

IQ_Math

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1 Preparation

```
## Load packages & Customized R functions
library(metafor)      # package for meta-analyses
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, fITD = fIQTD)
bg.vIQ = data.frame(vIQASD=vIQASD, vITD = vIQTD)
bg.nvIQ = data.frame(nvIQASD=nvIQASD, nvITD = nvIQTD)

AgexfIQ = data.frame(Age = scale(Age), fIQASD = scale(fIQASD),
                      Interaction = scale(Age)*scale(fIQASD))

```

```

AgexvIQ = data.frame(Age = scale(Age),vIQASD = scale(vIQASD),
                     Interation = scale(Age)*scale(vIQASD))
AgexnvIQ = data.frame(Age = scale(Age),nvIQASD = scale(nvIQASD),
                     Interation = 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	fITD	-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	vITD	-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	nVQASD	0.04521654	0.013319737	3.3947023	6.725921	1.224651e-02
## 18	nVTD	-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, 'Math.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	fITD	-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	vITD	0.0077905612	0.004166143	1.869969542	8.073012
## 16	Intercept	0.2393306194	0.071587430	3.343193336	8.244874
## 17	nVQASD	-0.0044019540	0.004819948	-0.913278276	7.521440
## 18	nVTD	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	Interaction	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      Iteration  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      Iteration -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, 'Math.xlsx', sheetName = 'vsTD.logSDR', append = T)
```


3 Math ability: ASD versus the norm group

3.1 Meta-analysis of SDM

3.1.1 Data preparation

```
#-----  
# remove studies not available to compute cohen's d  
var.sel = c('mathscores', 'SDmathscores', 'n', 'standardization_NOT')  
del = which(is.na(dall[,var.sel]), arr.ind = T)  
del = unique(del[,1])  
dsub = dall[-del,]  
  
# Compute effect sizes  
rr.math = dsub$Cronbach_math  
id = dsub$id # study labels  
Nstudy = nrow(dsub) # number of primary studies  
x1 = dsub$mathscores # group means  
x2 = rep(100, Nstudy)  
n1 = dsub$n # sample sizes  
n2 = n1  
s1 = dsub$SDmathscores # group SDs  
s2 = rep(15, Nstudy)  
sp = sqrt(((n1-1)*s1^2 + (n2-1)*s2^2)/(n1+n2-2))  
tmp = escalc(measure = 'SMD', m1i = x1, sd1i = s1, n1i = n1,  
             m2i = x2, sd2i = s2, n2i = n2)  
hedgesgmath = tmp$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  
  
#### 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$nvIQASD  
  
AgexfIQ = data.frame(Age = scale(Age), fIQASD = scale(fIQASD),  
                    Inter = scale(Age)*scale(fIQASD))  
AgexvIQ = data.frame(Age = scale(Age), vIQASD = scale(vIQASD),  
                    Inter = scale(Age)*scale(vIQASD))  
AgexnvIQ = data.frame(Age = scale(Age), nvIQASD = scale(nvIQASD),  
                    Inter = 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,
             fIQASD = fIQASD, vIQASD = vIQASD, nvIQASD = nvIQASD,
             AgexfIQ=AgexfIQ, AgexvIQ=AgexvIQ, AgexnvIQ=AgexnvIQ)

mods.plot = c(rep(0,4),rep(1,6))

```

3.1.2 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. -0.3267161 0.1190399 -2.744594 59.70827 0.007990553 -0.5648552
##          CI.U sig
## 1 -0.08857703 ***

```

3.1.3 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
## 1 No moderator -0.3267161230 0.119039854 -2.74459446 59.708272
## 2 Intercept -0.3276378604 0.123261061 -2.65808080 54.854093
## 3 Age 0.0154981030 0.020394703 0.75990826 10.104874
## 4 Intercept -0.3417799072 0.222276546 -1.53763370 14.956903

```

```

## 5 Publication.Year 0.0006184932 0.010006652 0.06180821 20.982856
## 6 Intercept -0.2519772261 0.299804866 -0.84047077 10.932556
## 7 ASD.Severity -0.5007288237 0.445613171 -1.12368497 5.671401
## 8 Intercept -0.2327705553 0.132665513 -1.75456719 42.782695
## 9 genderratio 0.6351214921 0.697633664 0.91039399 2.282020
## 10 Intercept -0.1023673420 0.050007257 -2.04704972 40.089130
## 11 fIQASD 0.0487003096 0.007017317 6.94001828 6.442134
## 12 Intercept -0.1150290274 0.068847966 -1.67076871 26.166774
## 13 vIQASD 0.0480943294 0.005184087 9.27729937 7.757141
## 14 Intercept -0.2371160132 0.049720405 -4.76898797 28.567350
## 15 nvIQASD 0.0528456697 0.002484336 21.27154539 5.826960
## 16 Intercept -0.1497718905 0.050192602 -2.98394353 37.157038
## 17 Age 0.0252442824 0.074412172 0.33924937 10.251705
## 18 fIQASD 0.7943128793 0.079569741 9.98259980 7.228606
## 19 Inter -0.1077078445 0.168168790 -0.64047464 3.893151
## 20 Intercept -0.2566062184 0.056365053 -4.55257657 23.796604
## 21 Age -0.0760164870 0.049078414 -1.54887822 7.161780
## 22 vIQASD 0.5379728993 0.070750276 7.60382760 6.842993
## 23 Inter 0.0344822611 0.144611703 0.23844724 4.194282
## 24 Intercept -0.2706640823 0.047731934 -5.67050319 22.456674
## 25 Age 0.0286096302 0.041058451 0.69680248 5.979826
## 26 nvIQASD 0.7175912725 0.032957424 21.77328176 6.281671
## 27 Inter 0.0032289900 0.059866917 0.05393613 5.853552
## prob CI.L CI.U sig
## 1 7.990553e-03 -0.56485521 -0.088577032 ***
## 2 1.027648e-02 -0.57467332 -0.080602404 **
## 3 4.646694e-01 -0.02988028 0.060876485
## 4 1.450218e-01 -0.81567007 0.132110260
## 5 9.513005e-01 -0.02019251 0.021429500
## 6 4.186468e-01 -0.91234029 0.408385839
## 7 3.064477e-01 -1.60660369 0.605146040
## 8 8.649359e-02 -0.50035536 0.034814253 *
## 9 4.483151e-01 -2.03764774 3.307890727
## 10 4.724674e-02 -0.20342878 -0.001305904 **
## 11 3.246294e-04 0.03181121 0.065589411 ***
## 12 1.066873e-01 -0.25650416 0.026446108
## 13 1.815163e-05 0.03607434 0.060114317 ***
## 14 4.984510e-05 -0.33887260 -0.135359429 ***
## 15 9.541535e-07 0.04672269 0.058968650 ***
## 16 5.006631e-03 -0.25145726 -0.048086525 ***
## 17 7.412690e-01 -0.14000623 0.190494792
## 18 1.742238e-05 0.60735989 0.981265866 ***
## 19 5.576125e-01 -0.57971673 0.364301038
## 20 1.319414e-04 -0.37299061 -0.140221826 ***
## 21 1.643797e-01 -0.19153917 0.039506199
## 22 1.411915e-04 0.36989379 0.706052006 ***
## 23 8.227344e-01 -0.35979478 0.428759302
## 24 9.802666e-06 -0.36953747 -0.171790695 ***
## 25 5.120899e-01 -0.07193899 0.129158255
## 26 3.733571e-07 0.63781585 0.797366692 ***
## 27 9.587796e-01 -0.14415307 0.150611055

```

```
write.xlsx(Mod.res, 'Math.xlsx', sheetName = 'vsNorm.SMD', append = T)
```

3.2 Meta-analysis of variability (log SD ratio)

3.2.1 Data preparation

```
var.sel = c('SDmathscores','n','standardization_NOT')
del = which(is.na(dall[,var.sel]),arr.ind = T)
del = unique(del[,1])
dsub = dall[-del,]
group = dsub$group #For multivariate meta-analysis with dependent effect sizes
Nstudy = nrow(dsub) # number of primary studies
s1 = dsub$SDmathscores # group SDs
s2 = rep(15,Nstudy)
n1 = dsub$n # sample sizes
n2 = n1
yi = log(s1/s2)+1/2/(n1-1)-1/2/(n2-1)
vi = 1/2/(n1-1)+1/2/(n2-1)
```

3.2.2 Meta-analysis with RVE

```
dat.sdmath = data.frame(yi,vi,id)
fit.res = robu(formula = yi ~ 1, data = dat.sdmath,
               studynum = id,var.eff.size = vi,
               modelweights = "CORR", small = TRUE)
fit.res$reg_table
```

```
##          labels          b.r          SE          t          dfs          prob          CI.L
## 1 X.Intercept. 0.1697604 0.02882973 5.888381 50.70939 3.121353e-07 0.1118743
##          CI.U sig
## 1 0.2276466 ***
```

3.2.3 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.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	prob
## 1	No moderator	-0.3267161230	0.119039854	-2.7445945	59.708272	7.990553e-03
## 2	Intercept	0.1712683866	0.026997725	6.3438082	44.751365	9.841265e-08
## 3	Age	0.0177977646	0.005278168	3.3719585	9.121522	8.075799e-03
## 4	Intercept	0.1900007619	0.067681623	2.8072725	15.478516	1.295872e-02
## 5	Publication.Year	-0.0008463283	0.002889228	-0.2929254	21.333445	7.724094e-01
## 6	Intercept	0.1367014397	0.062439045	2.1893583	10.493116	5.216750e-02
## 7	ASD.Severity	-0.0861160982	0.048801894	-1.7646056	5.357371	1.339847e-01
## 8	Intercept	0.1652950763	0.034625643	4.7737764	34.764177	3.216017e-05
## 9	genderratio	-0.1357438878	0.136364686	-0.9954475	2.381945	4.096569e-01
## 10	Intercept	0.1630728920	0.030826862	5.2899608	37.162210	5.674875e-06
## 11	fIQASD	-0.0041432421	0.001603145	-2.5844462	5.806559	4.277560e-02
## 12	Intercept	0.1808782610	0.036557236	4.9478100	23.523262	5.002051e-05
## 13	vIQASD	-0.0014541519	0.002872124	-0.5062984	7.536978	6.271199e-01
## 14	Intercept	0.1705401632	0.035689121	4.7784916	27.914707	5.117200e-05
## 15	nvIQASD	0.0009150934	0.002668855	0.3428787	4.413101	7.474082e-01
## 16	Intercept	0.1753100202	0.028440550	6.1640868	33.511911	5.596145e-07
## 17	Age	0.0935158596	0.032139247	2.9097091	9.751419	1.596708e-02
## 18	fIQASD	-0.0572518830	0.026527472	-2.1582110	5.983054	7.438869e-02
## 19	Inter	0.0131262194	0.037393597	0.3510285	3.640764	7.449253e-01
## 20	Intercept	0.2030026274	0.033645328	6.0336053	20.263204	6.367588e-06
## 21	Age	0.0111199403	0.025658736	0.4333783	7.736389	6.765692e-01
## 22	vIQASD	-0.0682309285	0.037996404	-1.7957207	6.976159	1.157516e-01
## 23	Inter	-0.2381612007	0.083131671	-2.8648673	5.588174	3.100098e-02
## 24	Intercept	0.1629705490	0.035594126	4.5785799	21.697509	1.514391e-04
## 25	Age	0.0111541256	0.042324864	0.2635360	6.293179	8.005554e-01
## 26	nvIQASD	0.0123260631	0.032332695	0.3812260	5.161231	7.182263e-01
## 27	Inter	-0.1136144037	0.067538591	-1.6822146	6.106908	1.426517e-01
##	CI.L	CI.U	sig			
## 1	-0.564855214	-0.0885770318	***			
## 2	0.116883838	0.2256529350	***			
## 3	0.005881923	0.0297136065	***			
## 4	0.046128260	0.3338732634	**			
## 5	-0.006849093	0.0051564365				
## 6	-0.001540282	0.2749431612	*			
## 7	-0.209089675	0.0368574784				
## 8	0.094984235	0.2356059178	***			
## 9	-0.640928007	0.3694402315				
## 10	0.100620938	0.2255248458	***			
## 11	-0.008097894	-0.0001885906	**			
## 12	0.105346831	0.2564096907	***			
## 13	-0.008148778	0.0052404740				
## 14	0.097424249	0.2436560772	***			
## 15	-0.006229137	0.0080593236				
## 16	0.117480845	0.2331391951	***			
## 17	0.021656939	0.1653747803	**			
## 18	-0.122206860	0.0077030940	*			
## 19	-0.094862642	0.1211150807				
## 20	0.132878100	0.2731271550	***			
## 21	-0.048401992	0.0706418722				
## 22	-0.158140430	0.0216785728				

```
## 23 -0.445266774 -0.0310556277 **
## 24  0.089093138  0.2368479601 ***
## 25 -0.091252716  0.1135609676
## 26 -0.070012882  0.0946650080
## 27 -0.278176622  0.0509478143

write.xlsx(Mod.res, 'Math.xlsx', sheetName = 'vsNorm.logSD', append = T)
```