

IQ_Math

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1 Preparation

```
## Load packages & Customized R functions
library(metafor)      # package for meta-analyses
library(robumeta)     # package for meta-analyses
library(xlsx)         # read in .xlsx files
library(psychmeta)    # range restriction and unreliability correction
library(clubSandwich) # Multivariate meta-analysis with dependent effect sizes

## set working directory
wd <- "D:/Research/2020/Meta Child/2024/RCode"
setwd(wd)              # set working directory

## Read in data
dall = read.xlsx('ASD meta-analysis data0405all.xlsx',1)
#summary(dall)         # take a look at the data
```

2 Correlation between full IQ and math scores

2.1 Data preparation

```
# remove studies not reporting correlations
var.sel = c('corr_fsiq_math','standardization_NOT')
del = which(is.na(dall[,var.sel]),arr.ind = T)
```

```

del = unique(del[,1])
dsub = dall[-del,]

# Compute effect sizes
Nstudy = nrow(dsub)      # number of primary studies
ri = dsub$corr_fsiq_math # effect sizes
ni = dsub$n              # sample sizes
vi = (1-ri^2)^2/(ni-1)   # sampling variances of effect sizes
sei = sqrt(vi)           # standard error observed correlations
id = dsub$id             # study labels

#### Organize moderators
Age = dsub$age
Age = Age - mean(Age, na.rm = T)

PubYear = dsub$PubYear - min(dsub$PubYear)

Severity = dsub$calibrated.severity.scores
Severity = Severity - mean(Severity, na.rm = T)

gender = dsub$gender.ratio
gender = gender - mean(gender, na.rm = T)

modsl = list(Age = Age, Publication.Year = PubYear, ASD.Severity = Severity,
             genderratio = gender)

```

2.1.1 Meta-analysis of correlation with RVE

```

dat.rmathfIQ = data.frame(ri,vi,id)
fit0 = robu(formula = ri ~ 1, data = dat.rmathfIQ,
            studynum = id, var.eff.size = vi,
            modelweights = "CORR", small = TRUE)
fit0$reg_table

##      labels      b.r      SE      t      dfs      prob      CI.L
## 1 X.Intercept. 0.6239115 0.04948207 12.60884 10.26193 1.416541e-07 0.5140389
##      CI.U sig
## 1 0.7337842 ***

# Forest plot: Visualize the meta-analytic results
png(filename = paste0('Forest.','MathXfIQ',' .png'))
forest.robu(fit0, es.lab = 'ri', study.lab = 'id')
dev.off()

## pdf
## 2

```

2.2 Moderator Analysis (meta-regression) with RVE

```

mods.names = names(modsl)
Mod.res = matrix(NA, 1, 9)
colnames(Mod.res) = c("labels", "b.r", "SE", "t",
                     "dfs", "prob", "CI.L", "CI.U", "sig" )
Mod.res = as.data.frame(Mod.res)

```

```

for(mi in 1:length(mods.names)){
  mod = as.matrix(modsl[[mi]])
  dat.tmp = cbind(dat.rmathfIQ,mod)
  fit.tmp = robu(formula = ri ~ 1 + mod, data = dat.tmp,
                 studynum = id,var.eff.size = vi,
                 modelweights = "CORR", small = TRUE)

  res.tmp = fit.tmp$reg_table
  res.tmp[1,1] = 'Intercept'
  nmod = ncol(mod)
  if(nmod == 1){
    res.tmp[2,1] = mods.names[mi]
  }else{
    res.tmp[2:(nmod+1),1] = colnames(mod)
  }
  Mod.res = rbind(Mod.res,res.tmp)
}
Mod.res[1,] = fit0$reg_table
Mod.res[1,1] = 'No moderator'
Mod.res

```

```

##          labels          b.r          SE          t          dfs          prob
## 1    No moderator  0.623911549  0.049482071  12.6088407  10.261931  1.416541e-07
## 2      Intercept  0.619993039  0.049797507  12.4502826   9.075303  5.204568e-07
## 3          Age   0.010087874  0.004861437   2.0750805   1.231221  2.472420e-01
## 4      Intercept  0.765624167  0.085366449   8.9686777   2.467399  6.073217e-03
## 5 Publication.Year -0.006542993  0.004880491  -1.3406424   3.186329  2.676099e-01
## 6      Intercept  0.442413263  0.141844051   3.1190117   1.000000  1.975177e-01
## 7    ASD.Severity -0.266808989  0.179645265  -1.4851991   1.000000  3.772532e-01
## 8      Intercept  0.627180205  0.068511747   9.1543455   6.312256  7.120720e-05
## 9    genderratio -0.271288708  0.477923472  -0.5676405   1.903038  6.300433e-01
##          CI.L          CI.U sig
## 1  0.51403889  0.733784207 ***
## 2  0.50748557  0.732500504 ***
## 3 -0.03001426  0.050190004
## 4  0.45756448  1.073683850 ***
## 5 -0.02157350  0.008487512
## 6 -1.35988629  2.244712819
## 7 -2.54941851  2.015800527
## 8  0.46152786  0.792832551 ***
## 9 -2.43136663  1.888789210

```

```

write.xlsx(Mod.res,'Correlation.xlsx',sheetName = 'MathfIQ',append = T)

```

3 Correlation Between Verbal IQ and Math Scores

3.1 Data preparation

```

# Data preparation
# remove studies not reporting correlations
var.sel = c('corr_viq_math','standardization_NOT')
del = which(is.na(dall[,var.sel]),arr.ind = T)
del = unique(del[,1])
dsub = dall[-del,]

```

```

Nstudy = nrow(dsub)      # number of primary studies
ri = dsub$corr_viq_math  # effect sizes
ni = dsub$n              # sample sizes
vi = (1-ri^2)^2/(ni-1)   # sampling variances of effect sizes
sei = sqrt(vi)           # standard error observed correlations
id = dsub$id             # study labels

#### Organize moderators
Age = dsub$age
Age = Age - mean(Age, na.rm = T)

PubYear = dsub$PubYear - min(dsub$PubYear)

Severity = dsub$calibrated.severity.scores
Severity = Severity - mean(Severity, na.rm = T)

gender = dsub$gender.ratio
gender = gender - mean(gender, na.rm = T)

modsl = list(Age = Age, Publication.Year = PubYear, ASD.Severity = Severity,
             genderratio = gender)

```

3.2 Meta-analysis of correlation with RVE

```

dat.rmathvIQ = data.frame(ri,vi,id)
fit0 = robu(formula = ri ~ 1, data = dat.rmathvIQ,
            studynum = id, var.eff.size = vi,
            modelweights = "CORR", small = TRUE)
fit0$reg_table

##          labels          b.r          SE          t          dfs          prob          CI.L
## 1 X.Intercept. 0.6250991 0.08693832 7.190144 4.468428 0.001285183 0.3933789
##          CI.U sig
## 1 0.8568193 ***

# Forest plot: Visualize the meta-analytic results
png(filename = paste0('Forest.', 'MathXvIQ', '.png'))
forest.robu(fit0, es.lab = 'ri', study.lab = 'id')
dev.off()

## pdf
## 2

```

3.3 Moderator Analysis (meta-regression) with RVE

```

mods.names = names(modsl)
Mod.res = matrix(NA, 1, 9)
colnames(Mod.res) = c("labels", "b.r", "SE", "t",
                     "dfs", "prob", "CI.L", "CI.U", "sig")
Mod.res = as.data.frame(Mod.res)
for(mi in 1:length(mods.names)){
  mod = as.matrix(modsl[[mi]])
  dat.tmp = cbind(dat.rmathvIQ, mod)
}

```

```

fit.tmp = robu(formula = ri ~ 1 + mod, data = dat.tmp,
               studynum = id, var.eff.size = vi,
               modelweights = "CORR", small = TRUE)
res.tmp = fit.tmp$reg_table
res.tmp[1,1] = 'Intercept'
nmod = ncol(mod)
if(nmod == 1){
  res.tmp[2,1] = mods.names[mi]
}else{
  res.tmp[2:(nmod+1),1] = colnames(mod)
}
Mod.res = rbind(Mod.res, res.tmp)
}
Mod.res[1,] = fit0$reg_table
Mod.res[1,1] = 'No moderator'
Mod.res

```

```

##          labels          b.r          SE          t          dfs          prob
## 1      No moderator  0.625099113  0.086938324  7.1901445  4.468428  0.001285183
## 2          Intercept  0.619431357  0.098712261  6.2751208  3.393940  0.005607770
## 3              Age   0.005785302  0.013980728  0.4138055  1.421756  0.732819378
## 4          Intercept  0.724111196  0.090904637  7.9656134  1.092443  0.066923642
## 5 Publication.Year -0.004072432  0.005045277 -0.8071771  1.542649  0.525080760
## 6          Intercept  0.412329651  0.115903268  3.5575326  1.000000  0.174448208
## 7      ASD.Severity -0.270886434  0.077268846 -3.5057653  1.000000  0.176894485
## 8          Intercept  0.617435967  0.109261795  5.6509777  3.611481  0.006530090
## 9      genderratio -0.226455462  1.330836666 -0.1701602  2.060483  0.880131595
##          CI.L          CI.U sig
## 1  0.39337888  0.85681935 ***
## 2  0.32493867  0.91392404 ***
## 3 -0.08513143  0.09670203
## 4 -0.22374394  1.67196633  *
## 5 -0.03328026  0.02513539
## 6 -1.06036101  1.88502031
## 7 -1.25268021  0.71090734
## 8  0.30076219  0.93410974 ***
## 9 -5.79448748  5.34157656

```

```

write.xlsx(Mod.res, 'Correlation.xlsx', sheetName = 'MathvIQ', append = T)

```

4 Correlation Between Nonverbal IQ and Math Scores

```

#### Data Preparation
# remove studies not reporting correlations
var.sel = c('corr_nviq_math', 'standardization_NOT')
del = which(is.na(dall[,var.sel]), arr.ind = T)
del = unique(del[,1])
dsub = dall[-del,]

Nstudy = nrow(dsub)      # number of primary studies
ri = dsub$corr_nviq_math # effect sizes
ni = dsub$n              # sample sizes
vi = (1-ri^2)^2/(ni-1)   # sampling variances of effect sizes

```

```

sei = sqrt(vi)           # standard error observed correlations
id = dsub$id             # study labels

#### Organize moderators
Age = dsub$age
Age = Age - mean(Age, na.rm = T)

PubYear = dsub$PubYear - min(dsub$PubYear)

Severity = dsub$calibrated.severity.scores
Severity = Severity - mean(Severity, na.rm = T)

gender = dsub$gender.ratio
gender = gender - mean(gender, na.rm = T)

modsl = list(Age = Age, Publication.Year = PubYear, ASD.Severity = Severity,
             genderratio = gender)

```

4.1 Meta-analysis of correlation with RVE

```

dat.rmathnviQ = data.frame(ri,vi,id)
fit0 = robu(formula = ri ~ 1, data = dat.rmathnviQ,
            studynum = id, var.eff.size = vi,
            modelweights = "CORR", small = TRUE)
fit0$reg_table

##          labels      b.r      SE      t      dfs      prob      CI.L
## 1 X.Intercept. 0.5120476 0.1611643 3.177178 1.852304 0.09531824 -0.237163
##          CI.U sig
## 1 1.261258    *

# Forest plot: Visualize the meta-analytic results
png(filename = paste0('Forest.', 'MathXnviQ', '.png'))
forest.robust(fit0, es.lab = 'ri', study.lab = 'id')
dev.off()

## pdf
## 2

```

4.2 Moderator Analysis (meta-regression) with RVE

```

mods.names = names(modsl)
Mod.res = matrix(NA, 1, 9)
colnames(Mod.res) = c("labels", "b.r", "SE", "t",
                     "dfs", "prob", "CI.L", "CI.U", "sig" )
Mod.res = as.data.frame(Mod.res)
for(mi in 1:length(mods.names)){
  mod = as.matrix(modsl[[mi]])
  dat.tmp = cbind(dat.rmathnviQ, mod)
  fit.tmp = try( robu(formula = ri ~ 1 + mod, data = dat.tmp,
                    studynum = id, var.eff.size = vi,
                    modelweights = "CORR", small = TRUE) )
  if( inherits(fit.tmp, 'try-error') ){
    res.tmp = c(mods.names[mi], rep(NA, 8))
  }
}

```

```

}else{
  res.tmp = fit.tmp$reg_table
  res.tmp[1,1] = 'Intercept'
  nmod = ncol(mod)
  if(nmod == 1){
    res.tmp[2,1] = mods.names[mi]
  }else{
    res.tmp[2:(nmod+1),1] = colnames(mod)
  }
}
Mod.res = rbind(Mod.res,res.tmp)
}

```

```

## Error in solve.default(sumXWX) :
## Lapack dgesv: : U[2,2] = 0

```

```

Mod.res[1,] = fit0$reg_table
Mod.res[1,1] = 'No moderator'
Mod.res

```

	labels	b.r	SE	t
## 1	No moderator	0.512047573968734	0.161164259451229	3.17717821378187
## 2	Intercept	0.483190890864693	0.18669802446128	2.5880878614487
## 3	Age	0.0273958507775802	0.0249288153478737	1.09896320363723
## 4	Intercept	0.789463549025648	0.262920354400145	3.0026718578971
## 5	Publication.Year	-0.0162271428907993	0.0121412363585836	-1.3365313392756
## 6	ASD.Severity	<NA>	<NA>	<NA>
## 7	Intercept	0.470241025877029	0.292412994201404	1.60813997736757
## 8	genderratio	0.0587355272831802	2.75705857973727	0.0213036921721037

	dfs	prob	CI.L	CI.U	sig
## 1	1.85230356267596	0.0953182355704538	-0.237162990050307	1.26125813798778	*
## 2	1	0.234731293293166	-1.88903243177969	2.85541421350907	
## 3	1	0.470006472731737	-0.289354780862797	0.344146482417957	
## 4	1	0.204662805178855	-2.55125630329021	4.1301834013415	
## 5	1	0.408933724100189	-0.170496177813251	0.138041892031652	
## 6	<NA>	<NA>	<NA>	<NA>	<NA>
## 7	1	0.354165039614493	-3.24521834596388	4.18570039771793	
## 8	1	0.986439699525842	-34.9730152564856	35.0904863110519	

```

write.xlsx(Mod.res,'Correlation.xlsx',sheetName = 'MathnvIQ',append = T)

```

5 Study-level analysis

5.1 Weighted Regression

```

# ### Only studies with control groups were included
# remove studies not available to compute hedges g
del = which(is.na(dall[, 'standardization_NOT']),arr.ind = T)
del = unique(del)
dsub = dall[-del,]

ni = dsub$n # sample sizes
fIQ = dsub$fsiq-100 # full IQ
vIQ = as.numeric(dsub$viq)-100 # verbal IQ

```

```

nvIQ = dsub$nvIQ-100      # non-verbal IQ
math = dsub$mathscores    # mathscores

summary(lm(math~fIQ,weights = ni))

##
## Call:
## lm(formula = math ~ fIQ, weights = ni)
##
## Weighted Residuals:
##      Min       1Q   Median       3Q      Max
## -62.086 -27.290  -3.378  18.926 142.999
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  98.27226    0.71127   138.16  <2e-16 ***
## fIQ          0.90108    0.04908    18.36  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 36.39 on 70 degrees of freedom
## ( 15 )
## Multiple R-squared:  0.828, Adjusted R-squared:  0.8256
## F-statistic: 337.1 on 1 and 70 DF, p-value: < 2.2e-16

summary(lm(math~vIQ,weights = ni))

##
## Call:
## lm(formula = math ~ vIQ, weights = ni)
##
## Weighted Residuals:
##      Min       1Q   Median       3Q      Max
## -82.408 -24.841   1.151  27.074 120.285
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  98.92626    0.92142  107.363  < 2e-16 ***
## vIQ          0.91463    0.09201   9.941 1.58e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 39.51 on 51 degrees of freedom
## ( 34 )
## Multiple R-squared:  0.6596, Adjusted R-squared:  0.6529
## F-statistic: 98.82 on 1 and 51 DF, p-value: 1.578e-13

summary(lm(math~nvIQ,weights = ni))

##
## Call:
## lm(formula = math ~ nvIQ, weights = ni)
##
## Weighted Residuals:
##      Min       1Q   Median       3Q      Max

```



```

## -77.54 -18.41 -2.27 19.59 79.96
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 96.34937    0.74702  128.98  <2e-16 ***
## nvIQ        0.88277    0.05629   15.68  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 33.37 on 52 degrees of freedom
## ( 33 )
## Multiple R-squared:  0.8255, Adjusted R-squared:  0.8221
## F-statistic: 246 on 1 and 52 DF, p-value: < 2.2e-16

```