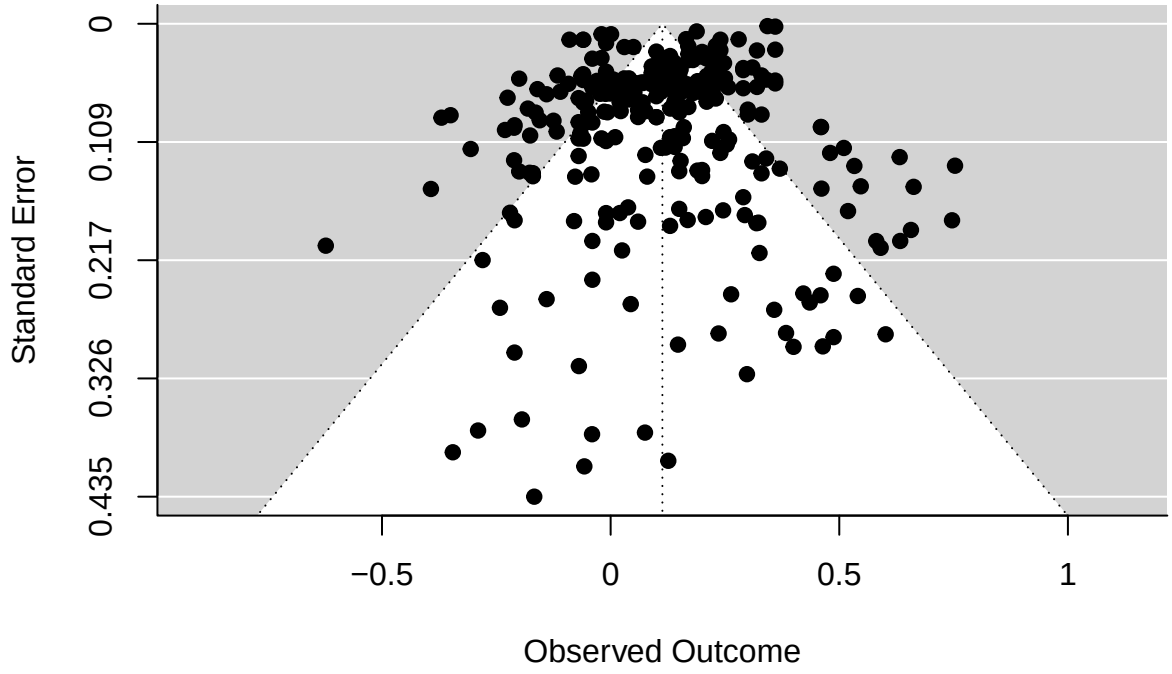
```
##
## Fixed-Effects Model (k = 273)
##
##     logLik    deviance         AIC         BIC        AICc
## -4024.8842   8936.0151   8051.7683   8055.3778   8051.7831
##
## I^2 (total heterogeneity / total variability):   96.96%
## H^2 (total variability / sampling variability):  32.85
##
## Test for Heterogeneity:
## Q(df = 272) = 8936.0151, p-val < .0001
##
## Model Results:
##
## estimate      se      zval    pval   ci.lb   ci.ub
##   0.2785  0.0014  199.1063  <.0001  0.2758  0.2813  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# REM
# rma(yi=r, vi=df1$`Adjusted Variance`, data=df1, method='REML') # Use the adjusted variance for depend
REM <- rma(yi=r, vi=Variance, data=df1, method='REML')
summary(REM)
```

```
##
## Random-Effects Model (k = 273; tau^2 estimator: REML)
##
##    logLik   deviance        AIC        BIC       AICc
##   57.7089  -115.4178  -111.4178  -104.2061  -111.3731
##
## tau^2 (estimated amount of total heterogeneity): 0.0225 (SE = 0.0026)
## tau (square root of estimated tau^2 value):      0.1499
## I^2 (total heterogeneity / total variability):   96.89%
## H^2 (total variability / sampling variability):  32.16
##
## Test for Heterogeneity:
```

```
## Q(df = 272) = 8936.0151, p-val < .0001
##
## Model Results:
##
## estimate      se     zval    pval   ci.lb   ci.ub
##   0.1132  0.0108  10.4884  <.0001  0.0920  0.1343  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Funnel plot
funnel(REM)
```




```r
# Trim and fill
trimfill(REM)
```

```
##
## Estimated number of missing studies on the left side: 8 (SE = 9.9584)
##
## Random-Effects Model (k = 281; tau^2 estimator: REML)
##
## tau^2 (estimated amount of total heterogeneity): 0.0262 (SE = 0.0029)
## tau (square root of estimated tau^2 value):      0.1618
## I^2 (total heterogeneity / total variability):   97.24%
## H^2 (total variability / sampling variability):  36.28
##
## Test for Heterogeneity:
## Q(df = 280) = 9096.4253, p-val < .0001
##
## Model Results:
##
## estimate      se    zval    pval   ci.lb   ci.ub
##   0.1031  0.0114  9.0753  <.0001  0.0809  0.1254  ***
##
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

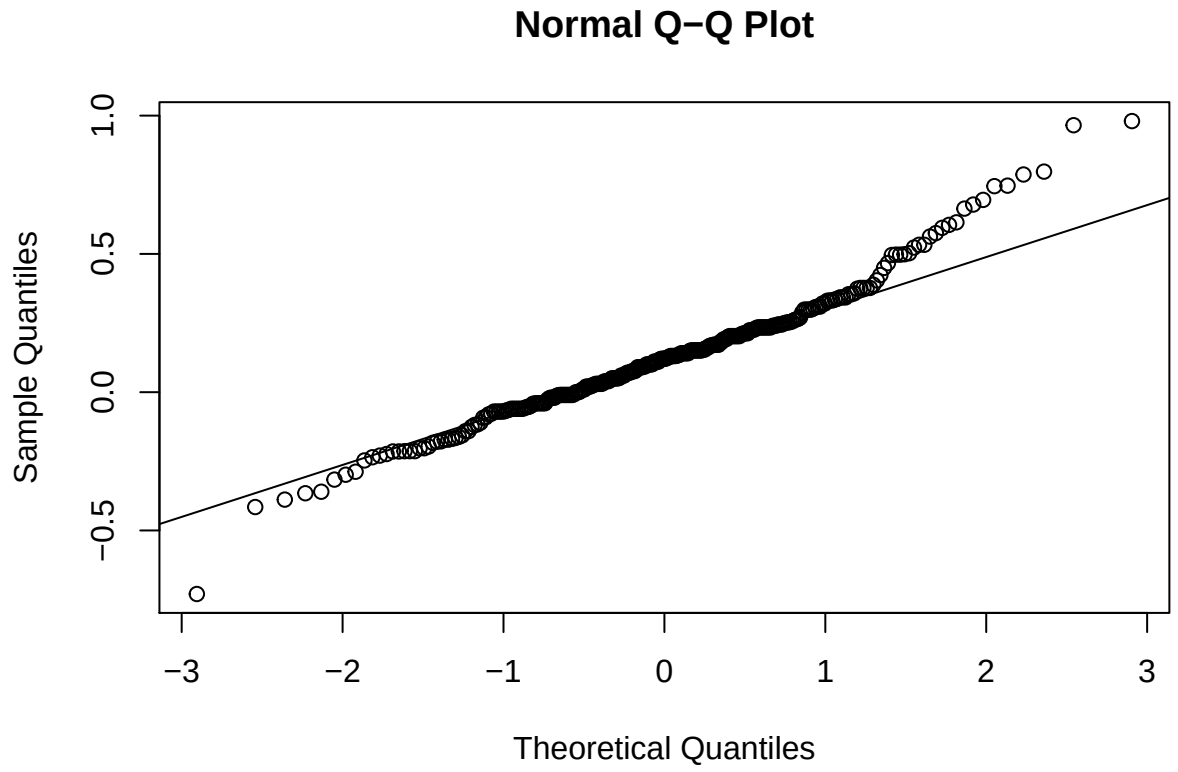
r transformed

```
## calculate r-to-z transformed correlations and corresponding sampling variances
df2 <- escalc(ri = r, ni = N, measure = 'ZCOR',  data = df1)
head(df2)
```

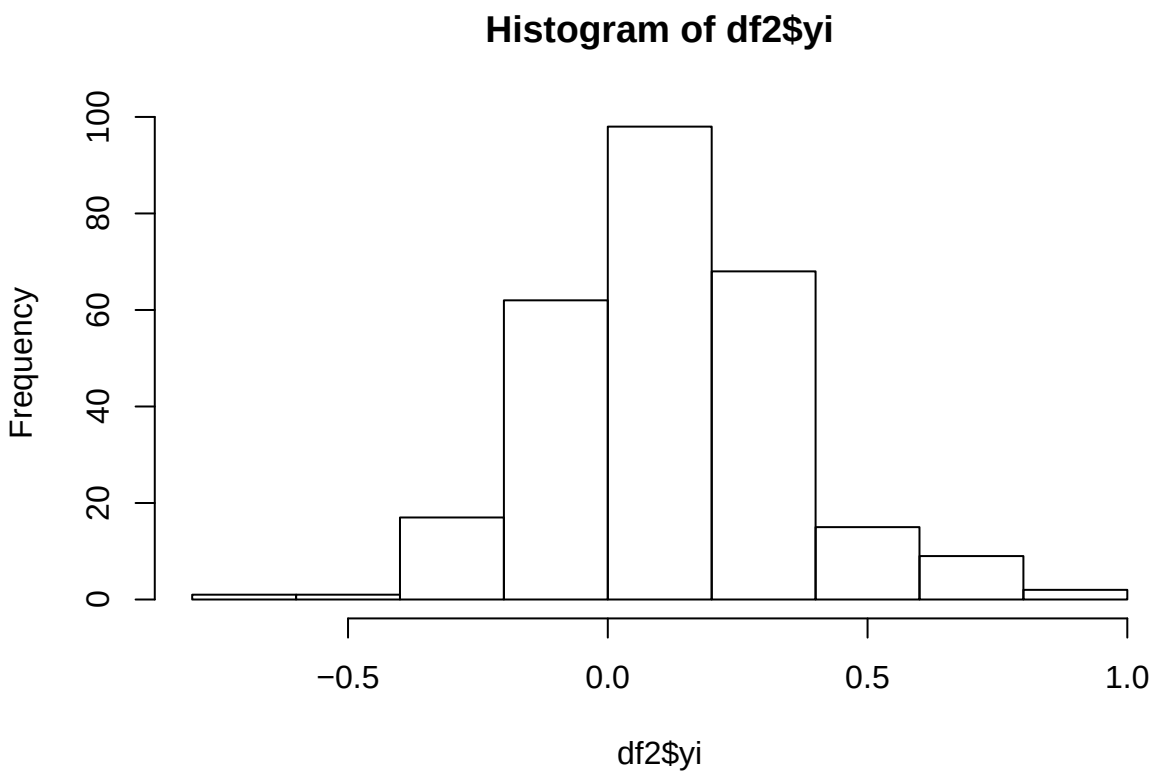
```
##   DocumentID StudyID SampleID Sample.Country ESID                Reference    N
## 1          1       1        1      Indonesia    1          Adatitomo (2015)  123
## 2          2       2        2            USA    2        Bagley (2016) - S1  400
## 3          2       2        3            USA    3        Bagley (2016) - S2 1019
## 4          2       2        4            USA    4        Bagley (2016) - S3  710
## 5          3       3        5            USA    5 Benningfield (2013) - S1  250
## 6          3       3      163            USA    6 Benningfield (2013) - S2  272
##   Adjusted.N
## 1   123.0000
## 2   400.0000
## 3  1019.0000
## 4   710.0000
## 5   250.0000
## 6   163.3974
##
## 1 second semester university students enrolled in an introductory behavioural statistics course at a
## 2
## 3
## 4
## 5
## 6
##     School.Level Development.Stage Risk.status          SES
## 1 post-secondary            Adults         low not reported
## 2 post-secondary            Adults    moderate not reported
## 3 post-secondary            Adults    moderate not reported
## 4 post-secondary            Adults    moderate not reported
## 5        primary          Children         low not reported
## 6        primary          Children         low not reported
##
## 1
## 2
## 3
## 4
## 5 Implicit theories of science ability scale adapted from Implicit Theories of Intelligence Scale fo
## 6 Implicit theories of science ability scale adapted from Implicit Theories of Intelligence Scale fo
##                                                  MS.Measure.Description
## 1 6 items, 3 growth and 3 fixed from Dweck (2006); Dweck, et al., (1995)
## 2                                                                4 items
## 3                                                                4 items
## 4                                                                4 items
## 5                                     3 items adapted from Dweck (2000)
## 6                                     3 items adapted from Dweck (2000)
##          Mindset.Type
## 1        Intelligence
## 2 Personal attributes
```

```
## 3 Personal attributes
## 4 Personal attributes
## 5     Science Ability
## 6     Science Ability
##                              Achievement.Measure.Description
## 1                               Statistics final exam grade
## 2 Developmental math course grade (percentage points earned)
## 3 Developmental math course grade (percentage points earned)
## 4 Developmental math course grade (percentage points earned)
## 5                             Test of Basic Skills: Science
## 6                             Test of Basic Skills: Science
##   Academic.Achievement.Measure.Type Lab.based Published    ES.type
## 1                       Course exam        no       yes continuous
## 2                      Course grade        no        no continuous
## 3                      Course grade        no        no continuous
## 4                      Course grade        no        no continuous
## 5                 Standardized test        no        no continuous
## 6                 Standardized test        no        no continuous
##                                Calculation     Variance Adjusted.Variance
## 1                              Pearson's r 0.0079425749      0.0079425749
## 2 sqrt of bivariate R^2 (i.e., Pearson's r) 0.0024188215      0.0024188215
## 3 sqrt of bivariate R^2 (i.e., Pearson's r) 0.0009073804      0.0009073804
## 4 sqrt of bivariate R^2 (i.e., Pearson's r) 0.0013815319      0.0013815319
## 5                              Pearson's r 0.0039194635      0.0039194635
## 6                              Pearson's r 0.0035663676      0.0059502404
##   Significant.          r Growth.M Growth.SD Other.M Other.SD Cohen.s.d rpb rb
## 1            N -0.1250000       NA        NA      NA       NA        NA  NA NA
## 2            Y  0.1326650       NA        NA      NA       NA        NA  NA NA
## 3            Y  0.1972308       NA        NA      NA       NA        NA  NA NA
## 4            Y  0.1014889       NA        NA      NA       NA        NA  NA NA
## 5            Y  0.1100000       NA        NA      NA       NA        NA  NA NA
## 6            Y  0.1300000       NA        NA      NA       NA        NA  NA NA
##   Calculated.r
## 1           NA
## 2           NA
## 3           NA
## 4           NA
## 5           NA
## 6           NA
##
## 1 the authors of the study also measured the correlation between mindset of intelligence and mid-ter
## 2                                                    the author also measured mindset of math intel
## 3                                                    the author also measured mindset of math intel
## 4                                                    the author also measured mindset of math intel
## 5
## 6
##        yi     vi
## 1 -0.1257 0.0083
## 2  0.1335 0.0025
## 3  0.1998 0.0010
## 4  0.1018 0.0014
## 5  0.1104 0.0040
## 6  0.1307 0.0037
```

```r
# Look at distribution of yi
qqnorm(df2$yi)
qqline(df2$yi)
```




```r
hist(df2$yi)
```



```r
shapiro.test(df2$yi)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  df2$yi
## W = 0.97159, p-value = 3.007e-05
```

```r
ks.test(df2$yi, 'pnorm')
```

```
## Warning in ks.test(df2$yi, "pnorm"): ties should not be present for the
## Kolmogorov-Smirnov test
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
## data:  df2$yi
## D = 0.37404, p-value < 2.2e-16
## alternative hypothesis: two-sided
```

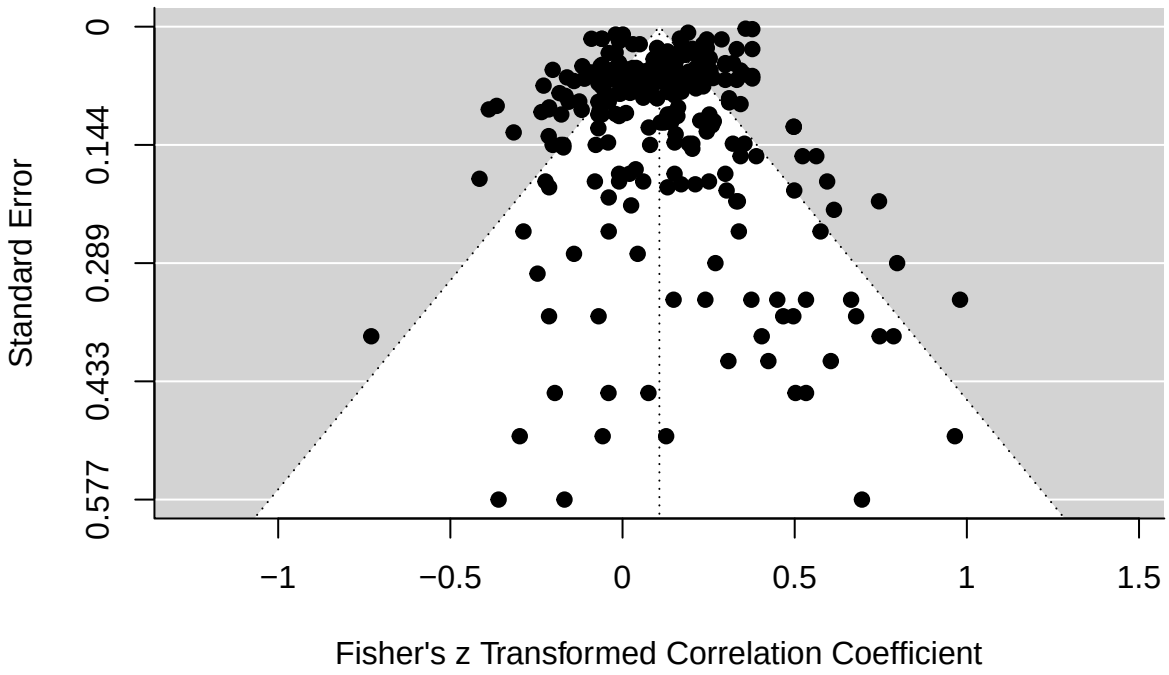
```r
### meta-analysis of the transformed correlations using a random-effects model
REM2 <- rma(yi = yi, vi = vi , data = df2)
summary(REM2)
```

```
##
## Random-Effects Model (k = 273; tau^2 estimator: REML)
##
##    logLik   deviance        AIC        BIC       AICc
##   60.3140  -120.6280  -116.6280  -109.4164  -116.5834
##
## tau^2 (estimated amount of total heterogeneity): 0.0187 (SE = 0.0023)
## tau (square root of estimated tau^2 value):      0.1369
## I^2 (total heterogeneity / total variability):   95.68%
## H^2 (total variability / sampling variability):  23.13
##
## Test for Heterogeneity:
## Q(df = 272) = 8958.2395, p-val < .0001
##
## Model Results:
##
## estimate      se     zval    pval   ci.lb   ci.ub
##   0.1071  0.0103  10.4110  <.0001  0.0869  0.1272  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
### average correlation with 95% CI
predict(REM2, transf=transf.ztor)
```

```
##
##    pred  ci.lb  ci.ub   pi.lb  pi.ub
##  0.1067 0.0867 0.1265 -0.1606 0.3594
```

```r
# Funnel
funnel(REM2)
```




```
# Trim and fill
trimfill(REM2)
```

```
##
## Estimated number of missing studies on the left side: 10 (SE = 10.0506)
##
## Random-Effects Model (k = 283; tau^2 estimator: REML)
##
## tau^2 (estimated amount of total heterogeneity): 0.0195 (SE = 0.0023)
## tau (square root of estimated tau^2 value):      0.1397
## I^2 (total heterogeneity / total variability):   95.69%
## H^2 (total variability / sampling variability):  23.23
##
## Test for Heterogeneity:
## Q(df = 282) = 9026.8722, p-val < .0001
##
## Model Results:
##
## estimate      se    zval    pval   ci.lb   ci.ub
##   0.1014  0.0104  9.7543  <.0001  0.0811  0.1218  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3-level model with r transformed

```
# Three level meta-analysis
multilevel3 <- rma.mv(yi = yi,
                      V = vi,
                      random = list(~1 | StudyID/ESID),
                      data = df2)
summary(multilevel3)
```

```
##
## Multivariate Meta-Analysis Model (k = 273; method: REML)
##
##    logLik   Deviance        AIC        BIC       AICc
##   83.4307  -166.8614  -160.8614  -150.0440  -160.7718
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed        factor
## sigma^2.1  0.0153  0.1238    129     no       StudyID
## sigma^2.2  0.0041  0.0644    273     no  StudyID/ESID
##
## Test for Heterogeneity:
## Q(df = 272) = 8958.2395, p-val < .0001
##
## Model Results:
##
## estimate      se    zval    pval   ci.lb   ci.ub
##   0.0906  0.0132  6.8419  <.0001  0.0647  0.1166  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Two level model
multilevel2 <- rma.mv(yi = yi,
                      V = vi,
                      data = df2)
summary(multilevel2)
```

```
##
## Multivariate Meta-Analysis Model (k = 273; method: REML)
##
##     logLik    Deviance         AIC         BIC        AICc
## -4064.5556   8129.1111   8131.1111   8134.7169   8131.1259
##
## Variance Components: none
##
## Test for Heterogeneity:
## Q(df = 272) = 8958.2395, p-val < .0001
##
## Model Results:
##
## estimate      se      zval    pval   ci.lb   ci.ub
##   0.2764  0.0015  178.9434  <.0001  0.2734  0.2795  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Hypotheses

- If their method under-corrects, I expect to find larger standard errors with the 3-level model
- If their method over-corrects, I expect to find smaller standard errors with the 3-level model
- Also the average effect size estimate may be different because studies that previously were assigned

a certain weight based on their adjusted sample size may have a different contribution in the 3-level analysis.