

An Introduction to When and How to Conduct a Meta-Analysis

Mike W.-L. Cheung and Ranjith Vijayakumar

25 Feb 2016

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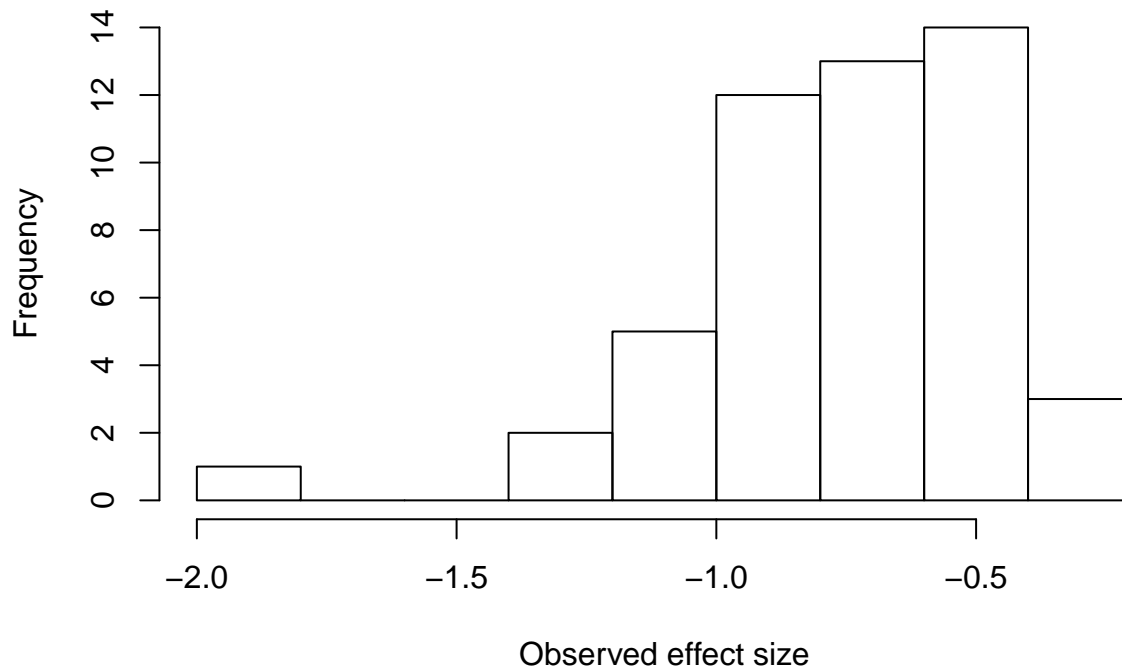
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Introduction

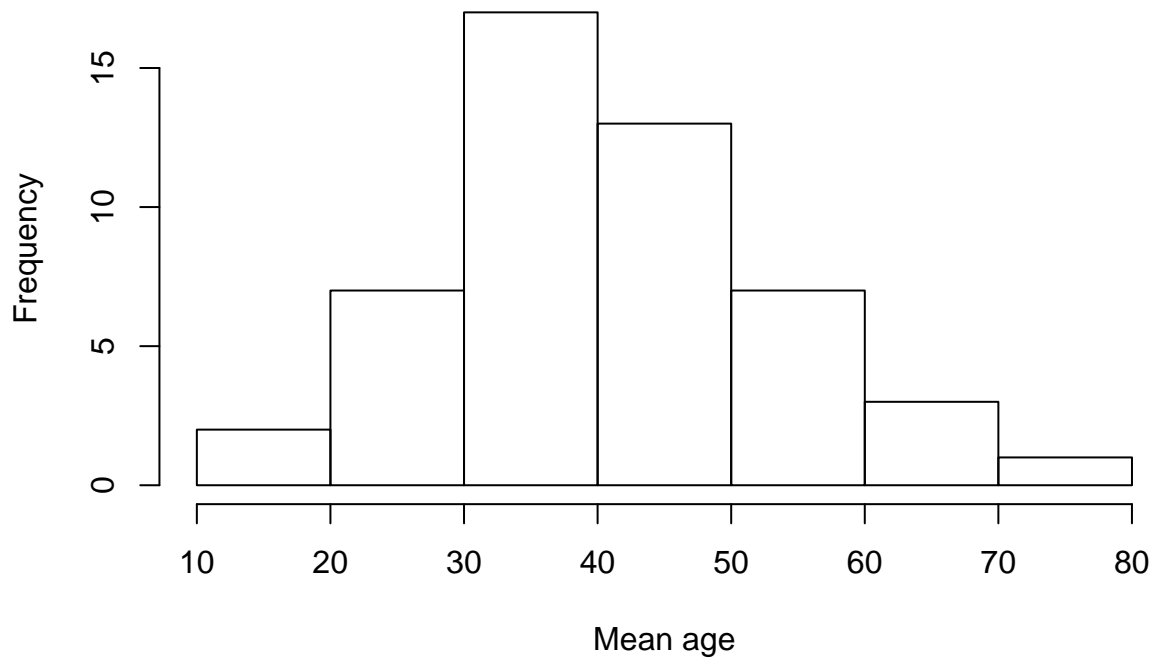
- This page is a supporting document to Cheung and Vijayakumar (2016). It provides a quick introduction on how to conduct meta-analysis in various software packages. Since different default estimators are used in different packages, the results may be slightly different.
- Cheung, M. W.-L., & Vijayakumar, R. (2016). *An introduction to when and how to conduct a meta-analysis*. Manuscript in preparation.

Descriptive statistics of the data

- The sample data sets are available as [CSV](#) and [plain text](#) formats.
- Effect size (y): standardized mean difference between schizophrenic and control groups.
- Sampling variance (v): Sampling variance of y .
- Moderator (x): Mean age of the participants.



- IV (x): Mean age of participants



R

- There are several [packages](#) to conduct meta-analysis in [R](#). We are going to illustrate the procedures with the [metaSEM](#) package.

Fixed-effects model

```
## You need to install the metaSEM package before using it.
## You need to install it only once.
## install.packages("metaSEM")

## Load the library
library(metaSEM)

## Read the data file
my.df <- read.csv("data.csv")

## Display the first few studies
head(my.df)
```



```
##           y           v           x
## 1 -1.8586 0.0743 64.92
```

```
## 2 -0.7913 0.0545 50.71
## 3 -0.6882 0.0375 39.71
## 4 -0.5261 0.0360 42.21
## 5 -0.4075 0.0412 34.43
## 6 -1.3356 0.0404 54.05

## Fixed-effects model by restricting the random effects to 0
summary(meta(y=y, v=v, data=my.df, RE.constraints = 0))

##
## Call:
## meta(y = y, v = v, data = my.df, RE.constraints = 0)
##
## 95% confidence intervals: z statistic approximation
## Coefficients:
##             Estimate Std.Error    lbound    ubound z value Pr(>|z|)
## Intercept1 -0.722451  0.028878 -0.779052 -0.665851 -25.017 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Q statistic on the homogeneity of effect sizes: 85.71155
## Degrees of freedom of the Q statistic: 49
## P value of the Q statistic: 0.0009179457
##
## Heterogeneity indices (based on the estimated Tau2):
##                               Estimate
## Intercept1: I2 (Q statistic)      0
##
## Number of studies (or clusters): 50
## Number of observed statistics: 50
## Number of estimated parameters: 1
## Degrees of freedom: 49
## -2 log likelihood: 19.40719
## OpenMx status1: 0 ("0" or "1": The optimization is considered fine.
## Other values may indicate problems.)
```

Random-effects model

```
summary(meta(y=y, v=v, data=my.df))

##
## Call:
## meta(y = y, v = v, data = my.df)
##
## 95% confidence intervals: z statistic approximation
## Coefficients:
##             Estimate Std.Error    lbound    ubound z value Pr(>|z|)
## Intercept1 -0.7286574  0.0373260 -0.8018151 -0.6554997 -19.5214 < 2e-16
## Tau2_1_1    0.0272966  0.0148155 -0.0017412  0.0563344  1.8424  0.06541
##
## Intercept1 ***
```

```
## Tau2_1_1 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Q statistic on the homogeneity of effect sizes: 85.71155
## Degrees of freedom of the Q statistic: 49
## P value of the Q statistic: 0.0009179457
##
## Heterogeneity indices (based on the estimated Tau2):
##                      Estimate
## Intercept1: I2 (Q statistic)  0.3955
##
## Number of studies (or clusters): 50
## Number of observed statistics: 50
## Number of estimated parameters: 2
## Degrees of freedom: 48
## -2 log likelihood: 13.01445
## OpenMx status1: 0 ("0" or "1": The optimization is considered fine.
## Other values may indicate problems.)
```

Mixed-effects model

```
summary(meta(y=y, v=v, x=x, data=my.df))
```

```
##
## Call:
## meta(y = y, v = v, x = x, data = my.df)
##
## 95% confidence intervals: z statistic approximation
## Coefficients:
##           Estimate Std. Error    lbound    ubound z value Pr(>|z|)
## Intercept1 -0.4439440  0.1214427 -0.6819674 -0.2059207 -3.6556 0.0002566
## Slope1_1    -0.0071136  0.0029137 -0.0128244 -0.0014029 -2.4414 0.0146292
## Tau2_1_1     0.0214313  0.0132301 -0.0044992  0.0473618  1.6199 0.1052553
##
## Intercept1 ***
## Slope1_1    *
## Tau2_1_1
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Q statistic on the homogeneity of effect sizes: 85.71155
## Degrees of freedom of the Q statistic: 49
## P value of the Q statistic: 0.0009179457
##
## Explained variances (R2):
##                      y1
## Tau2 (no predictor)    0.0273
## Tau2 (with predictors) 0.0214
## R2                     0.2149
##
## Number of studies (or clusters): 50
```

```
## Number of observed statistics: 50
## Number of estimated parameters: 3
## Degrees of freedom: 47
## -2 log likelihood: 7.187943
## OpenMx status1: 0 ("0" or "1": The optimization is considered fine.
## Other values may indicate problems.)
```

Mplus

- [Mike Cheung](#) provides sample [Mplus code](#) on how to conduct meta-analysis in [Mplus](#).
- The sample data set for Mplus is available [here](#).

Fixed-effects model

Mplus input file

```
TITLE: Fixed-effects model
DATA: FILE IS data.dat;
VARIABLE: NAMES y v x;
          USEVARIABLES ARE y w2; ! Use both y and w2 in the analysis

DEFINE: w2 = SQRT(v**(-1));      ! Weight for transformation
        y = w2*y;                ! Transformed effect size

MODEL:
        [y@0.0];                 ! Intercept fixed at 0
        y@1.0;                   ! Error variance fixed at 1
        y ON w2;                 ! Common effect estimate beta_F

OUTPUT: SAMPSTAT;
        CINTERVAL(symmetric);    ! Wald CI
```

Mplus output file

```
Mplus VERSION 7.4
MUTHEN & MUTHEN
02/20/2016 2:05 PM
```

INPUT INSTRUCTIONS

```
TITLE: Fixed-effects model
DATA: FILE IS data.dat;
VARIABLE: NAMES y v x;
          USEVARIABLES ARE y w2; ! Use both y and w2 in the analysis

DEFINE: w2 = SQRT(v**(-1));      ! Weight for transformation
        y = w2*y;                ! Transformed effect size

MODEL:
        [y@0.0];                 ! Intercept fixed at 0
        y@1.0;                   ! Error variance fixed at 1
```

```

y ON w2;                ! Common effect estimate beta_F

OUTPUT: SAMPSTAT;
       CINTERVAL(symmetric);  ! Wald CI

INPUT READING TERMINATED NORMALLY

Fixed-effects model

SUMMARY OF ANALYSIS

Number of groups                1
Number of observations          50

Number of dependent variables   1
Number of independent variables 1
Number of continuous latent variables 0

Observed dependent variables

Continuous
Y

Observed independent variables
W2

Estimator                      ML
Information matrix              OBSERVED
Maximum number of iterations    1000
Convergence criterion           0.500D-04
Maximum number of steepest descent iterations 20

Input data file(s)
data.dat

Input data format  FREE

```

SAMPLE STATISTICS

SAMPLE STATISTICS

	Means	
	Y	W2
1	----- -3.568	----- 4.881
	Covariances	
	Y	W2

Y	----- 1.497	-----
W2	0.092	0.157

	Correlations	
	Y	W2
Y	----- 1.000	-----
W2	0.190	1.000

UNIVARIATE SAMPLE STATISTICS

UNIVARIATE HIGHER-ORDER MOMENT DESCRIPTIVE STATISTICS

Variable/ Sample Size	Mean/ Variance	Skewness/ Kurtosis	Minimum/ Maximum	% with Min/Max	Percentiles 20%/60%	40%/80%	Median
Y	-3.568	-0.461	-6.819	2.00%	-4.377	-3.767	-3.399
50.000	1.497	0.475	-1.134	2.00%	-3.282	-2.741	
W2	4.881	-0.291	3.669	2.00%	4.623	4.784	4.891
50.000	0.157	0.785	5.882	2.00%	4.933	5.206	

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 1

Loglikelihood

H0 Value	-88.803
H1 Value	-80.122

Information Criteria

Akaike (AIC)	179.605
Bayesian (BIC)	181.517
Sample-Size Adjusted BIC	178.379
(n* = (n + 2) / 24)	

Chi-Square Test of Model Fit

Value	17.362
Degrees of Freedom	2
P-Value	0.0002

RMSEA (Root Mean Square Error Of Approximation)

Estimate	0.392
90 Percent C.I.	0.236 0.571

Probability RMSEA <= .05 0.000

CFI/TLI

CFI 0.000

TLI -8.154

Chi-Square Test of Model Fit for the Baseline Model

Value 1.839

Degrees of Freedom 1

P-Value 0.1751

SRMR (Standardized Root Mean Square Residual)

Value 0.322

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Y ON				
W2	-0.722	0.029	-25.017	0.000
Intercepts				
Y	0.000	0.000	999.000	999.000
Residual Variances				
Y	1.000	0.000	999.000	999.000

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.100E+01
(ratio of smallest to largest eigenvalue)

CONFIDENCE INTERVALS OF MODEL RESULTS

	Lower .5%	Lower 2.5%	Lower 5%	Estimate	Upper 5%	Upper 2.5%	Upper .5%
Y ON							
W2	-0.797	-0.779	-0.770	-0.722	-0.675	-0.666	-0.648
Intercepts							
Y	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Residual Variances							
Y	1.000	1.000	1.000	1.000	1.000	1.000	1.000

DIAGRAM INFORMATION

Use View Diagram under the Diagram menu in the Mplus Editor to view the diagram.
If running Mplus from the Mplus Diagrammer, the diagram opens automatically.

Diagram output

d:\dropbox\aaa\nerv paper\illustrations\mplus1.dgm

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Support: Support@StatModel.com

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Random-effects model

[Mplus input file](#)

```
TITLE: Random-effects model
DATA: FILE IS data.dat;
VARIABLE: NAMES y v x;
          USEVARIABLES ARE y w2; ! Use both y and w2 in the analysis

DEFINE: w2 = SQRT(v**(-1));      ! Weight for transformation
          y = w2*y;              ! Transformed effect size

ANALYSIS: TYPE=RANDOM;          ! Use random slopes analysis
          ESTIMATOR=ML;          ! Use ML estimation

MODEL:
          [y@0.0];              ! Intercept fixed at 0
          y@1.0;                ! Error variance fixed at 1
          f | y ON w2;           ! f: Study specific random effects
          f*;                    ! var(f): tau^2
          [f*];                 ! mean(f): Average effect size beta_R

OUTPUT: SAMPSTAT;
          CINTERVAL(symmetric); ! Wald CI
```

[Mplus output file](#)

Mplus VERSION 7.4

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INPUT INSTRUCTIONS

```
TITLE: Random-effects model
DATA: FILE IS data.dat;
VARIABLE: NAMES y v x;
          USEVARIABLES ARE y w2; ! Use both y and w2 in the analysis

DEFINE: w2 = SQRT(v**(-1));      ! Weight for transformation
        y = w2*y;                ! Transformed effect size

ANALYSIS: TYPE=RANDOM;           ! Use random slopes analysis
          ESTIMATOR=ML;          ! Use ML estimation

MODEL:
        [y@0.0];                 ! Intercept fixed at 0
        y@1.0;                   ! Error variance fixed at 1
        f | y ON w2;              ! f: Study specific random effects
        f*;                       ! var(f): tau^2
        [f*];                     ! mean(f): Average effect size beta_R

OUTPUT: SAMPSTAT;
        CINTERVAL(symmetric);    ! Wald CI
```

INPUT READING TERMINATED NORMALLY

Random-effects model

SUMMARY OF ANALYSIS

Number of groups	1
Number of observations	50

Number of dependent variables	1
Number of independent variables	1
Number of continuous latent variables	1

Observed dependent variables

Continuous
Y

Observed independent variables
W2

Continuous latent variables
F

```

Estimator                      ML
Information matrix              OBSERVED
Maximum number of iterations    100
Convergence criterion           0.100D-05
Maximum number of EM iterations 500
Convergence criteria for the EM algorithm
  Loglikelihood change          0.100D-02
  Relative loglikelihood change 0.100D-05
  Derivative                    0.100D-03
Minimum variance                0.100D-03
Maximum number of steepest descent iterations 20
Optimization algorithm          EMA

Input data file(s)
  data.dat
Input data format  FREE

```

SAMPLE STATISTICS

ESTIMATED SAMPLE STATISTICS

```

Means
  Y      W2
-----
1      -3.568      4.881

Covariances
  Y      W2
-----
Y      1.497
W2      0.092      0.157

Correlations
  Y      W2
-----
Y      1.000
W2      0.190      1.000

```

UNIVARIATE SAMPLE STATISTICS

UNIVARIATE HIGHER-ORDER MOMENT DESCRIPTIVE STATISTICS

	Variable/ Sample Size	Mean/ Variance	Skewness/ Kurtosis	Minimum/ Maximum	% with Min/Max	Percentiles 20%/60%	Percentiles 40%/80%	Median
Y	50.000	-3.568	-0.461	-6.819	2.00%	-4.377	-3.767	-3.399
W2	50.000	4.881	-0.291	3.669	2.00%	4.623	4.784	4.891
		0.157	0.785	5.882	2.00%	4.933	5.206	

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 2

Loglikelihood

HO Value -85.606

Information Criteria

Akaike (AIC) 175.213
 Bayesian (BIC) 179.037
 Sample-Size Adjusted BIC 172.759
 (n* = (n + 2) / 24)

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Means				
F	-0.729	0.037	-19.522	0.000
Intercepts				
Y	0.000	0.000	999.000	999.000
Variances				
F	0.027	0.015	1.842	0.065
Residual Variances				
Y	1.000	0.000	999.000	999.000

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.858E-01
 (ratio of smallest to largest eigenvalue)

CONFIDENCE INTERVALS OF MODEL RESULTS

	Lower .5%	Lower 2.5%	Lower 5%	Estimate	Upper 5%	Upper 2.5%	Upper .5%
Means							
F	-0.825	-0.802	-0.790	-0.729	-0.667	-0.656	-0.633
Intercepts							
Y	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Variances							
F	-0.011	-0.002	0.003	0.027	0.052	0.056	0.065
Residual Variances							
Y	1.000	1.000	1.000	1.000	1.000	1.000	1.000

DIAGRAM INFORMATION

Use View Diagram under the Diagram menu in the Mplus Editor to view the diagram.
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Diagram output

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Mixed-effects model

[Mplus input file](#)

```

TITLE: Random-effects model
DATA: FILE IS data.dat;
VARIABLE: NAMES y v x;
          USEVARIABLES ARE y w2; ! Use both y and w2 in the analysis

DEFINE: w2 = SQRT(v**(-1));      ! Weight for transformation
          y = w2*y;              ! Transformed effect size

ANALYSIS: TYPE=RANDOM;           ! Use random slopes analysis
          ESTIMATOR=ML;          ! Use ML estimation

MODEL:
          [y@0.0];               ! Intercept fixed at 0
          y@1.0;                 ! Error variance fixed at 1
          f | y ON w2;           ! f: Study specific random effects
          f*;                     ! var(f): tau^2

```

```

[f*];                                ! mean(f): Average effect size beta_R

OUTPUT: SAMPSTAT;
        CINTERVAL(symmetric);    ! Wald CI

```

Mplus output file

```

Mplus VERSION 7.4
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```

INPUT INSTRUCTIONS

```

TITLE:   Random-effects model
DATA:    FILE IS data.dat;
VARIABLE: NAMES y v x;
          USEVARIABLES ARE y w2;    ! Use both y and w2 in the analysis

DEFINE:  w2 = SQRT(v**(-1));        ! Weight for transformation
          y = w2*y;                 ! Transformed effect size

ANALYSIS: TYPE=RANDOM;              ! Use random slopes analysis
          ESTIMATOR=ML;             ! Use ML estimation

MODEL:
  [y@0.0];                          ! Intercept fixed at 0
  y@1.0;                             ! Error variance fixed at 1
  f | y ON w2;                       ! f: Study specific random effects
  f*;                                ! var(f): tau^2
  [f*];                             ! mean(f): Average effect size beta_R

OUTPUT: SAMPSTAT;
        CINTERVAL(symmetric);    ! Wald CI

```

INPUT READING TERMINATED NORMALLY

Random-effects model

SUMMARY OF ANALYSIS

Number of groups	1
Number of observations	50
Number of dependent variables	1
Number of independent variables	1
Number of continuous latent variables	1

Observed dependent variables

Continuous

Y

Observed independent variables

W2

Continuous latent variables

F

Estimator	ML
Information matrix	OBSERVED
Maximum number of iterations	100
Convergence criterion	0.100D-05
Maximum number of EM iterations	500
Convergence criteria for the EM algorithm	
Loglikelihood change	0.100D-02
Relative loglikelihood change	0.100D-05
Derivative	0.100D-03
Minimum variance	0.100D-03
Maximum number of steepest descent iterations	20
Optimization algorithm	EMA

Input data file(s)

data.dat

Input data format FREE

SAMPLE STATISTICS

ESTIMATED SAMPLE STATISTICS

	Means	
	Y	W2
1	----- -3.568	----- 4.881

	Covariances	
	Y	W2
Y	----- 1.497	-----
W2	0.092	0.157

	Correlations	
	Y	W2
Y	----- 1.000	-----
W2	0.190	1.000

UNIVARIATE SAMPLE STATISTICS

UNIVARIATE HIGHER-ORDER MOMENT DESCRIPTIVE STATISTICS

Variable/	Mean/	Skewness/	Minimum/ % with	Percentiles
-----------	-------	-----------	-----------------	-------------

	Sample Size	Variance	Kurtosis	Maximum	Min/Max	20%/60%	40%/80%	Median
Y		-3.568	-0.461	-6.819	2.00%	-4.377	-3.767	-3.399
	50.000	1.497	0.475	-1.134	2.00%	-3.282	-2.741	
W2		4.881	-0.291	3.669	2.00%	4.623	4.784	4.891
	50.000	0.157	0.785	5.882	2.00%	4.933	5.206	

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 2

Loglikelihood

H0 Value -85.606

Information Criteria

Akaike (AIC) 175.213
 Bayesian (BIC) 179.037
 Sample-Size Adjusted BIC 172.759
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Intercepts				
Y	0.000	0.000	999.000	999.000
Variances				
F	0.027	0.015	1.842	0.065
Residual Variances				
Y	1.000	0.000	999.000	999.000

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.858E-01
 (ratio of smallest to largest eigenvalue)

CONFIDENCE INTERVALS OF MODEL RESULTS

	Lower .5%	Lower 2.5%	Lower 5%	Estimate	Upper 5%	Upper 2.5%	Upper .5%
Means							
F	-0.825	-0.802	-0.790	-0.729	-0.667	-0.656	-0.633
Intercepts							
Y	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Variances							
F	-0.011	-0.002	0.003	0.027	0.052	0.056	0.065
Residual Variances							
Y	1.000	1.000	1.000	1.000	1.000	1.000	1.000

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Diagram output

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Stata

- There are several user-contributed packages in [meta-analysis](#) in Stata.
- The followings files are used in this illustration: [data](#), [do-file](#), and [log file](#).

Fixed- and random-effects models

```
* Read the data file "data.csv".
. import delim using data.csv
```

```
(3 vars, 50 obs)
```

```
* Generate se (standard error) from v (sampling variance).
. generate se=sqrt(v)

* Display the content.
. describe
```

Contains data

```
obs:      50
vars:      4
size:     800
```

variable name	storage type	display format	value label	variable label
y	float	%9.0g		
v	float	%9.0g		
x	float	%9.0g		
se	float	%9.0g		

```
* Run a meta-analysis on y with se as the standard error.
. meta y se
```

Meta-analysis

Method	Pooled Est	95% CI Lower	95% CI Upper	Asymptotic z_value	Asymptotic p_value	No. of studies
Fixed	-0.722	-0.779	-0.666	-25.017	0.000	50
Random	-0.729	-0.804	-0.654	-19.030	0.000	

Test for heterogeneity: Q= 85.712 on 49 degrees of freedom (p= 0.001)
Moment-based estimate of between studies variance = 0.031

Mixed-effects model

```
* Run a mixed-effects meta-analysis on y with x as the predictor and se as the standard error.
. metareg y x, wsse(se)
```

Meta-regression	Number of obs	=	50
REML estimate of between-study variance	tau2	=	.02432
% residual variation due to heterogeneity	I-squared_res	=	38.44%
Proportion of between-study variance explained	Adj R-squared	=	15.93%
With Knapp-Hartung modification			

	y	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
x		-.0071645	.0030496	-2.35	0.023	-.0132961 -.0010329
_cons		-.4422977	.1273233	-3.47	0.001	-.6982984 -.1862969

SPSS

- To use SPSS to conduct meta-analysis, we use the [macros](#) provided by [David Wilson](#).
- There are three macros at the site for meta-analysis. We use MEANES macro to conduct the basic meta-analysis, and the METAREG macro for study-level moderator analysis, using meta-regression. METAF is used to conduct moderator analysis with a categorical moderator.
- In our dataset, our study effect size is labeled y , its sampling variance as v , and moderator Mean Age of the participants as x .
- Because the macros require us to input study weights, we first compute a new variable labelled w , which indicates the weights allotted to each study. We use the formula: $w = 1/v$ to compute this variable.
- Once we have the variables y , x , and w in SPSS, we are ready to use the macros.

Fixed- and random- effects models

- SPSS syntax:

```
INCLUDE 'C:\MEANES.SPS'.  
MEANES ES = y /W = w.
```

- Output:

Run MATRIX procedure:

Version 2005.05.23

***** Meta-Analytic Results *****

```
----- Distribution Description -----  
              N      Min ES      Max ES      Wghtd SD  
          50.000      -1.859      -.234      .267
```

```
----- Fixed & Random Effects Model -----  
              Mean ES      -95%CI      +95%CI      SE      Z      P  
Fixed      -.7225      -.7791      -.6659      .0289      -25.0171      .0000  
Random      -.7292      -.8043      -.6541      .0383      -19.0298      .0000
```

```
----- Random Effects Variance Component -----  
v      =      .031257
```

```
----- Homogeneity Analysis -----  
              Q      df      p  
          85.7115      49.0000      .0009
```

Random effects v estimated via noniterative method of moments.

```
----- END MATRIX -----
```

Mixed-effects model

- There are three estimation methods that can be used: method-of-moments(M-M) which is non-iterative; maximum likelihood (ML); and restricted maximum likelihood (REML).

- These different methods can be called by specifying one of the following commands in SPSS syntax:

```

- METAREG ES = y /W = w /IVS = x /MODEL = MM.
- METAREG ES = y /W = w /IVS = x /MODEL = ML.
- METAREG ES = y /W = w /IVS = x /MODEL = REML.

```

- We will use ML to estimate the meta-regression mixed model by the following command:

```

INCLUDE 'C:\METAREG.SPS' .
METAREG ES = y /W = w /IVS = x /MODEL = ML.

```

- Output:

Run MATRIX procedure:

Version 2005.05.23

```

***** Inverse Variance Weighted Regression *****

***** Random Intercept, Fixed Slopes Model *****

----- Descriptives -----
      Mean ES      R-Square      k
      -0.7277      .1020      50.0000

----- Homogeneity Analysis -----
              Q              df              p
Model          6.0021          1.0000          .0143
Residual       52.8294         48.0000          .2929
Total          58.8314         49.0000          .1587

----- Regression Coefficients -----
              B              SE      -95% CI      +95% CI              Z              P              Beta
Constant     -0.4439         .1212      -0.6815      -0.2064     -3.6632          .0002          .0000
x             -0.0071         .0029      -0.0128      -0.0014     -2.4499          .0143         -0.3194

----- Maximum Likelihood Random Effects Variance Component -----
v            =      .02143
se(v)        =      .01263

----- END MATRIX -----

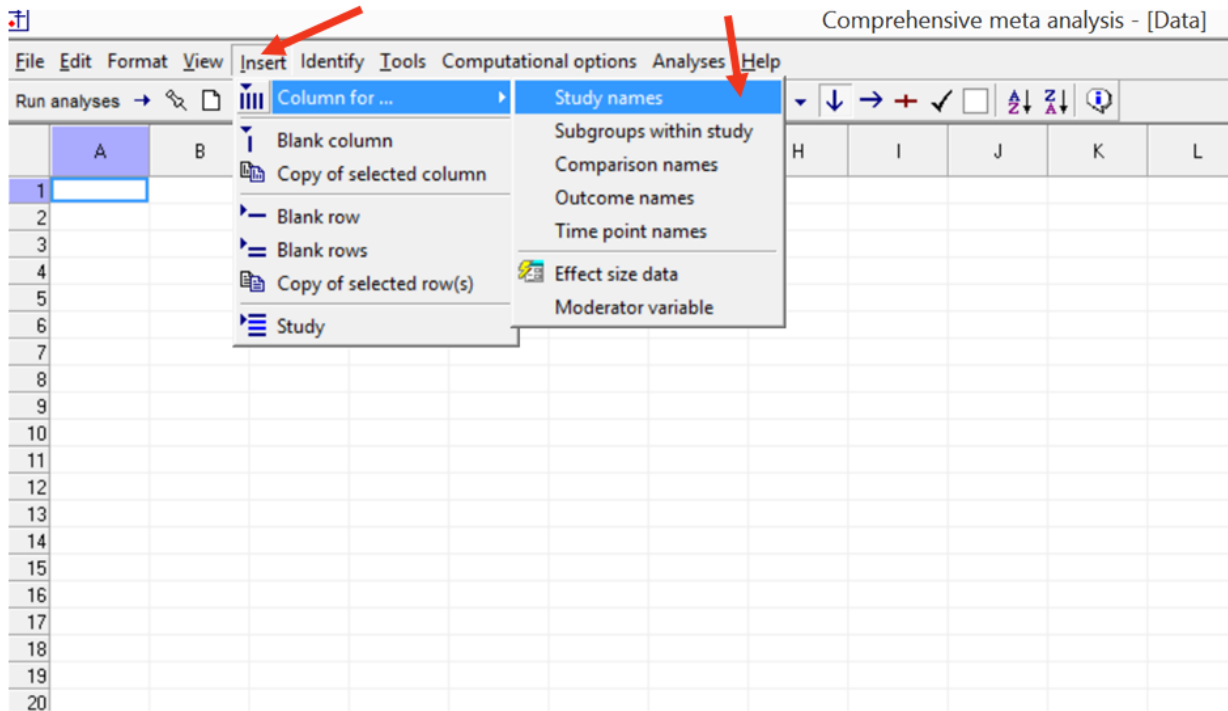
```

Comprehensive Meta-Analysyis (CMA)

- [CMA](#) provides a graphical user interface to conduct meta-analysis. The program has a regular spreadsheet like window. This makes it easier to copy data from spreadsheets onto this program.

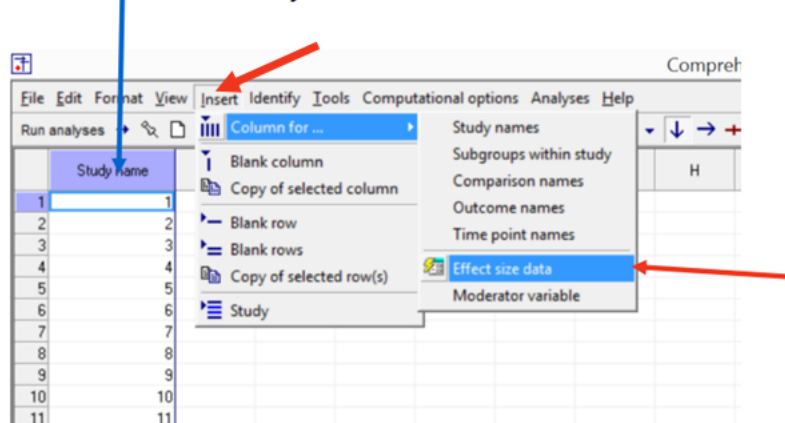
Data Entry

- To initiate a meta-analysis, you can first include the study names into a column specially designated for it, by using the drop-down options as shown below:

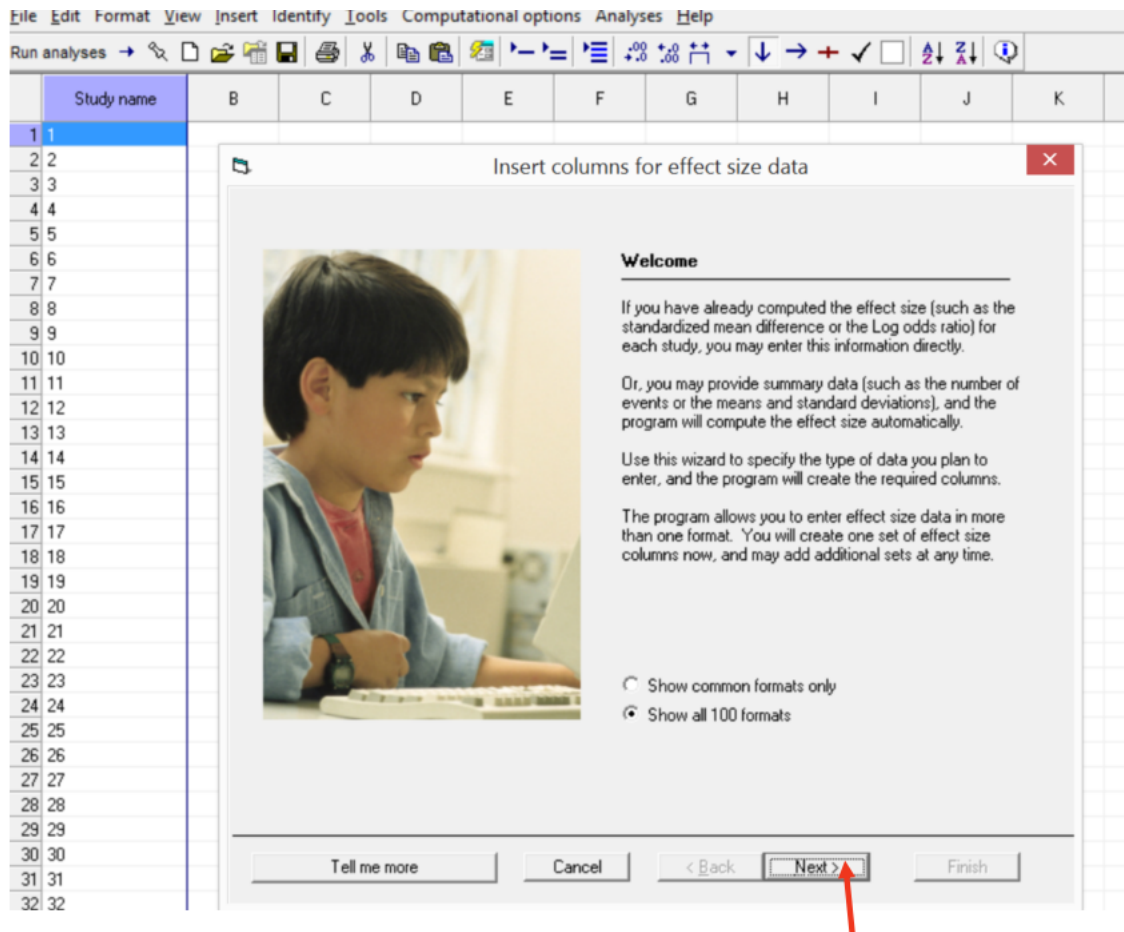


- This creates a column for the study names. It is customary to have the first author and year in the study detail. For our purposes, i just labeled studies by numbers (see screenshot below).
- After this, you can input effect sizes. CMA can accept many varieties of effect size parameters, so you need to specify it. We will specify Hedges's d as our effect size.

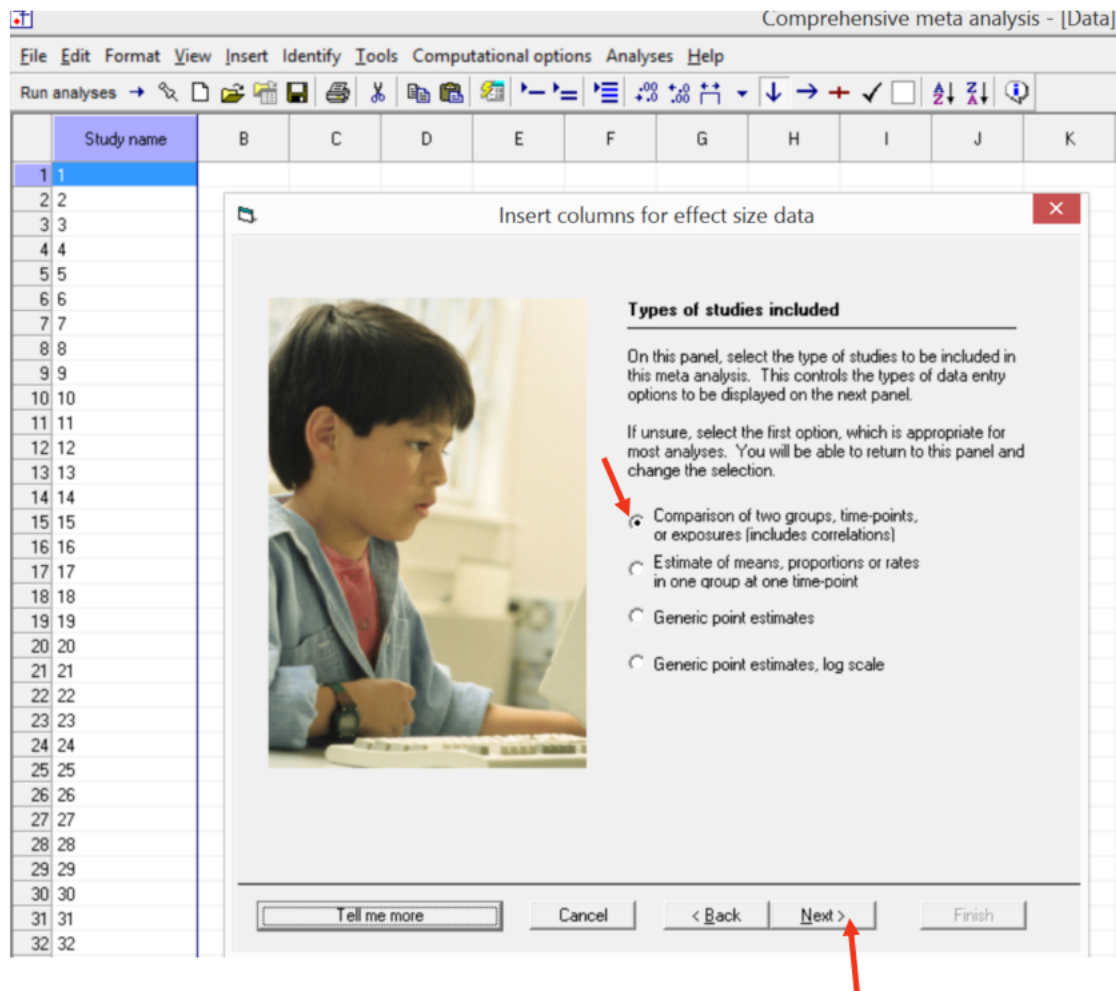
Column for study name



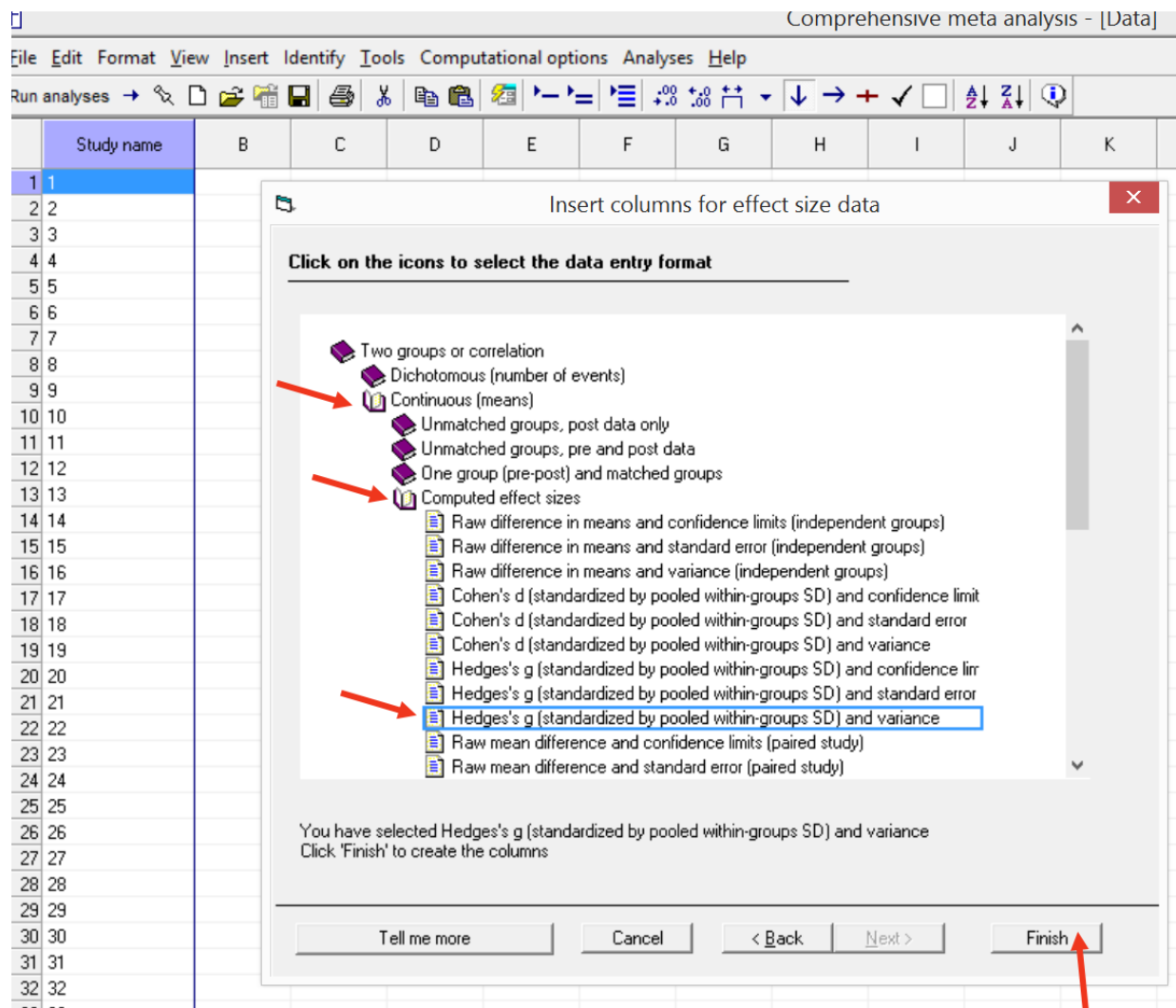
The following window pops up. Click 'Next'.



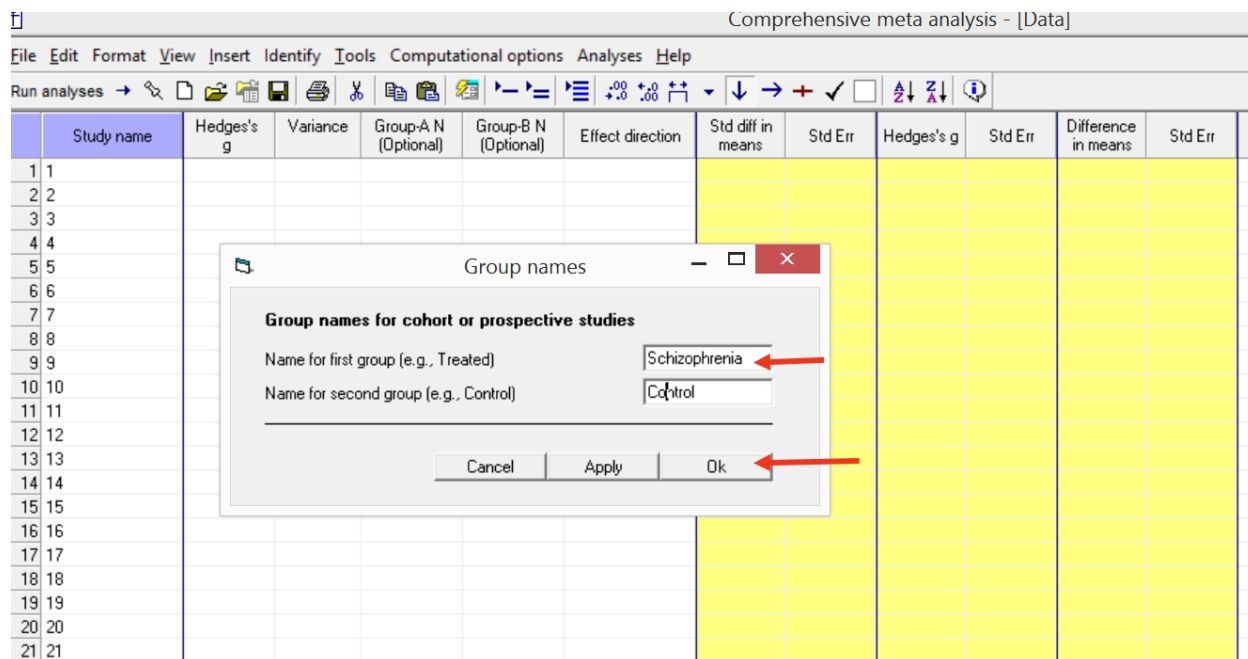
- You can now select the kind of studies you are analyzing. Here, since we are comparing studies that compare schizophrenics with a control group, we choose the first option, and then click 'Next'. See below.



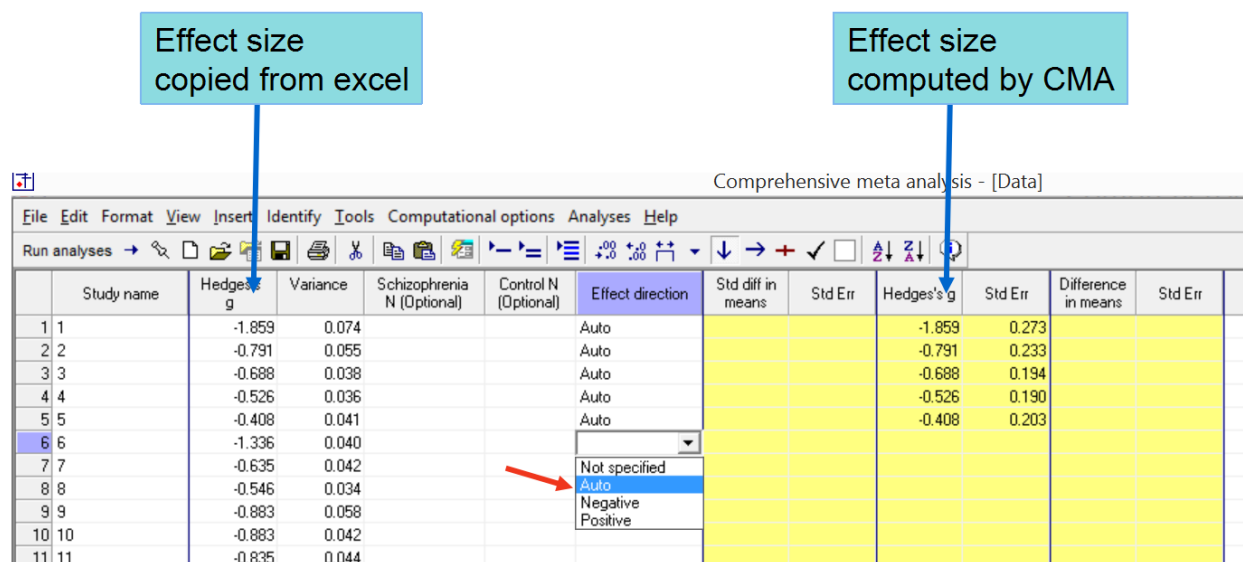
- A new window appears, from which you can choose the desired effect size metric. Our metric is Hedge's d , so we click on 'continuous means', which gives us the option, 'computed effect sizes', which then gives us a lot of effect sizes, from which we choose Hedges's d with variance. See below.



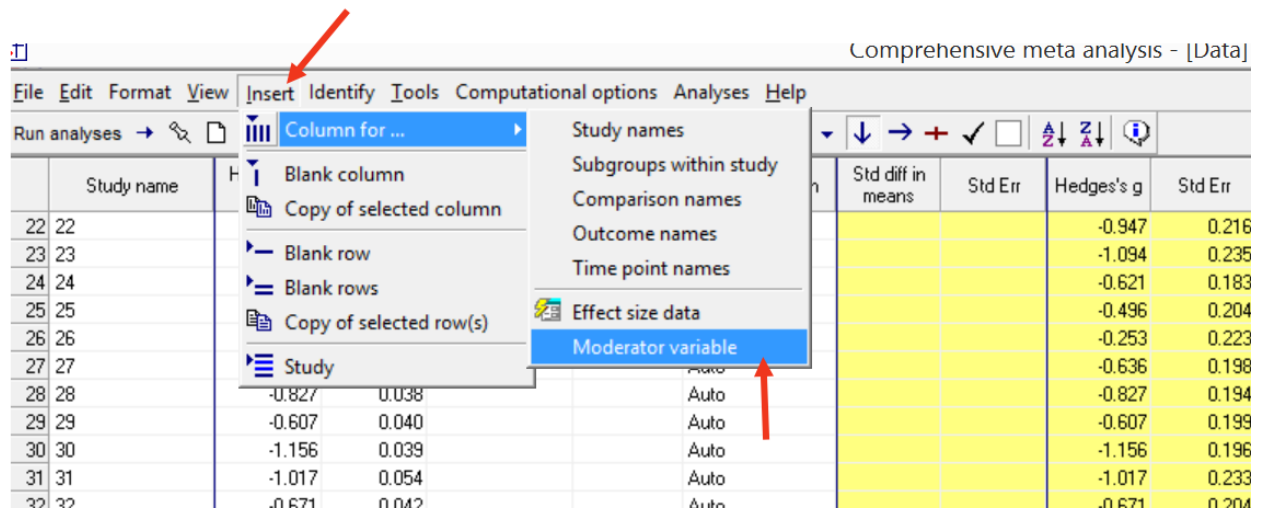
- The main window now appears with columns where we can input the effect sizes of individual studies. We can also optionally label our groups as well. We label them as 'Schizophrenia' and 'Control', as below.



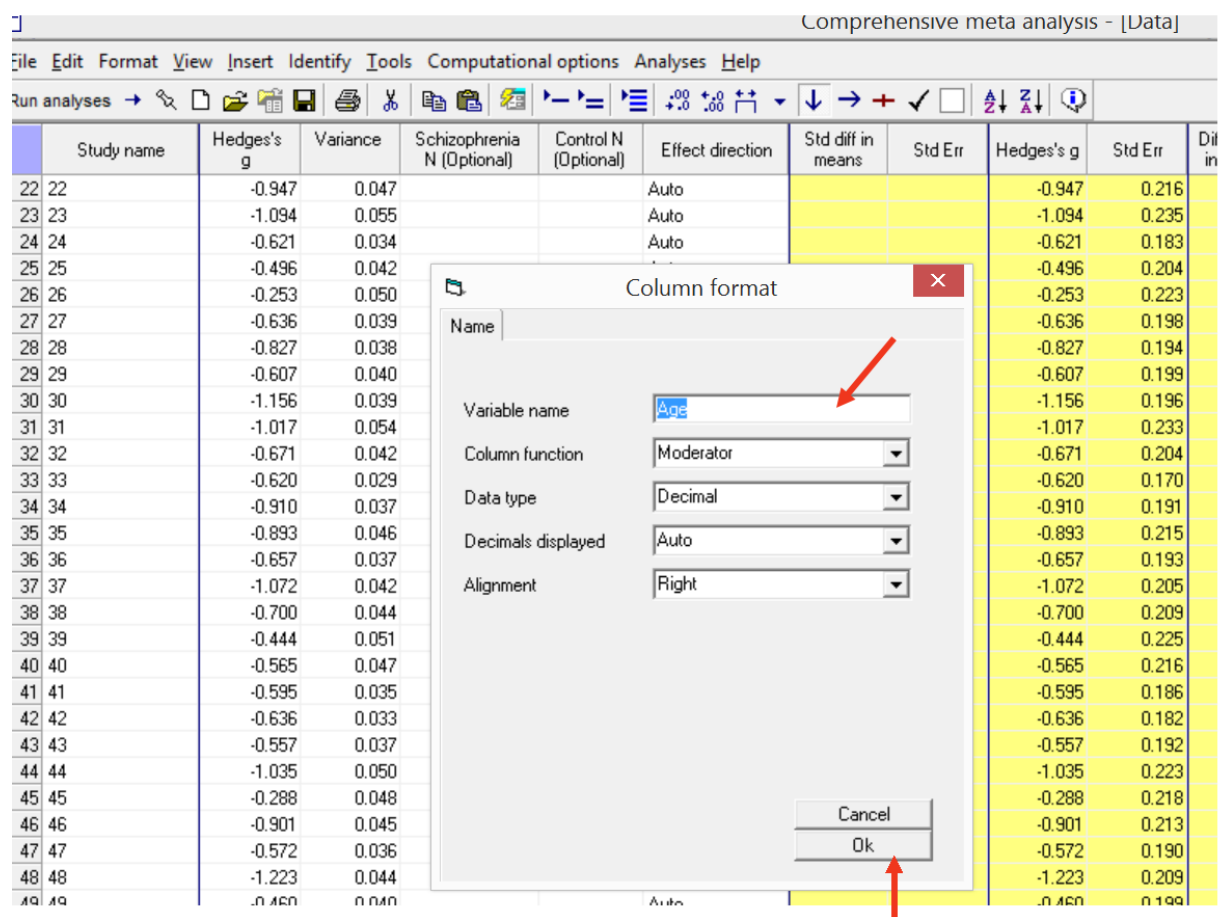
- We can now transfer our effect sizes from spreadsheets onto this window. The window after transferring our effect size and variance column is as below.



- As shown above, you have to specify the direction (sign) of the effect size. For each study we specify it to be 'auto'; it then takes the sign of our input Hedges's d .
- You can also see that the yellow-highlighted columns are calculated outputs by CMA. In our case, since we have given the effect sizes already, this seems redundant. But you can instead opt to input just the means and SDs of the two groups; CMA will calculate the effect size and display it in the yellow column.
- We are also interested in looking at the effect of age as a moderator. So we will include the age in the dataset as follows:



- We then get a new window where we can specify the variable name and data type. We specify 'Age' as the moderator.



- We get the final dataset with both the effect size and moderator columns, as shown below.

Column for moderator

↓

Comprehensive meta analysis - [U:\FNU stuff\research projects\mike\neuropsychology meta-analysis\simulations\neuropsych_scniz_

File Edit Format View Insert Identify Tools Computational options Analyses Help

Run analyses → [Icons]

	Study name	Hedges's g	Variance	Schizophrenia N (Optional)	Control N (Optional)	Effect direction	Std diff in means	Std Err	Hedges's g	Std Err	Difference in means	Std Err	Age	N
1	1	-1.859	0.074			Auto			-1.859	0.273			64.920	
2	2	-0.791	0.055			Auto			-0.791	0.233			50.710	
3	3	-0.688	0.038			Auto			-0.688	0.194			39.710	
4	4	-0.526	0.036			Auto			-0.526	0.190			42.210	
5	5	-0.408	0.041			Auto			-0.408	0.203			34.430	
6	6	-1.336	0.040			Auto			-1.336	0.201			54.050	
7	7	-0.635	0.042			Auto			-0.635	0.204			18.500	
8	8	-0.546	0.034			Auto			-0.546	0.184			45.870	
9	9	-0.883	0.058			Auto			-0.883	0.242			30.900	
10	10	-0.883	0.042			Auto			-0.883	0.204			40.950	

- Now we can conduct our analysis. We will do both a meta-analysis using fixed effects model as well as random-effects model. We will then do a meta-regression, with age as the moderator.

Fixed- and mixed-effects models

- Click the 'run analyses' icon, as shown below.

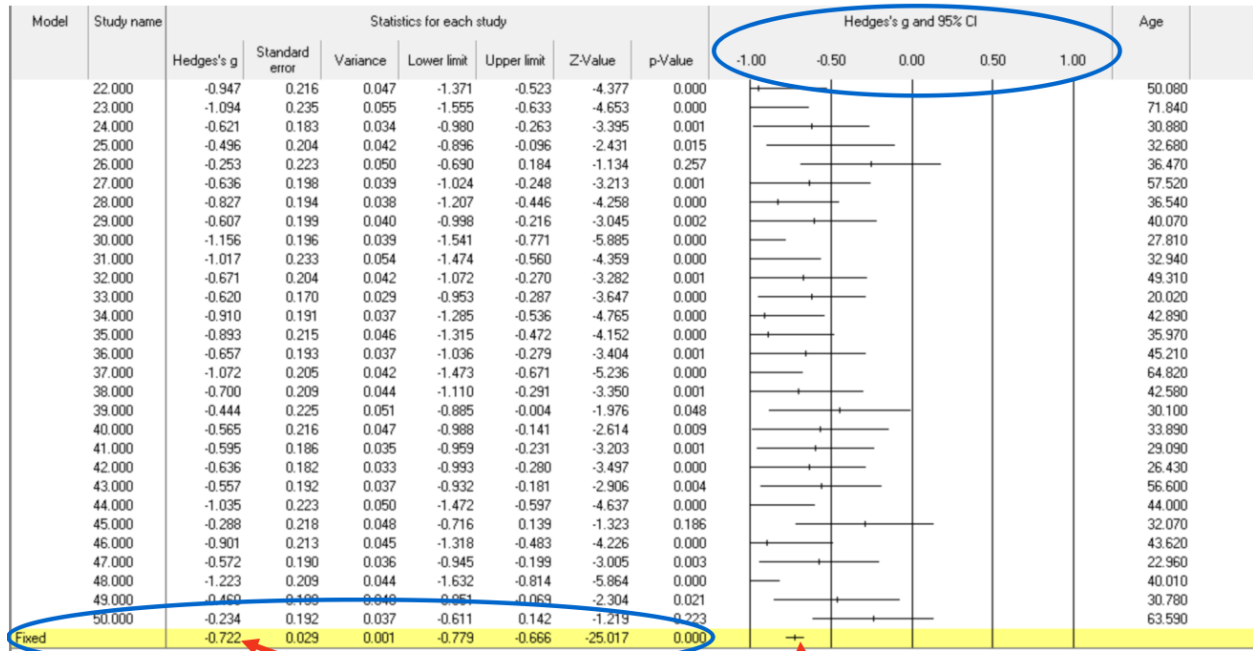
↓

File Edit Format View Insert Identify Tools Computational options Analyses Help

Run analyses → [Icons]

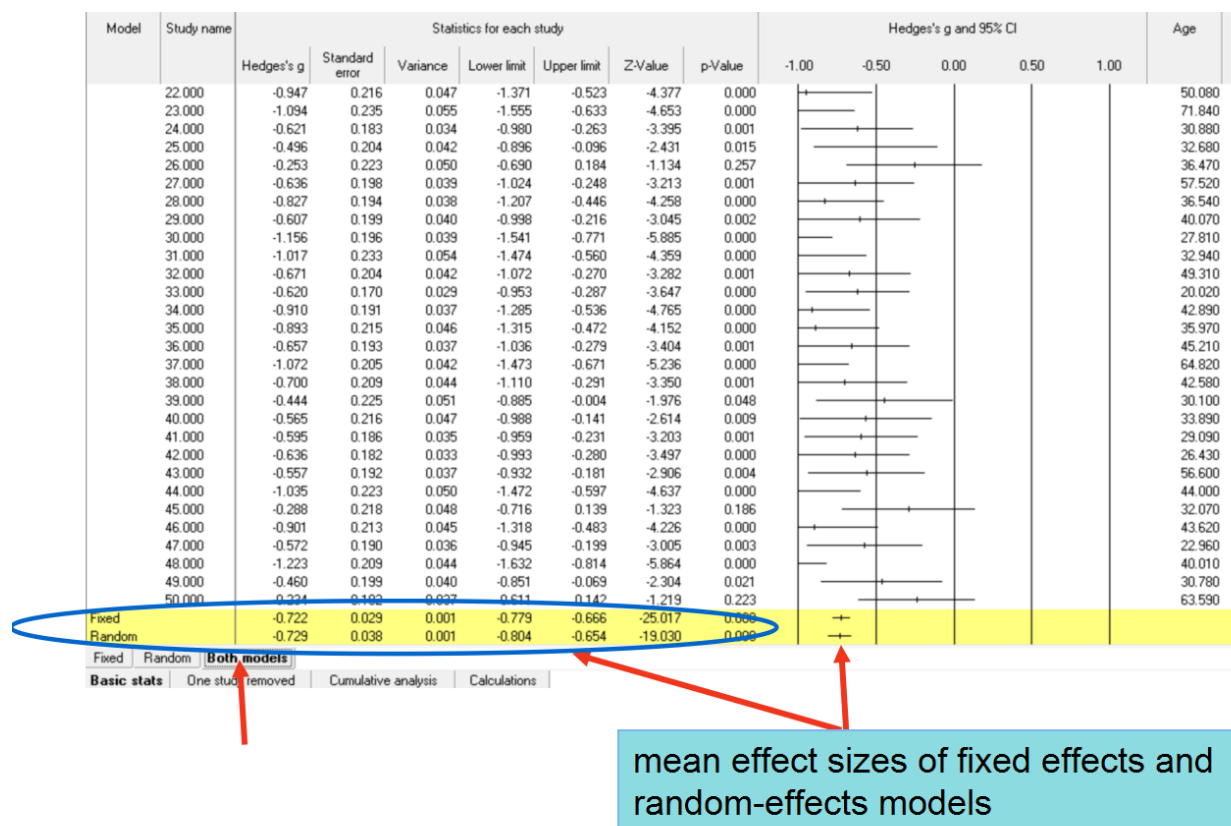
	Study name	Hedges's g	Variance	Schizophrenia N (Optional)	Control N (Optional)	Effect direction	Std diff in means	Std Err	Hedges's g	Std Err	Dir
1	1	-1.859	0.074			Auto			-1.859	0.273	
2	2	-0.791	0.055			Auto			-0.791	0.233	
3	3	-0.688	0.038			Auto			-0.688	0.194	
4	4	-0.526	0.036			Auto			-0.526	0.190	
5	5	-0.408	0.041			Auto			-0.408	0.203	
6	6	-1.336	0.040			Auto			-1.336	0.201	
7	7	-0.635	0.042			Auto			-0.635	0.204	
8	8	-0.546	0.034			Auto			-0.546	0.184	
9	9	-0.883	0.058			Auto			-0.883	0.242	
10	10	-0.883	0.042			Auto			-0.883	0.204	

- The default analysis is fixed effects model, so you get the display below.

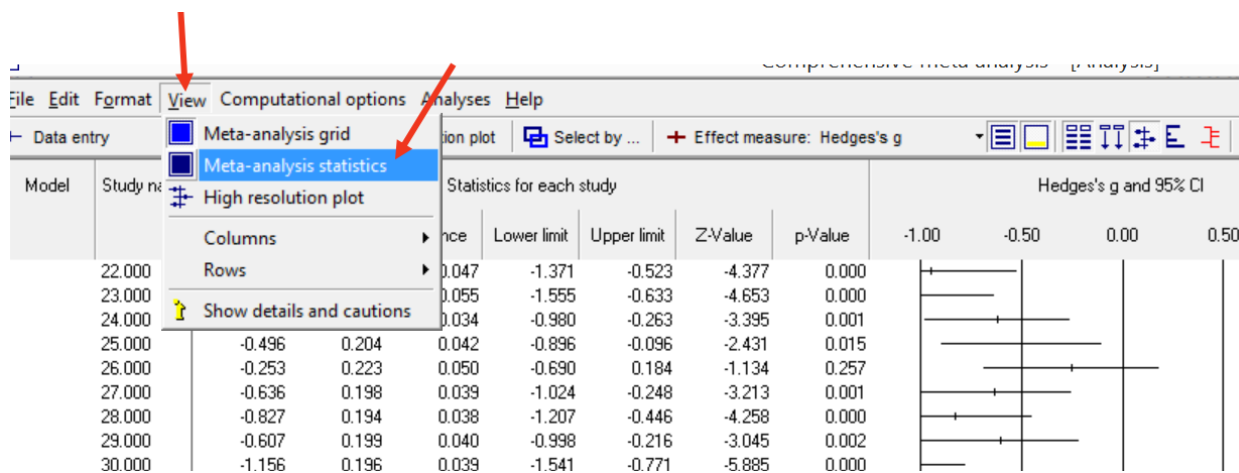


estimated true effect size in a fixed model

- Clicking on “Both models” icon (see figure below) will show both fixed-effects and random-effects models.



- Clicking on 'View', as shown below, brings up the 'statistics' option.

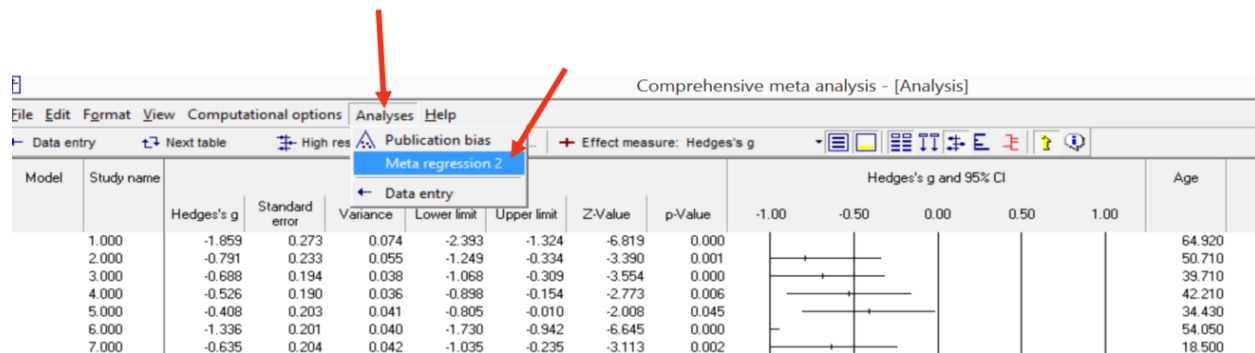


- That brings up the window below. It gives both the fixed-effects as well as random-effects results.

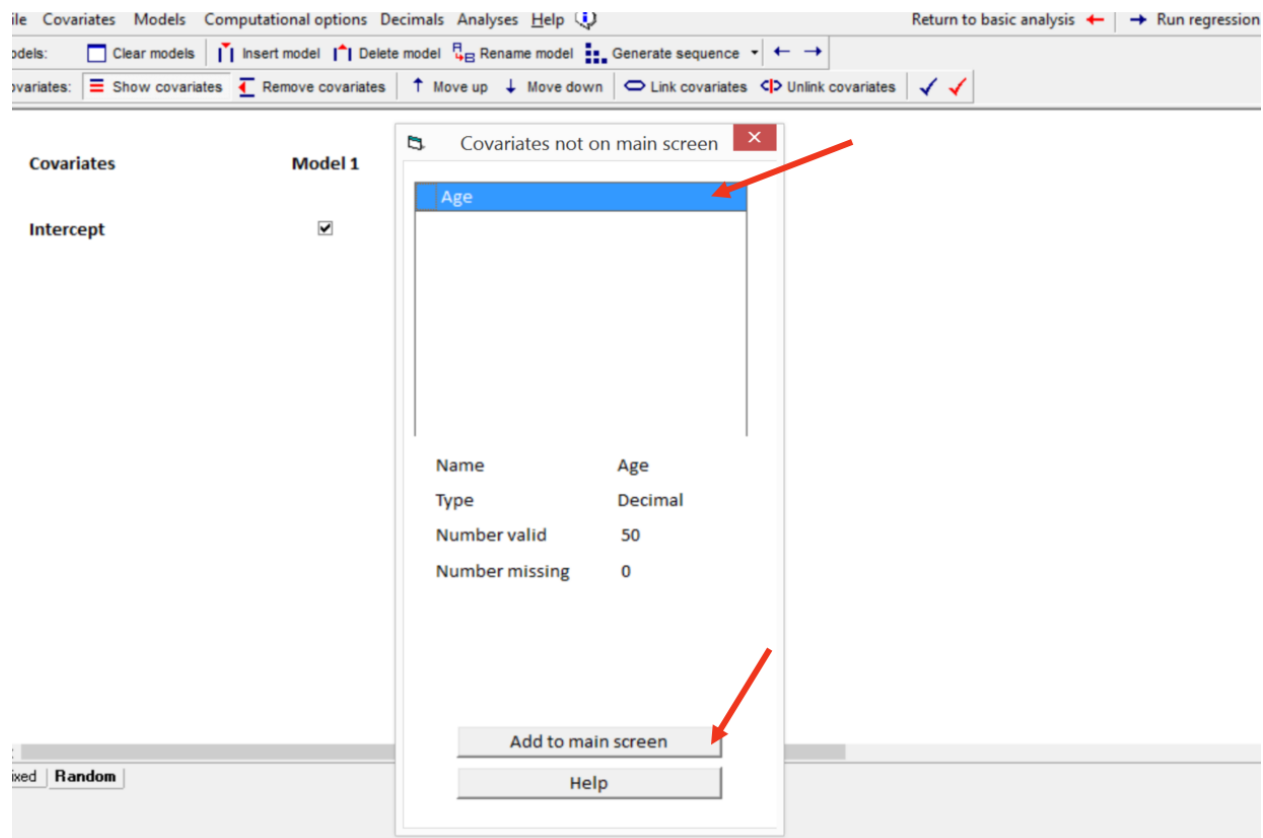
Model		Effect size and 95% confidence interval					Test of null (2-Tail)		Heterogeneity				Tau-squared			
Model	Number Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared	Standard Error	Variance	Tau
Fixed	50	-0.722	0.029	0.001	-0.779	-0.666	-25.017	0.000	85.712	49	0.001	42.832	0.031	0.015	0.000	0.177
Random	50	-0.729	0.038	0.001	-0.804	-0.654	-19.030	0.000								

Mixed-effects model

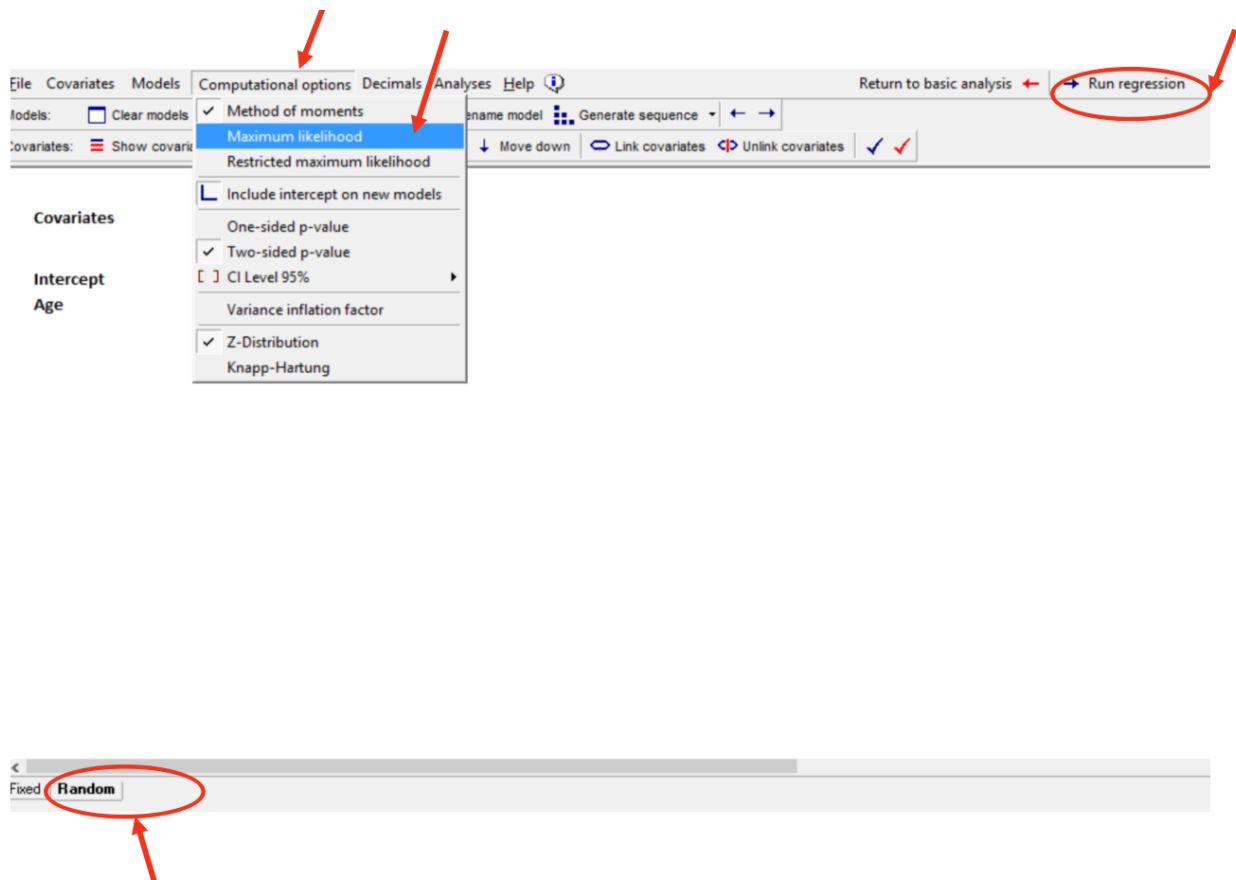
- Click on ‘analyses’ and then ‘meta regression 2’ icons as shown below:



- We get the screen below. This screen shows all variables we had included in the main window spreadsheet under the label ‘moderator’. The window shows that currently, we do not have any moderators in our meta-analysis model. We specify that we should include ‘age’ in our model, by clicking on ‘Age’, and then ‘Add to main screen.’



- Then, we specify the type of estimation method we want to employ (‘Maximum Likelihood’), make sure the “Random” icon at the lower left is highlighted to specify a mixed model, and then click ‘Run Regression’. See below.



- We get the results below:

Main results for Model 1, Random effects (ML), Z-Distribution, Hedges's g						
Covariate	Coefficient	Standard Error	95% Lower	95% Upper	Z-value	2-sided P-value
Intercept	-0.4439	0.1212	-0.6815	-0.2064	-3.66	0.0002
Age	-0.0071	0.0029	-0.0128	-0.0014	-2.45	0.0143

Statistics for Model 1

Test of the model: Simultaneous test that all coefficients (excluding intercept) are zero
 $Q = 6.00$, $df = 1$, $p = 0.0143$

Goodness of fit: Test that unexplained variance is zero
 $\tau^2 = 0.0214$, $\tau = 0.1464$, $i^2 = 38.44\%$, $Q = 77.97$, $df = 48$, $p = 0.0040$

Comparison of Model 1 with the null model

Total between-study variance (Intercept only)
 $\tau^2 = 0.0273$, $\tau = 0.1652$, $i^2 = 42.83\%$, $Q = 85.71$, $df = 49$, $p = 0.0009$

Proportion of total between-study variance explained by Model 1
 R^2 analog = 0.21

Number of studies in the analysis 50

- We can get more details by clicking on the tabs at the top of the window. For instance, clicking on “Scatterplot” gives you the following figure:

