

IQ_Math

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1 Preparation

```
## Load packages & Customized R functions
library(metafor)
library(robumeta)
library(xlsx)      # read in .xlsx files
library(psychmeta) # range restriction and unreliability correction

## 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 Math ability: ASD versus TD controls

2.1 Meta-analysis of Standardized mean difference (SMD)

2.1.1 Data preparation

```
#### Data Preparation
#-----
# ### Only studies with control groups were included
# remove studies not available to compute hedges g
var.sel = c('mathscores', 'SDmathscores', 'n', 'control.group.mathscores.mean',
            'control.group.mathscores.SD', 'control.group.N')
del = which(is.na(dall[,var.sel]),arr.ind = T)
del = unique(del[,1])
dsub = dall[-del,]
```

```

# Compute effect sizes for math
rr.math = dsub$Cronbach_math
id = dsub$id # study labels
Nstudy = nrow(dsub) # number of primary studies
x1 = dsub$mathscores # group means
x2 = dsub$control.group.mathscores.mean
n1 = dsub$n # sample sizes
n2 = dsub$control.group.N
s1 = dsub$SDmathscores # group SDs
s2 = dsub$control.group.mathscores.SD
sp = sqrt(((n1-1)*s1^2+(n2-1)*s2^2)/(n1+n2-2))
tmp = escalc(measure = 'SMD', m1i = x1, sd1i = s1, n1i=n1,
             m2i = x2, sd2i = s2, n2i=n2)

hedgesgmath = tmp$yi # unbiased effect sizes for math: hedge's g
vimath = tmp$vi # sampling variances of effect sizes for math

group = dsub$group #For Multivariate meta-analysis with dependent effect sizes

#### Compute effect sizes for IQs

## For fIQ
id = dsub$id # study labels
Nstudy = nrow(dsub) # number of primary studies
x1 = dsub$fsiq # group means
x2 = dsub$control.group.fsiq
n1 = dsub$n # sample sizes
n2 = dsub$control.group.N
s1 = dsub$SDfsiq # group SDs
s2 = dsub$control.group.SDfsiq
sp = sqrt(((n1-1)*s1^2+(n2-1)*s2^2)/(n1+n2-2))
tmp = escalc(measure = 'SMD', m1i = x1, sd1i = s1, n1i=n1,
             m2i = x2, sd2i = s2, n2i=n2)

hedgesg = tmp$yi # unbiased effect sizes: hedge's g
vi = tmp$vi # sampling variances of effect sizes
fIQ.hedgesg.c = hedgesg

## For vIQ
id = dsub$id # study labels
Nstudy = nrow(dsub) # number of primary studies
x1 = as.numeric(dsub$viq) # group means
x2 = dsub$control.group.viq
n1 = dsub$n # sample sizes
n2 = dsub$control.group.N
s1 = dsub$SDviq # group SDs
s2 = dsub$control.group.SDviq
sp = sqrt(((n1-1)*s1^2+(n2-1)*s2^2)/(n1+n2-2))
tmp = escalc(measure = 'SMD', m1i = x1, sd1i = s1, n1i=n1,
             m2i = x2, sd2i = s2, n2i=n2)

hedgesg = tmp$yi # unbiased effect sizes: hedge's g
vi = tmp$vi # sampling variances of effect sizes
vIQ.hedgesg.c = hedgesg

## For nvIQ

```

```

id = dsub$id                      # study labels
Nstudy = nrow(dsub)               # number of primary studies
x1 = dsub$nviq                    # group means
x2 = dsub$control.group.nviq
n1 = dsub$n                       # sample sizes
n2 = dsub$control.group.N
s1 = dsub$SDnviq                  # group SDs
s2 = dsub$control.group.SDnviq
sp = sqrt(((n1-1)*s1^2+(n2-1)*s2^2)/(n1+n2-2))
tmp = escalc(measure = 'SMD', m1i = x1, sd1i = s1, n1i=n1,
              m2i = x2, sd2i = s2, n2i=n2)
hedgesg = tmp$yi                  # unbiased effect sizes: hedge's g
vi = tmp$vi                       # sampling variances of effect sizes
nvIQ.hedgesg.c = hedgesg

#### 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)

fIQASD = dsub$fsiq-100
vIQASD = as.numeric(dsub$viq)-100
nvIQASD = dsub$nviq-100

fIQTD = dsub$control.group.fsiq-100
vIQTD = as.numeric(dsub$control.group.viq)-100
nvIQTD = dsub$control.group.nviq-100

bg.fIQ = data.frame(fIQASD=fIQASD, fIQTD = fIQTD)
bg.vIQ = data.frame(vIQASD=vIQASD, vIQTD = vIQTD)
bg.nvIQ = data.frame(nvIQASD=nvIQASD, nvIQTD = nvIQTD)

AgexfIQ = data.frame(Age = scale(Age), fIQASD = scale(fIQASD),
                     Interaction = scale(Age)*scale(fIQASD))
AgexvIQ = data.frame(Age = scale(Age), vIQASD = scale(vIQASD),
                     Interaction = scale(Age)*scale(vIQASD))
AgexnvIQ = data.frame(Age = scale(Age), nvIQASD = scale(nvIQASD),
                     Interaction = scale(Age)*scale(nvIQASD))

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

modsl = list(Age = Age, Publication.Year = PubYear, ASD.Severity = Severity,
             genderratio = gender,
             bg.fIQ=bg.fIQ, bg.vIQ=bg.vIQ, bg.nvIQ=bg.nvIQ,
             AgexfIQ=AgexfIQ, AgexvIQ=AgexvIQ, AgexnvIQ=AgexnvIQ,
             fIQd = as.numeric(fIQ.hedgesg.c), vIQd = as.numeric(vIQ.hedgesg.c),
             nvIQd = as.numeric(nvIQ.hedgesg.c) )

```

2.1.2 Meta-analysis with RVE

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

```
##          labels      b.r      SE      t      dfs      prob      CI.L
## 1 X.Intercept. -0.67605 0.1413047 -4.784341 37.59174 2.654887e-05 -0.9622085
##          CI.U sig
## 1 -0.3898915 ***
```

2.1.3 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.hedgesgmth,mod)
  fit.tmp = robu(formula = hedgesgmth ~ 1 + mod, data = dat.tmp,
                studynum = id,var.eff.size = vimath,
                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 -0.67605002 0.141304730 -4.7843411 37.591738 2.654887e-05
## 2 Intercept -0.53143513 0.096391573 -5.5132946 26.964491 7.729438e-06
## 3 Age 0.01941970 0.013765225 1.4107799 10.502655 1.872360e-01
## 4 Intercept 0.10807356 0.195012524 0.5541878 7.192178 5.962536e-01
## 5 Publication.Year -0.03082193 0.011084693 -2.7805850 10.151796 1.917377e-02
## 6 Intercept -0.46161587 0.200457563 -2.3028109 7.870970 5.076473e-02
## 7 ASD.Severity -0.03032513 0.292094485 -0.1038196 3.071244 9.237223e-01
## 8 Intercept -0.43866324 0.075674144 -5.7967388 27.816201 3.244117e-06
## 9 genderratio -0.39738991 0.432578040 -0.9186548 4.835568 4.017772e-01
## 10 Intercept -0.28818627 0.096644769 -2.9819127 8.618379 1.615022e-02
## 11 fIQASD 0.05198581 0.013193076 3.9403862 9.387108 3.135101e-03
## 12 fIQTD -0.03670274 0.009435817 -3.8897254 7.007878 5.964404e-03
## 13 Intercept -0.33991231 0.092988793 -3.6554115 9.341608 4.952998e-03
```

```

## 14      vIQASD  0.05352393 0.016393917  3.2648653  5.660975 1.864224e-02
## 15      vIQTD -0.02263020 0.010531678 -2.1487744  8.048676 6.369296e-02
## 16      Intercept -0.18662096 0.114954620 -1.6234316  8.219444 1.421441e-01
## 17      nvIQASD  0.04521654 0.013319737  3.3947023  6.725921 1.224651e-02
## 18      vIQTD -0.05434568 0.011728426 -4.6336726  7.323134 2.120725e-03
## 19      Intercept -0.46291776 0.073853473 -6.2680567 16.680560 9.267377e-06
## 20      Age -0.02599932 0.055399721 -0.4693041  6.199993 6.549032e-01
## 21      fIQASD  0.28531212 0.068862832  4.1431947  8.122850 3.133638e-03
## 22      Interation -0.15948347 0.044421634 -3.5902207  4.914754 1.617279e-02
## 23      Intercept -0.74963722 0.114113898 -6.5692018 13.515476 1.487362e-05
## 24      Age  0.10946294 0.089153356  1.2278050  6.272534 2.635929e-01
## 25      vIQASD  0.73120659 0.217829418  3.3567853  9.891824 7.391335e-03
## 26      Interation -0.08556844 0.329865539 -0.2594040  5.385327 8.049509e-01
## 27      Intercept -0.60605422 0.140195177 -4.3229321 15.538383 5.590177e-04
## 28      Age  0.09460271 0.100771642  0.9387831  4.904813 3.917328e-01
## 29      nvIQASD  0.45354755 0.213529299  2.1240530 12.134238 5.488927e-02
## 30      Interation -0.31933438 0.242416347 -1.3172972  5.764116 2.376768e-01
## 31      Intercept -0.23728777 0.100693456 -2.3565361 13.579811 3.404693e-02
## 32      fIQd  0.48798808 0.155166693  3.1449280  6.846486 1.674484e-02
## 33      Intercept -0.21517493 0.100612140 -2.1386578 20.245264 4.483077e-02
## 34      vIQd  0.41849370 0.106685487  3.9226863  3.766053 1.930656e-02
## 35      Intercept -0.23166677 0.092247356 -2.5113648 20.095851 2.067886e-02
## 36      nvIQd  0.70563466 0.067641306 10.4320082  3.212033 1.385799e-03
##      CI.L      CI.U sig
## 1  -0.96220855 -0.389891493 ***
## 2  -0.72922649 -0.333643776 ***
## 3  -0.01105332  0.049892725
## 4  -0.35057169  0.566718814
## 5  -0.05547020 -0.006173663 **
## 6  -0.92519419  0.001962447 *
## 7  -0.94781947  0.887169201
## 8  -0.59372086 -0.283605629 ***
## 9  -1.52083714  0.726057320
## 10 -0.50829655 -0.068075984 **
## 11  0.02232756  0.081644065 ***
## 12 -0.05900982 -0.014395660 ***
## 13 -0.54910080 -0.130723814 ***
## 14  0.01281986  0.094228005 **
## 15 -0.04689075  0.001630351 *
## 16 -0.45047993  0.077238006
## 17  0.01345831  0.076974771 **
## 18 -0.08183285 -0.026858520 ***
## 19 -0.61896259 -0.306872933 ***
## 20 -0.16050462  0.108505985
## 21  0.12693121  0.443693017 ***
## 22 -0.27427122 -0.044695724 **
## 23 -0.99521292 -0.504061524 ***
## 24 -0.10641035  0.325336226
## 25  0.24513198  1.217281209 ***
## 26 -0.91558708  0.744450202
## 27 -0.90397392 -0.308134529 ***
## 28 -0.16595842  0.355163850
## 29 -0.01112263  0.918217740 *
## 30 -0.91843994  0.279771185

```

```
## 31 -0.45388236 -0.020693172 **
## 32  0.11940279  0.856573372 **
## 33 -0.42488530 -0.005464564 **
## 34  0.11488751  0.722099881 **
## 35 -0.42403256 -0.039300973 **
## 36  0.49818972  0.913079604 ***

write.xlsx(Mod.res, 'GMath.xlsx', sheetName = 'vsTD.SMD', append = T)
```

2.2 Meta-analysis of variability (log SD ratio) with RVE

2.2.1 Data preparation

```
var.sel = c('SDmathscores', 'n', 'control.group.mathscores.SD', 'control.group.N')
del = which(is.na(dall[, var.sel]), arr.ind = T)
del = unique(del[, 1])
dsub = dall[-del, ]

group = dsub$group #For multivariate meta-analysis with dependent effect sizes

s1 = dsub$SDmathscores      # group SDs
s2 = dsub$control.group.mathscores.SD
n1 = dsub$n                 # sample sizes
n2 = dsub$control.group.N
yi = log(s1/s2)+1/2/(n1-1)-1/2/(n2-1)
vi = 1/2/(n1-1)+1/2/(n2-1)
```

2.2.2 Meta-analysis with RVE

```
dat.sdmath = data.frame(yi, vi, id)
fit0 = robu(formula = yi ~ 1, data = dat.sdmath,
            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.  0.3119509  0.05177691  6.024904  37.14031  5.728296e-07  0.2070543
##          CI.U sig
## 1 0.4168476 ***
```

2.2.3 Moderator Analysis (meta-regression) with RVE

```
mods.names = names(mods1)
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(mods1[[mi]])
  dat.tmp = cbind(dat.sdmath, mod)
  fit.tmp = robu(formula = yi ~ 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
## 1	No moderator	0.3119509452	0.051776913	6.024904331	37.140310
## 2	Intercept	0.2780205362	0.051222218	5.427733257	26.571396
## 3	Age	-0.0016451069	0.009740958	-0.168885537	10.815815
## 4	Intercept	0.1529200429	0.114514149	1.335381211	7.404730
## 5	Publication.Year	0.0062086035	0.004802795	1.292706423	10.338370
## 6	Intercept	0.3625320787	0.073744997	4.916022664	7.484890
## 7	ASD.Severity	0.2057428310	0.119828662	1.716975114	3.013034
## 8	Intercept	0.2570521545	0.048139697	5.339712819	27.038143
## 9	genderratio	0.0013019584	0.241577487	0.005389403	4.679482
## 10	Intercept	0.2393892589	0.068829350	3.478011306	8.634765
## 11	fIQASD	0.0028674878	0.008320620	0.344624287	9.201920
## 12	fIQTD	-0.0001123425	0.010218465	-0.010994066	6.743120
## 13	Intercept	0.1744635071	0.057007205	3.060376454	8.786949
## 14	vIQASD	-0.0033249933	0.004285143	-0.775935115	5.378511
## 15	vIQTD	0.0077905612	0.004166143	1.869969542	8.073012
## 16	Intercept	0.2393306194	0.071587430	3.343193336	8.244874
## 17	nvIQASD	-0.0044019540	0.004819948	-0.913278276	7.521440
## 18	vIQTD	0.0065237983	0.006781342	0.962021712	6.907498
## 19	Intercept	0.2692155847	0.058322629	4.615971313	16.940535
## 20	Age	0.0503346213	0.045656047	1.102474365	6.219089
## 21	fIQASD	-0.0591500641	0.068529171	-0.863137020	8.046325
## 22	Interation	0.1098887600	0.058990382	1.862825014	4.949811
## 23	Intercept	0.2432838325	0.060128260	4.046081360	13.179537
## 24	Age	0.0016753056	0.039213373	0.042722813	6.306497
## 25	vIQASD	-0.0174934496	0.094967954	-0.184203711	10.295177
## 26	Interation	0.0588797457	0.100526747	0.585712236	6.438281
## 27	Intercept	0.3022137754	0.074282710	4.068426899	15.534669
## 28	Age	-0.0426910317	0.092411410	-0.461967108	5.202426
## 29	nvIQASD	-0.0650014079	0.084575071	-0.768564625	11.901346
## 30	Interation	-0.0033824937	0.115923715	-0.029178617	6.574449
## 31	Intercept	0.2544801430	0.052053581	4.888811446	12.998056
## 32	fIQd	0.0486362593	0.088172399	0.551604130	6.174893
## 33	Intercept	0.2099479231	0.045636969	4.600391482	18.033200
## 34	vIQd	-0.0468057750	0.039430987	-1.187030280	3.207333
## 35	Intercept	0.2495146175	0.059650947	4.182911260	21.141152
## 36	nvIQd	-0.0728821061	0.061934450	-1.176761983	1.985978
##	prob	CI.L	CI.U	sig	
## 1	5.728296e-07	0.207054332	0.416847559	***	
## 2	1.017646e-05	0.172841845	0.383199227	***	
## 3	8.690036e-01	-0.023129439	0.019839225		

```

## 4 2.213406e-01 -0.114891249 0.420731335
## 5 2.242554e-01 -0.004445404 0.016862611
## 6 1.419163e-03 0.190416996 0.534647161 ***
## 7 1.840892e-01 -0.174673930 0.586159592
## 8 1.218824e-05 0.158284176 0.355820133 ***
## 9 9.959220e-01 -0.632706898 0.635310815
## 10 7.415132e-03 0.082676712 0.396101806 ***
## 11 7.381225e-01 -0.015892291 0.021627266
## 12 9.915463e-01 -0.024463031 0.024238346
## 13 1.394464e-02 0.045026041 0.303900973 **
## 14 4.705158e-01 -0.014111177 0.007461190
## 15 9.807745e-02 -0.001801480 0.017382602 *
## 16 9.752462e-03 0.075099249 0.403561990 ***
## 17 3.894322e-01 -0.015641083 0.006837175
## 18 3.684973e-01 -0.009555162 0.022602758
## 19 2.486508e-04 0.146132681 0.392298488 ***
## 20 3.110813e-01 -0.060434602 0.161103845
## 21 4.130486e-01 -0.217020389 0.098720261
## 22 1.221185e-01 -0.042214474 0.261991994
## 23 1.350199e-03 0.113564274 0.373003391 ***
## 24 9.672432e-01 -0.093157227 0.096507838
## 25 8.574315e-01 -0.228275753 0.193288853
## 26 5.780106e-01 -0.183097786 0.300857278
## 27 9.444437e-04 0.144357232 0.460070319 ***
## 28 6.627828e-01 -0.277488743 0.192106679
## 29 4.571324e-01 -0.249444215 0.119441399
## 30 9.775880e-01 -0.281136698 0.274371710
## 31 2.960623e-04 0.142023509 0.366936777 ***
## 32 6.005974e-01 -0.165641189 0.262913707
## 33 2.210810e-04 0.114080861 0.305814986 ***
## 34 3.156385e-01 -0.167826215 0.074214665
## 35 4.145204e-04 0.125514095 0.373515140 ***
## 36 3.611024e-01 -0.341175769 0.195411557

```

```

write.xlsx(Mod.res,'GMath.xlsx',sheetName = 'vsTD.logSDR',append = T)

```