Example name	Multiple outcomes reading and math
Effect size	Standardized mean difference
Analysis type	Multiple outcomes from same subjects
Level	Advanced

Synopsis

This analysis uses fictional data. Each study in the analysis has one set of subjects, and these subjects provide data for the impact of tutoring. Outcome is the standardized mean difference for the tutored group vs. the control group. Each study reports three outcomes – the effect size (a) for reading (b) for math (c) for music.

We use this example to show

- How to enter data for multiple outcomes within a study
- How compute a combined effect across outcomes ("What is the effect for "Achievement")
- How to compare the effect size for different outcomes ("Is the effect larger for reading than for math?")

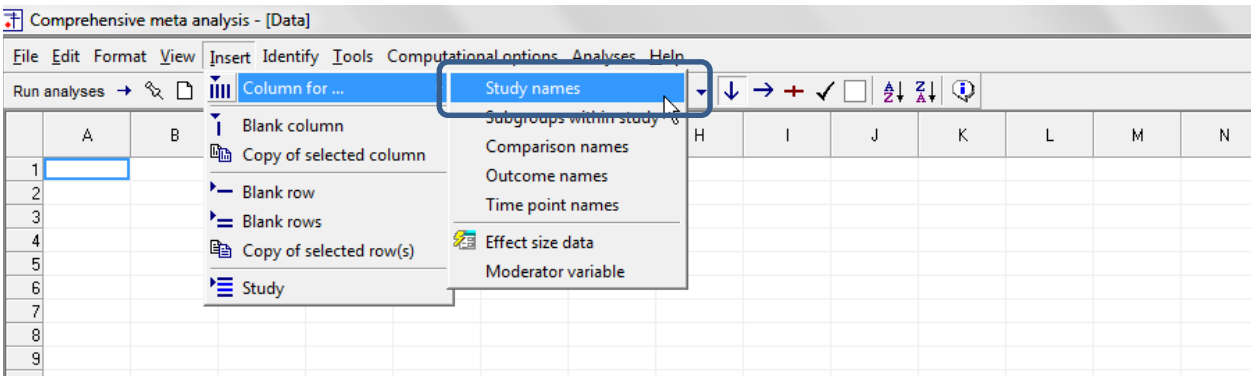
To open a CMA file > Download and Save file | Start CMA | Open file from within CMA

Download CMA file for computers that use a period to indicate decimals
Download CMA file for computers that use a comma to indicate decimals

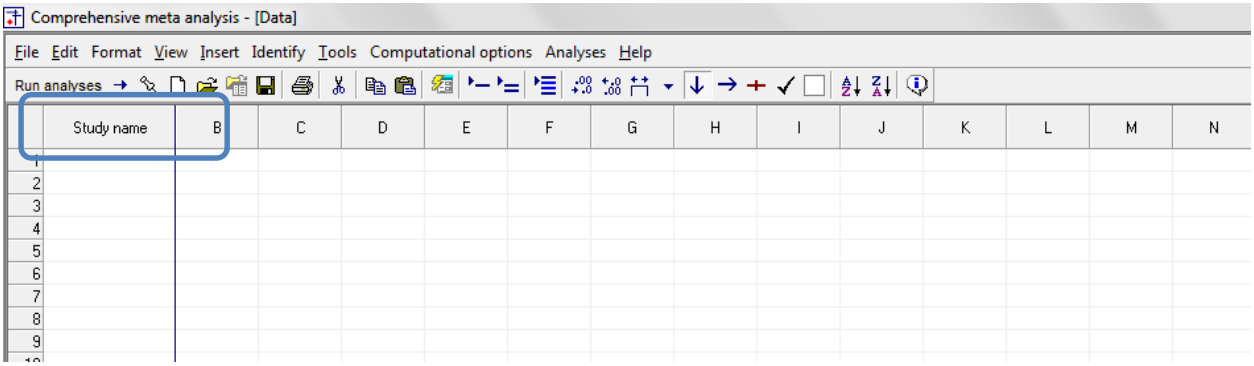
Download this PDF
Download data in Excel
Download trial of CMA

Start the program

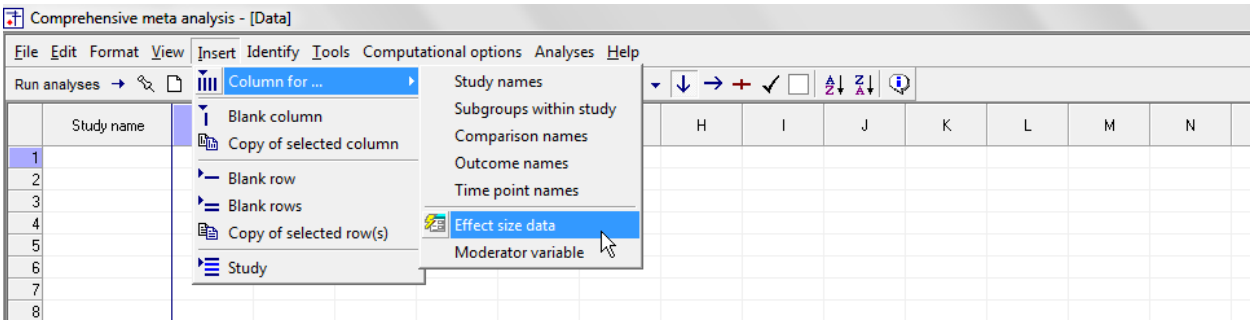
- Select the option [Start a blank spreadsheet]
- Click [Ok]
- Click Insert > Column for > Study names



The screen should look like this

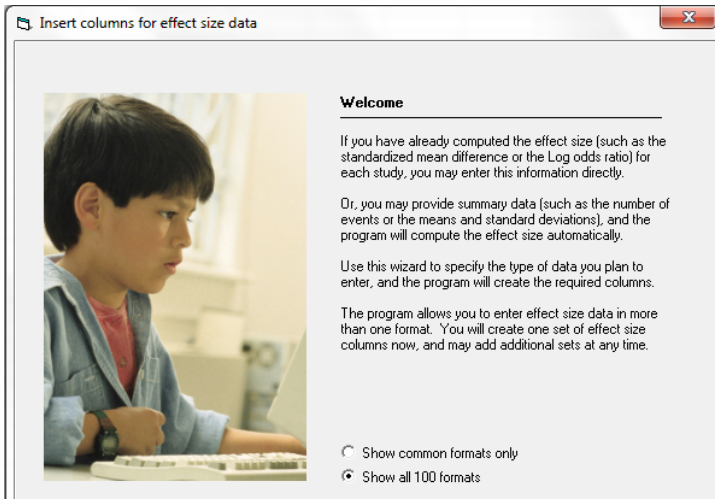


Click Insert > Column for > Effect size data

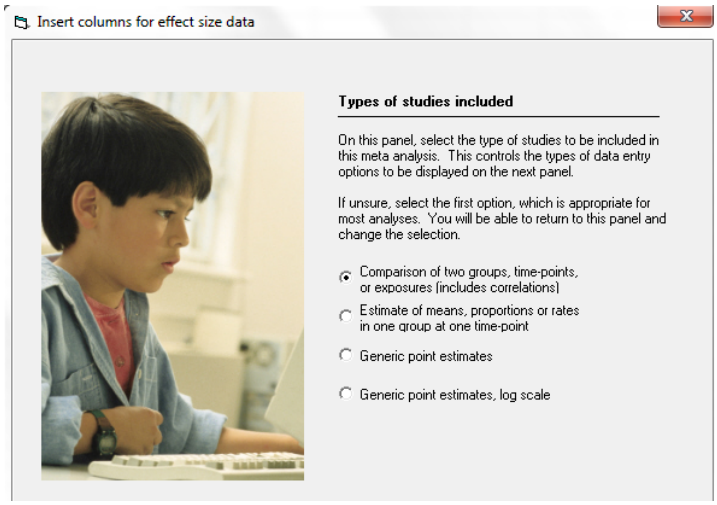


The program displays this wizard

Select [Show all 100 formats]
Click [Next]

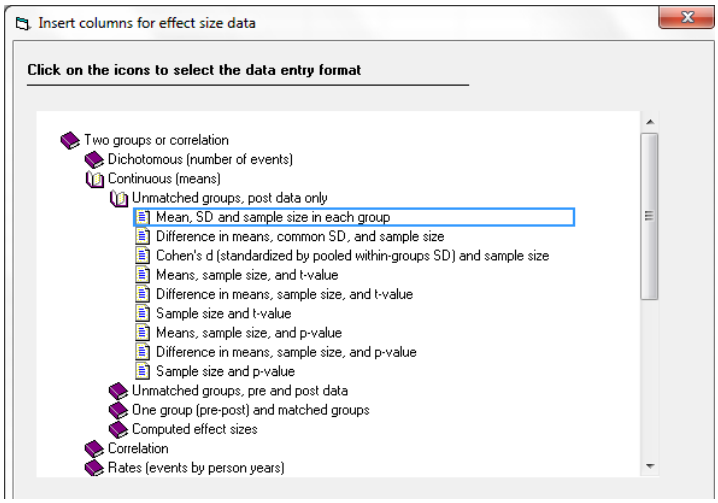


Select [Comparison of two groups…]
Click [Next]



Drill down to

Continuous (means)
Unmatched groups, post-data only
Mean, SD and sample size in each group

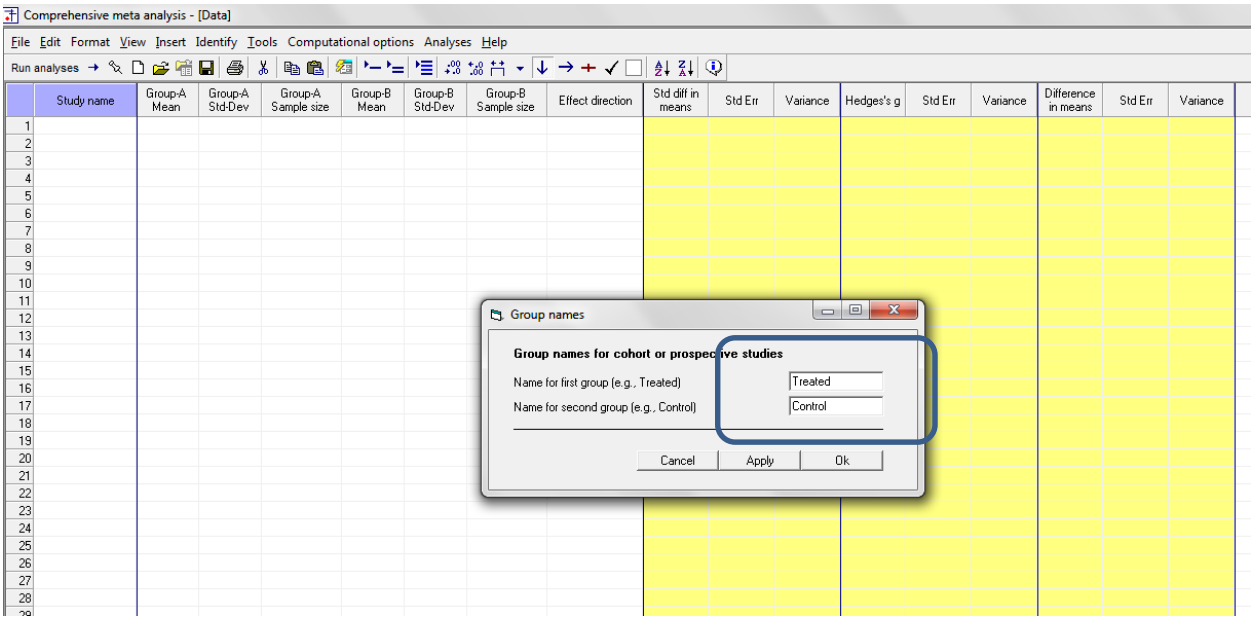


The program displays this wizard

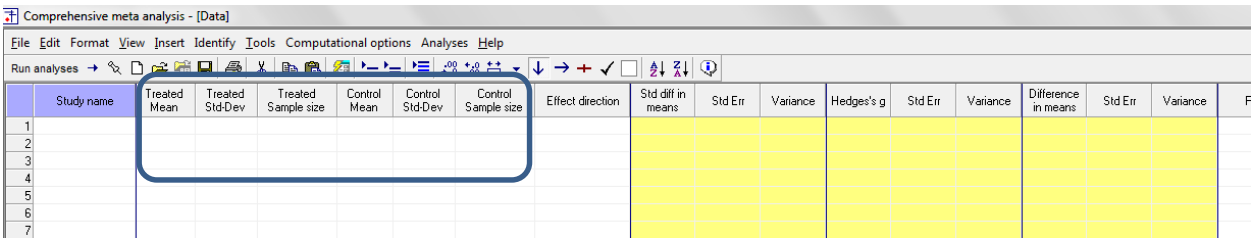
Enter the following labels into the wizard

- First group > Treated
- Second group > Control

Click [Ok] and the program will copy the names into the grid



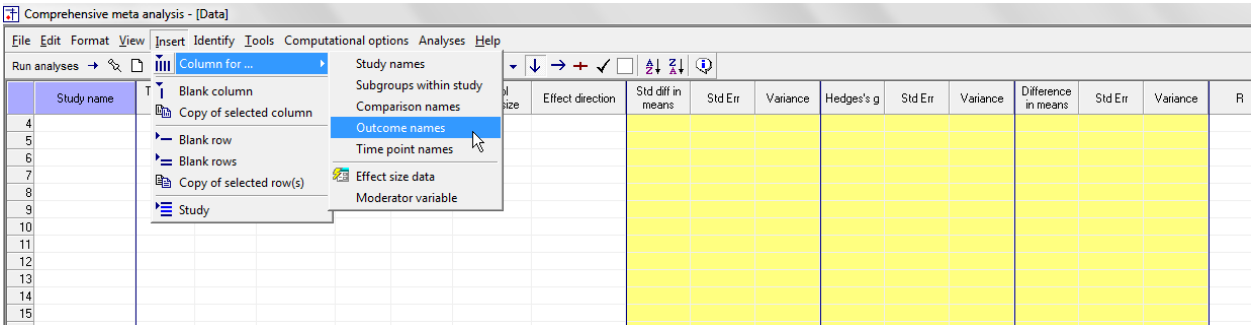
The screen should look like this



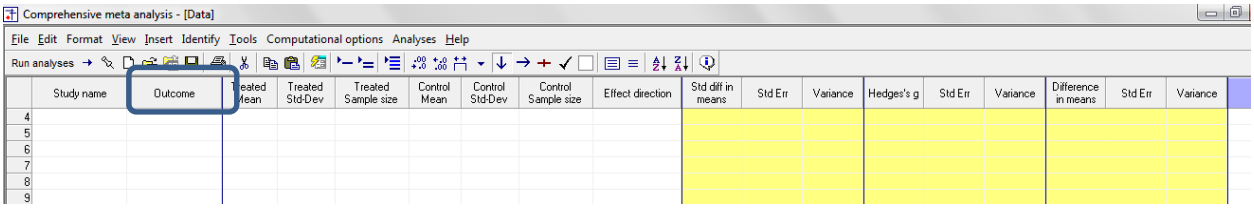
Some (or all) studies will include data for two or more outcomes. These outcomes are based on THE SAME subjects.

The possible outcomes are Reading, Math, and Music. We will be using multiple rows for each study, and need a column that will identify the outcome for each row.

Click Insert > Column for > Outcome names

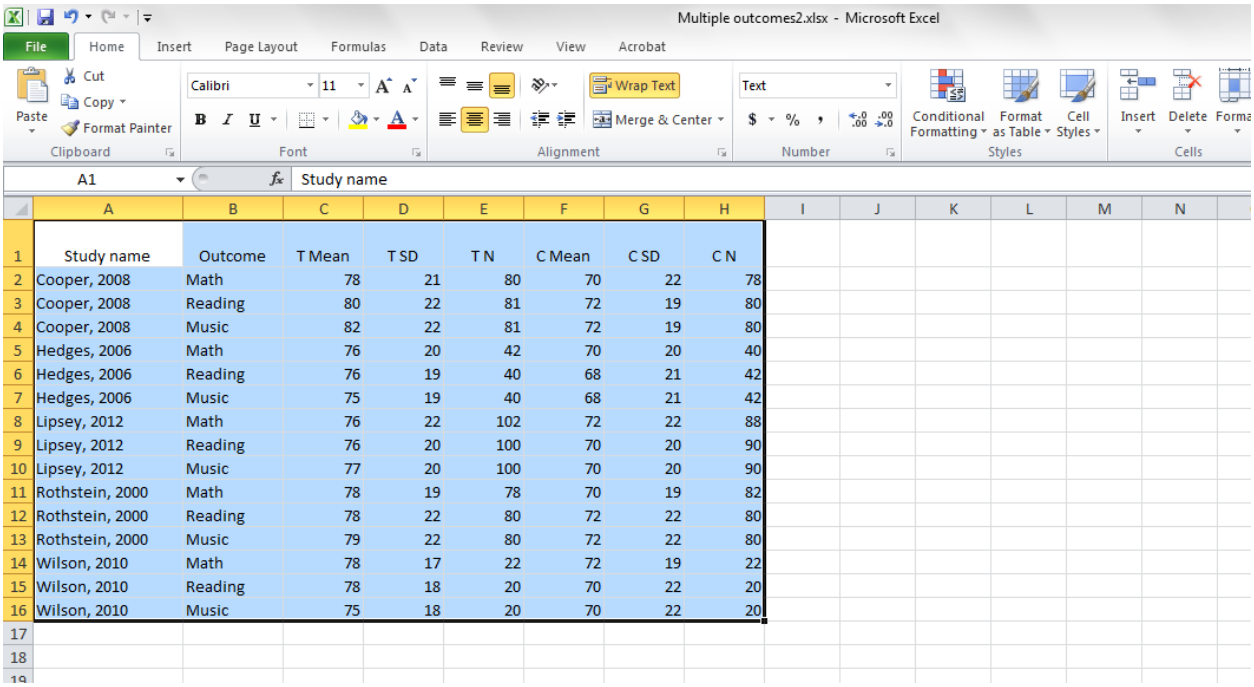


The screen should look like this



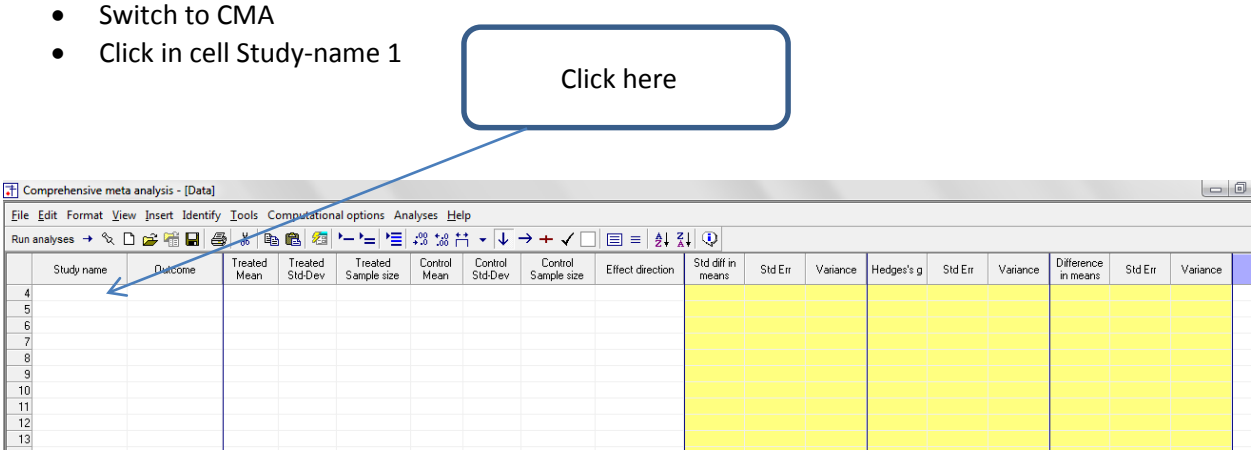
Rather than enter the data directly into CMA we will copy the data from Excel

- Switch to Excel and open the file “Multiple Outcomes”
- Highlight the rows and columns as shown, and press CTRL-C to copy to clipboard



	A	B	C	D	E	F	G	H
1	Study name	Outcome	T Mean	T SD	T N	C Mean	C SD	C N
2	Cooper, 2008	Math	78	21	80	70	22	78
3	Cooper, 2008	Reading	80	22	81	72	19	80
4	Cooper, 2008	Music	82	22	81	72	19	80
5	Hedges, 2006	Math	76	20	42	70	20	40
6	Hedges, 2006	Reading	76	19	40	68	21	42
7	Hedges, 2006	Music	75	19	40	68	21	42
8	Lipsey, 2012	Math	76	22	102	72	22	88
9	Lipsey, 2012	Reading	76	20	100	70	20	90
10	Lipsey, 2012	Music	77	20	100	70	20	90
11	Rothstein, 2000	Math	78	19	78	70	19	82
12	Rothstein, 2000	Reading	78	22	80	72	22	80
13	Rothstein, 2000	Music	79	22	80	72	22	80
14	Wilson, 2010	Math	78	17	22	72	19	22
15	Wilson, 2010	Reading	78	18	20	70	22	20
16	Wilson, 2010	Music	75	18	20	70	22	20
17								
18								

- Switch to CMA
- Click in cell Study-name 1



- Press [CTRL-V] to paste the data
- The screen should look like this

Comprehensive meta analysis - [Data]

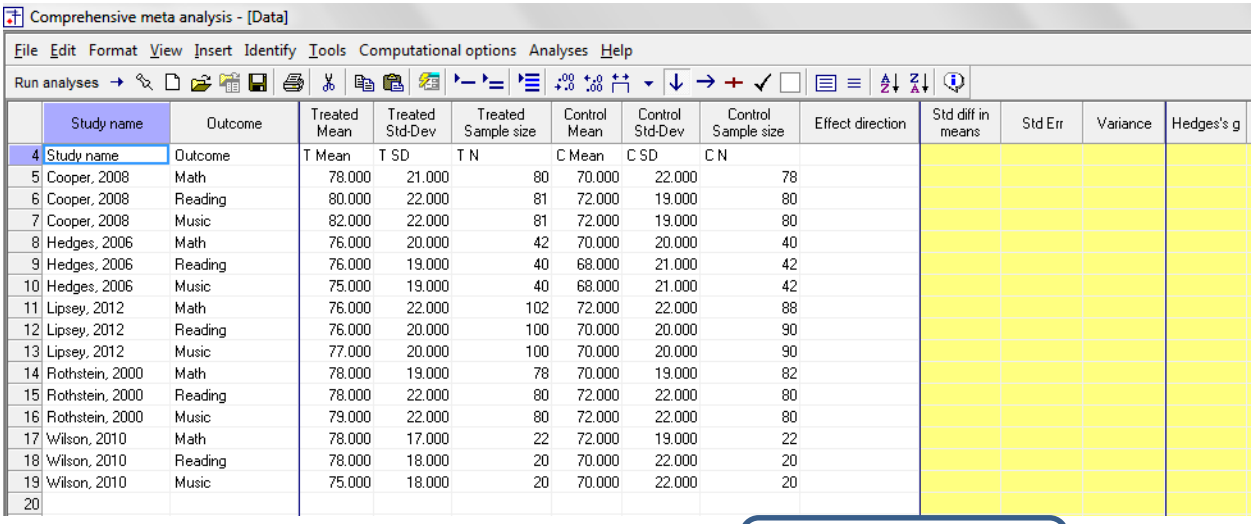
File Edit Format View Insert Identify Tools Computational options Analyses Help

Run analyses

	Study name	Outcome	Treated Mean	Treated Std-Dev	Treated Sample size	Control Mean	Control Std-Dev	Control Sample size	Effect direction	Std diff in means	Std Err	Variance	Hedges's g
4	Study name	Outcome	T Mean	T SD	T N	C Mean	C SD	C N					
5	Cooper, 2008	Math	78.000	21.000	80	70.000	22.000	78					
6	Cooper, 2008	Reading	80.000	22.000	81	72.000	19.000	80					
7	Cooper, 2008	Music	82.000	22.000	81	72.000	19.000	80					
8	Hedges, 2006	Math	76.000	20.000	42	70.000	20.000	40					
9	Hedges, 2006	Reading	76.000	19.000	40	68.000	21.000	42					
10	Hedges, 2006	Music	75.000	19.000	40	68.000	21.000	42					
11	Lipsey, 2012	Math	76.000	22.000	102	72.000	22.000	88					
12	Lipsey, 2012	Reading	76.000	20.000	100	70.000	20.000	90					
13	Lipsey, 2012	Music	77.000	20.000	100	70.000	20.000	90					
14	Rothstein, 2000	Math	78.000	19.000	78	70.000	19.000	82					
15	Rothstein, 2000	Reading	78.000	22.000	80	72.000	22.000	80					
16	Rothstein, 2000	Music	79.000	22.000	80	72.000	22.000	80					
17	Wilson, 2010	Math	78.000	17.000	22	72.000	19.000	22					
18	Wilson, 2010	Reading	78.000	18.000	20	70.000	22.000	20					
19	Wilson, 2010	Music	75.000	18.000	20	70.000	22.000	20					
20													

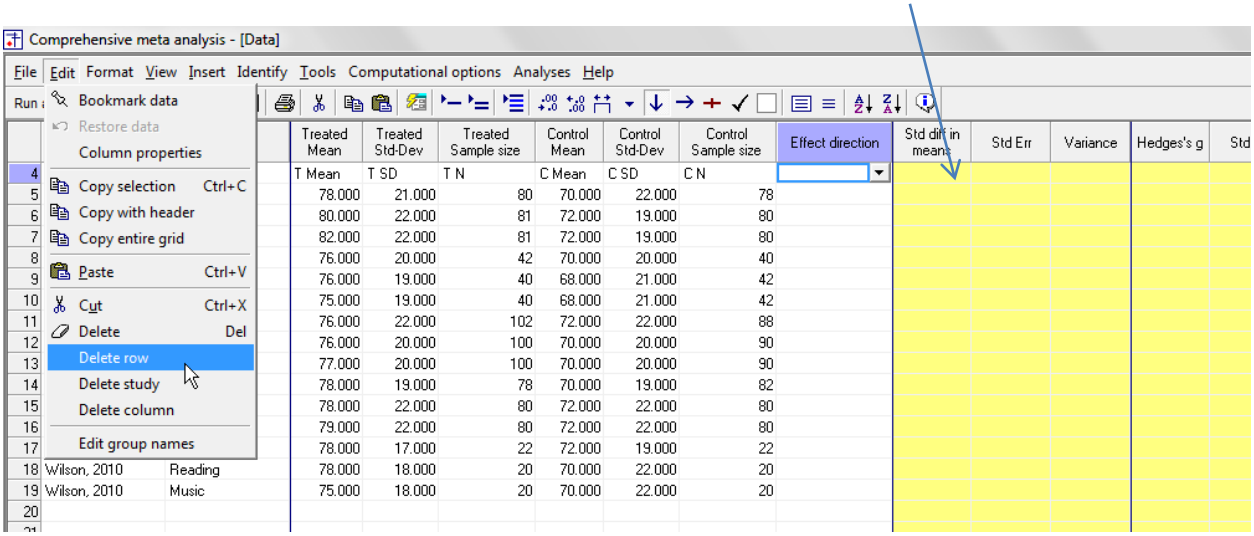
At this point we should check that the data has been copied correctly

The column that had been called “T Mean” is now “Treated Mean”. Similarly, all columns have the intended labels

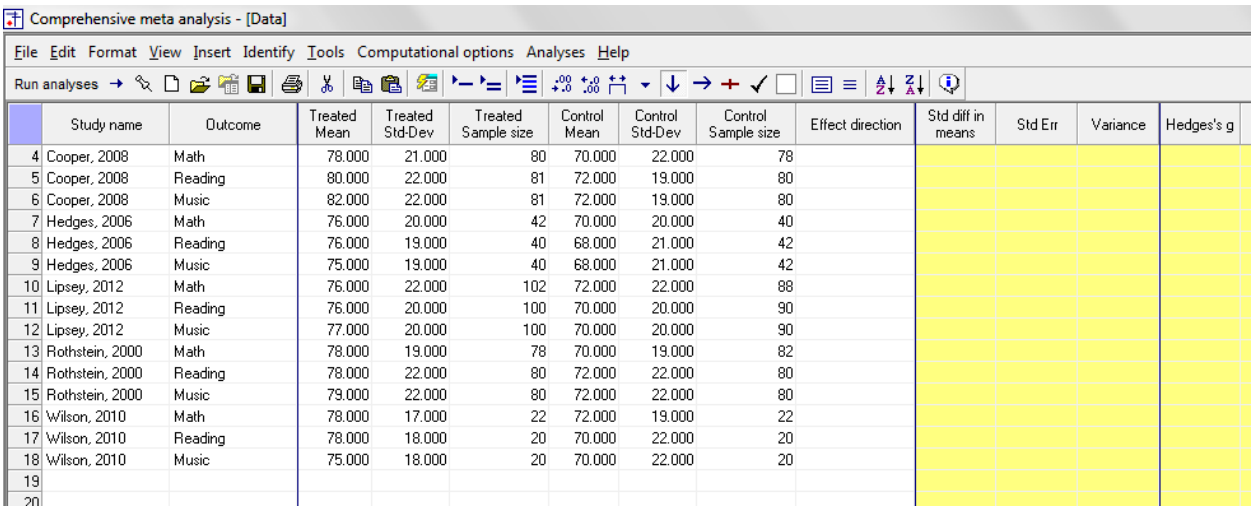


- Click anywhere in Row 1
- Select Edit > Delete row, and confirm

Click here

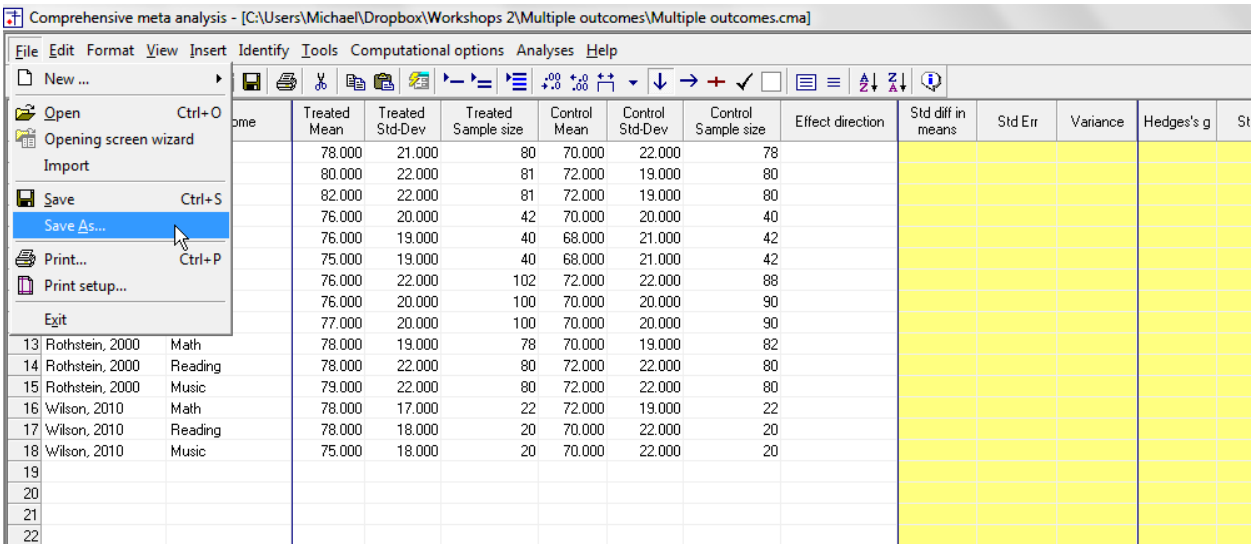


The screen should look like this



	Study name	Outcome	Treated Mean	Treated Std-Dev	Treated Sample size	Control Mean	Control Std-Dev	Control Sample size	Effect direction	Std diff in means	Std Err	Variance	Hedges's g
4	Cooper, 2008	Math	78.000	21.000	80	70.000	22.000	78					
5	Cooper, 2008	Reading	80.000	22.000	81	72.000	19.000	80					
6	Cooper, 2008	Music	82.000	22.000	81	72.000	19.000	80					
7	Hedges, 2006	Math	76.000	20.000	42	70.000	20.000	40					
8	Hedges, 2006	Reading	76.000	19.000	40	68.000	21.000	42					
9	Hedges, 2006	Music	75.000	19.000	40	68.000	21.000	42					
10	Lipsey, 2012	Math	76.000	22.000	102	72.000	22.000	88					
11	Lipsey, 2012	Reading	76.000	20.000	100	70.000	20.000	90					
12	Lipsey, 2012	Music	77.000	20.000	100	70.000	20.000	90					
13	Rothstein, 2000	Math	78.000	19.000	78	70.000	19.000	82					
14	Rothstein, 2000	Reading	78.000	22.000	80	72.000	22.000	80					
15	Rothstein, 2000	Music	79.000	22.000	80	72.000	22.000	80					
16	Wilson, 2010	Math	78.000	17.000	22	72.000	19.000	22					
17	Wilson, 2010	Reading	78.000	18.000	20	70.000	22.000	20					
18	Wilson, 2010	Music	75.000	18.000	20	70.000	22.000	20					
19													
20													

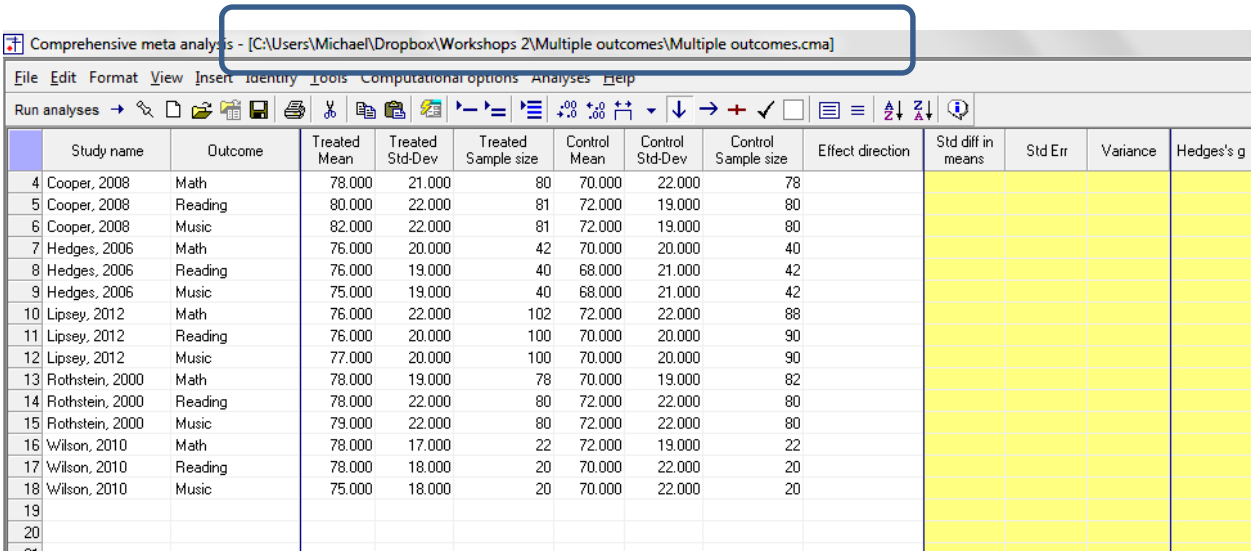
Click File > Save As and save the file



	Study name	Outcome	Treated Mean	Treated Std-Dev	Treated Sample size	Control Mean	Control Std-Dev	Control Sample size	Effect direction	Std diff in means	Std Err	Variance	Hedges's g
			78.000	21.000	80	70.000	22.000	78					
			80.000	22.000	81	72.000	19.000	80					
			82.000	22.000	81	72.000	19.000	80					
			76.000	20.000	42	70.000	20.000	40					
			76.000	19.000	40	68.000	21.000	42					
			75.000	19.000	40	68.000	21.000	42					
			76.000	22.000	102	72.000	22.000	88					
			76.000	20.000	100	70.000	20.000	90					
			77.000	20.000	100	70.000	20.000	90					
13	Rothstein, 2000	Math	78.000	19.000	78	70.000	19.000	82					
14	Rothstein, 2000	Reading	78.000	22.000	80	72.000	22.000	80					
15	Rothstein, 2000	Music	79.000	22.000	80	72.000	22.000	80					
16	Wilson, 2010	Math	78.000	17.000	22	72.000	19.000	22					
17	Wilson, 2010	Reading	78.000	18.000	20	70.000	22.000	20					
18	Wilson, 2010	Music	75.000	18.000	20	70.000	22.000	20					
19													
20													
21													
22													

Note that the file name is now in the header.

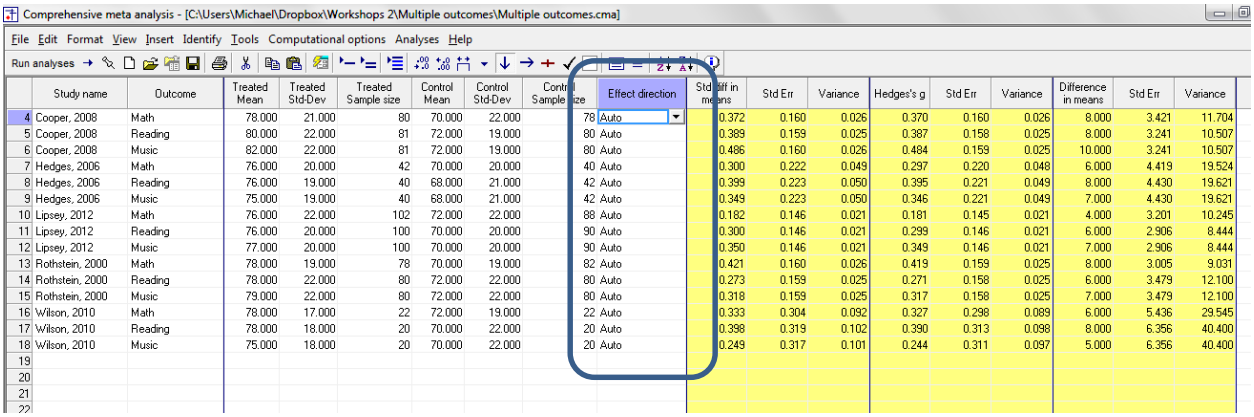
- [Save] will over-write the prior version of this file without warning
- [Save As…] will allow you to save the file with a new name



	Study name	Outcome	Treated Mean	Treated Std-Dev	Treated Sample size	Control Mean	Control Std-Dev	Control Sample size	Effect direction	Std diff in means	Std Err	Variance	Hedges's g
4	Cooper, 2008	Math	78.000	21.000	80	70.000	22.000	78					
5	Cooper, 2008	Reading	80.000	22.000	81	72.000	19.000	80					
6	Cooper, 2008	Music	82.000	22.000	81	72.000	19.000	80					
7	Hedges, 2006	Math	76.000	20.000	42	70.000	20.000	40					
8	Hedges, 2006	Reading	76.000	19.000	40	68.000	21.000	42					
9	Hedges, 2006	Music	75.000	19.000	40	68.000	21.000	42					
10	Lipsey, 2012	Math	76.000	22.000	102	72.000	22.000	88					
11	Lipsey, 2012	Reading	76.000	20.000	100	70.000	20.000	90					
12	Lipsey, 2012	Music	77.000	20.000	100	70.000	20.000	90					
13	Rothstein, 2000	Math	78.000	19.000	78	70.000	19.000	82					
14	Rothstein, 2000	Reading	78.000	22.000	80	72.000	22.000	80					
15	Rothstein, 2000	Music	79.000	22.000	80	72.000	22.000	80					
16	Wilson, 2010	Math	78.000	17.000	22	72.000	19.000	22					
17	Wilson, 2010	Reading	78.000	18.000	20	70.000	22.000	20					
18	Wilson, 2010	Music	75.000	18.000	20	70.000	22.000	20					
19													
20													

We need to tell the program the direction for each effect size

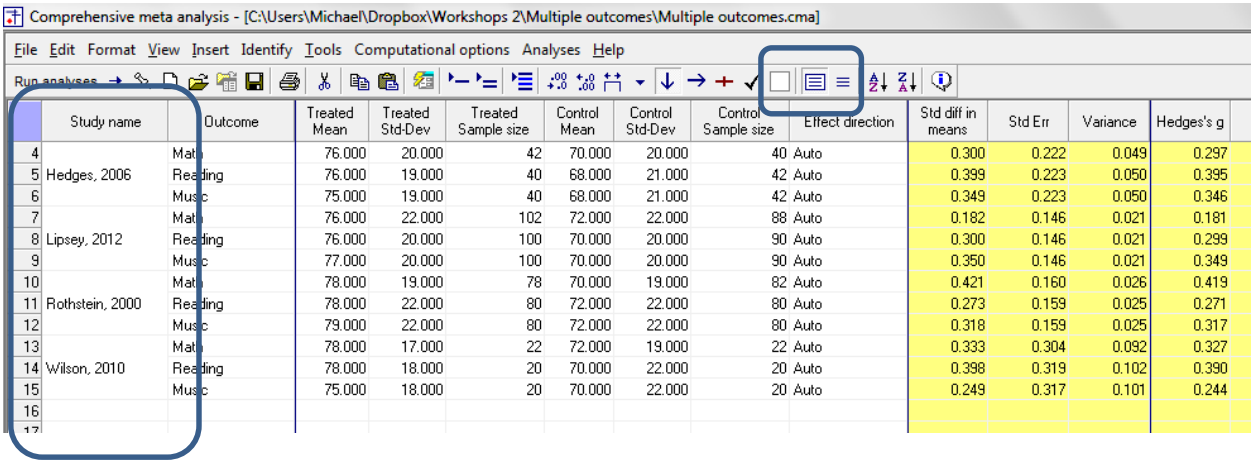
For each study, click in the Direction column and select Auto



	Study name	Outcome	Treated Mean	Treated Std-Dev	Treated Sample size	Control Mean	Control Std-Dev	Control Sample size	Effect direction	Std Diff in means	Std Err	Variance	Hedges's g	Std Err	Variance	Difference in means	Std Err	Variance
4	Cooper, 2008	Math	78.000	21.000	80	70.000	22.000	78	Auto	0.372	0.160	0.026	0.370	0.160	0.026	8.000	3.421	11.704
5	Cooper, 2008	Reading	80.000	22.000	81	72.000	19.000	80	Auto	0.389	0.159	0.025	0.387	0.158	0.025	8.000	3.241	10.507
6	Cooper, 2008	Music	82.000	22.000	81	72.000	19.000	80	Auto	0.486	0.160	0.026	0.484	0.159	0.025	10.000	3.241	10.507
7	Hedges, 2006	Math	76.000	20.000	42	70.000	20.000	40	Auto	0.300	0.222	0.049	0.297	0.220	0.048	6.000	4.419	19.524
8	Hedges, 2006	Reading	76.000	19.000	40	68.000	21.000	42	Auto	0.399	0.223	0.050	0.395	0.221	0.049	8.000	4.430	19.621
9	Hedges, 2006	Music	75.000	19.000	40	68.000	21.000	42	Auto	0.349	0.223	0.050	0.346	0.221	0.049	7.000	4.430	19.621
10	Lipsey, 2012	Math	76.000	22.000	102	72.000	22.000	88	Auto	0.182	0.146	0.021	0.181	0.145	0.021	4.000	3.201	10.245
11	Lipsey, 2012	Reading	76.000	20.000	100	70.000	20.000	90	Auto	0.300	0.146	0.021	0.299	0.146	0.021	6.000	2.906	8.444
12	Lipsey, 2012	Music	77.000	20.000	100	70.000	20.000	90	Auto	0.350	0.146	0.021	0.349	0.146	0.021	7.000	2.906	8.444
13	Rothstein, 2000	Math	78.000	19.000	78	70.000	19.000	82	Auto	0.421	0.160	0.026	0.419	0.159	0.025	8.000	3.005	9.031
14	Rothstein, 2000	Reading	78.000	22.000	80	72.000	22.000	80	Auto	0.273	0.159	0.025	0.271	0.158	0.025	6.000	3.479	12.100
15	Rothstein, 2000	Music	79.000	22.000	80	72.000	22.000	80	Auto	0.318	0.159	0.025	0.317	0.158	0.025	7.000	3.479	12.100
16	Wilson, 2010	Math	78.000	17.000	22	72.000	19.000	22	Auto	0.333	0.304	0.092	0.327	0.298	0.089	6.000	5.436	29.545
17	Wilson, 2010	Reading	78.000	18.000	20	70.000	22.000	20	Auto	0.398	0.319	0.102	0.390	0.313	0.098	8.000	6.356	40.400
18	Wilson, 2010	Music	75.000	18.000	20	70.000	22.000	20	Auto	0.249	0.317	0.101	0.244	0.311	0.097	5.000	6.356	40.400
19																		
20																		
21																		
22																		

- Click the Merge Rows icon

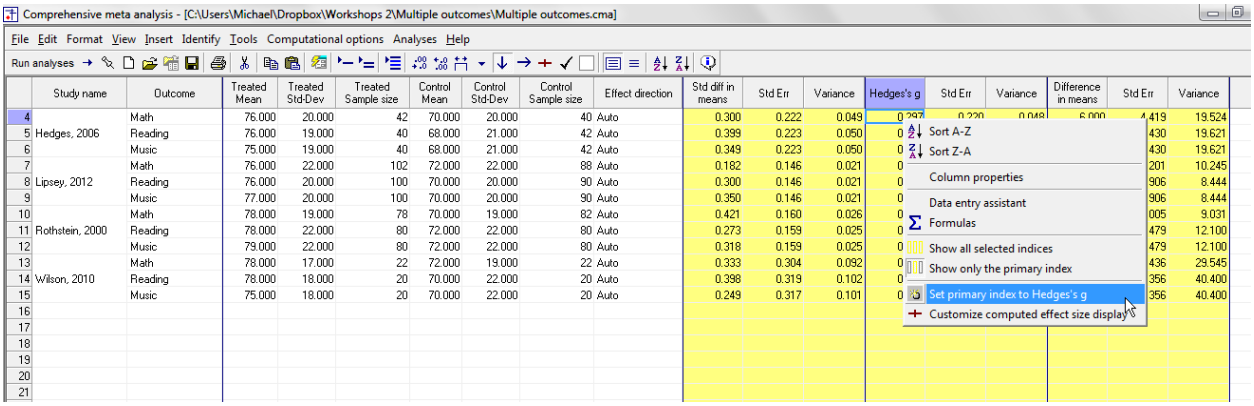
The program will merge the study names for each study



	Study name	Outcome	Treated Mean	Treated Std-Dev	Treated Sample size	Control Mean	Control Std-Dev	Control Sample size	Effect direction	Std diff in means	Std Err	Variance	Hedges's g
4		Math	76.000	20.000	42	70.000	20.000	40	Auto	0.300	0.222	0.049	0.297
5	Hedges, 2006	Reading	76.000	19.000	40	68.000	21.000	42	Auto	0.399	0.223	0.050	0.395
6		Music	75.000	19.000	40	68.000	21.000	42	Auto	0.349	0.223	0.050	0.346
7		Math	76.000	22.000	102	72.000	22.000	88	Auto	0.182	0.146	0.021	0.181
8	Lipsey, 2012	Reading	76.000	20.000	100	70.000	20.000	90	Auto	0.300	0.146	0.021	0.299
9		Music	77.000	20.000	100	70.000	20.000	90	Auto	0.350	0.146	0.021	0.349
10		Math	78.000	19.000	78	70.000	19.000	82	Auto	0.421	0.160	0.026	0.419
11	Rothstein, 2000	Reading	78.000	22.000	80	72.000	22.000	80	Auto	0.273	0.159	0.025	0.271
12		Music	79.000	22.000	80	72.000	22.000	80	Auto	0.318	0.159	0.025	0.317
13		Math	78.000	17.000	22	72.000	19.000	22	Auto	0.333	0.304	0.092	0.327
14	Wilson, 2010	Reading	78.000	18.000	20	70.000	22.000	20	Auto	0.398	0.319	0.102	0.390
15		Music	75.000	18.000	20	70.000	22.000	20	Auto	0.249	0.317	0.101	0.244
16													

The screen should look like this

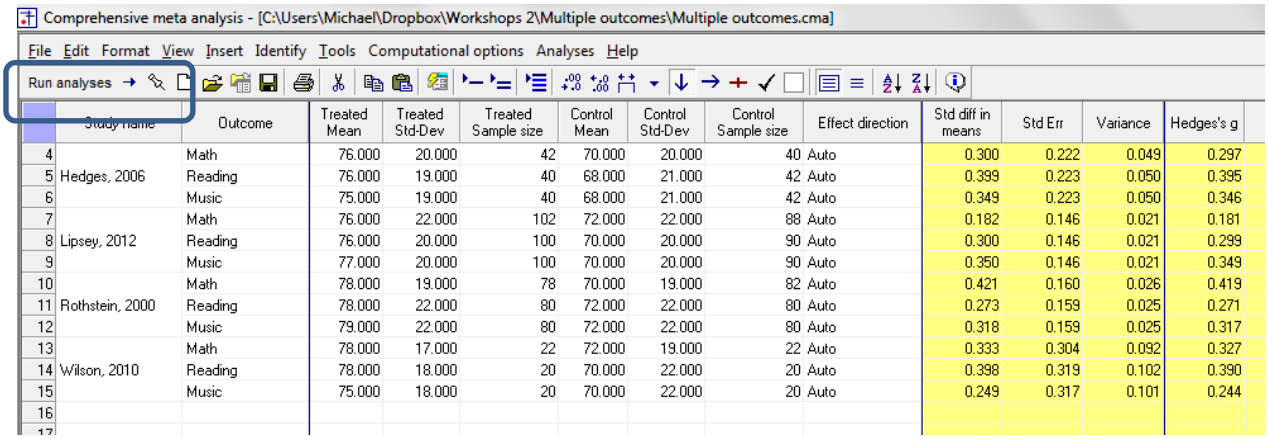
There are three effect sizes displayed



	Study name	Outcome	Treated Mean	Treated Std-Dev	Treated Sample size	Control Mean	Control Std-Dev	Control Sample size	Effect direction	Std diff in means	Std Err	Variance	Hedges's g	Std Err	Variance	Difference in means	Std Err	Variance
4		Math	76.000	20.000	42	70.000	20.000	40	Auto	0.300	0.222	0.049	0.297	0.220	0.049	6.000	4.419	19.524
5	Hedges, 2006	Reading	76.000	19.000	40	68.000	21.000	42	Auto	0.399	0.223	0.050	0				430	19.621
6		Music	75.000	19.000	40	68.000	21.000	42	Auto	0.349	0.223	0.050	0				430	19.621
7		Math	76.000	22.000	102	72.000	22.000	88	Auto	0.182	0.146	0.021	0				201	10.245
8	Lipsey, 2012	Reading	76.000	20.000	100	70.000	20.000	90	Auto	0.300	0.146	0.021	0				906	8.444
9		Music	77.000	20.000	100	70.000	20.000	90	Auto	0.350	0.146	0.021	0				906	8.444
10		Math	78.000	19.000	78	70.000	19.000	82	Auto	0.421	0.160	0.026	0				005	9.031
11	Rothstein, 2000	Reading	78.000	22.000	80	72.000	22.000	80	Auto	0.273	0.159	0.025	0				479	12.100
12		Music	79.000	22.000	80	72.000	22.000	80	Auto	0.318	0.159	0.025	0				479	12.100
13		Math	78.000	17.000	22	72.000	19.000	22	Auto	0.333	0.304	0.092	0				436	29.545
14	Wilson, 2010	Reading	78.000	18.000	20	70.000	22.000	20	Auto	0.398	0.319	0.102	0				356	40.400
15		Music	75.000	18.000	20	70.000	22.000	20	Auto	0.249	0.317	0.101	0				356	40.400
16																		
17																		
18																		
19																		
20																		
21																		

- Right-click in the section for Hedges's g
- Select Set primary index to Hedges's g

- To run the analysis, click [Run analysis]



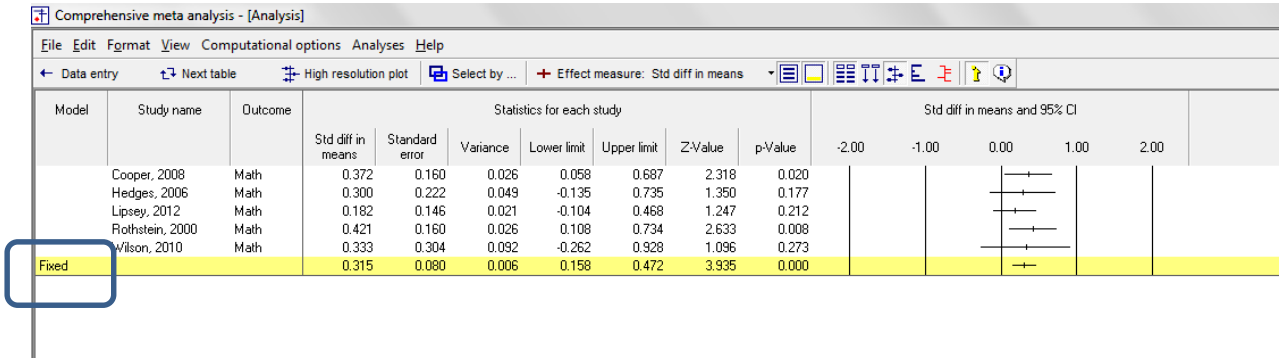
	Study name	Outcome	Treated Mean	Treated Std-Dev	Treated Sample size	Control Mean	Control Std-Dev	Control Sample size	Effect direction	Std diff in means	Std Err	Variance	Hedges's g
4		Math	76.000	20.000	42	70.000	20.000	40	Auto	0.300	0.222	0.049	0.297
5	Hedges, 2006	Reading	76.000	19.000	40	68.000	21.000	42	Auto	0.399	0.223	0.050	0.395
6		Music	75.000	19.000	40	68.000	21.000	42	Auto	0.349	0.223	0.050	0.346
7		Math	76.000	22.000	102	72.000	22.000	88	Auto	0.182	0.146	0.021	0.181
8	Lipsey, 2012	Reading	76.000	20.000	100	70.000	20.000	90	Auto	0.300	0.146	0.021	0.299
9		Music	77.000	20.000	100	70.000	20.000	90	Auto	0.350	0.146	0.021	0.349
10		Math	78.000	19.000	78	70.000	19.000	82	Auto	0.421	0.160	0.026	0.419
11	Rothstein, 2000	Reading	78.000	22.000	80	72.000	22.000	80	Auto	0.273	0.159	0.025	0.271
12		Music	79.000	22.000	80	72.000	22.000	80	Auto	0.318	0.159	0.025	0.317
13		Math	78.000	17.000	22	72.000	19.000	22	Auto	0.333	0.304	0.092	0.327
14	Wilson, 2010	Reading	78.000	18.000	20	70.000	22.000	20	Auto	0.398	0.319	0.102	0.390
15		Music	75.000	18.000	20	70.000	22.000	20	Auto	0.249	0.317	0.101	0.244
16													

The issue we need to address when working with multiple outcomes is the fact that the outcomes are not independent of each other, and therefore do not contain independent information

If we compute an effect size for math only, or for reading only, or for math and reading separately, the effect size and its variance are valid. But, if we compute an effect size based on math and reading, a variance that is based on the combined sample size (counting each subject once for math and again for reading) overstates the amount of information contained in the data, over-estimates the precision of the summary effect and under-estimates the variance.

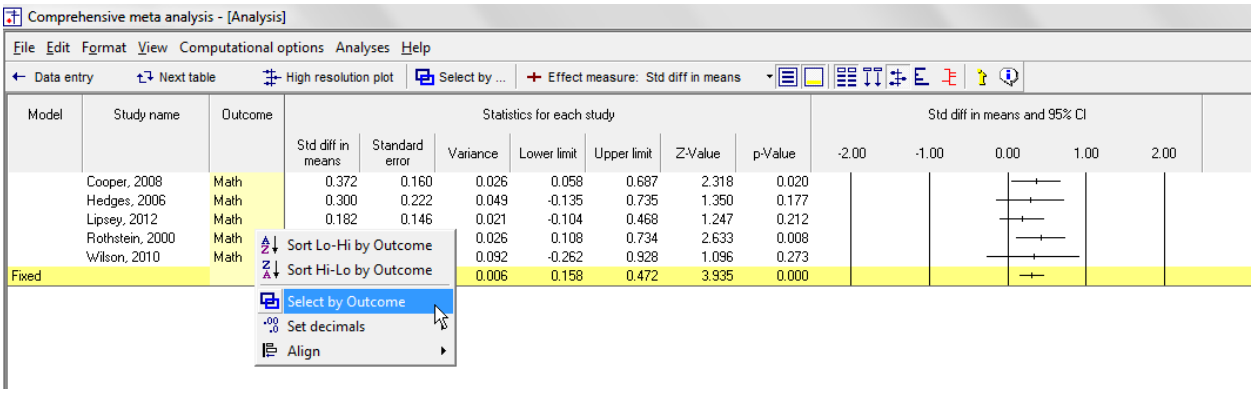
We can see how this plays out in the analyses that follow.

By default the program picks one outcome for each study. Since each study had a row for math, the program is showing an analysis for Math only.

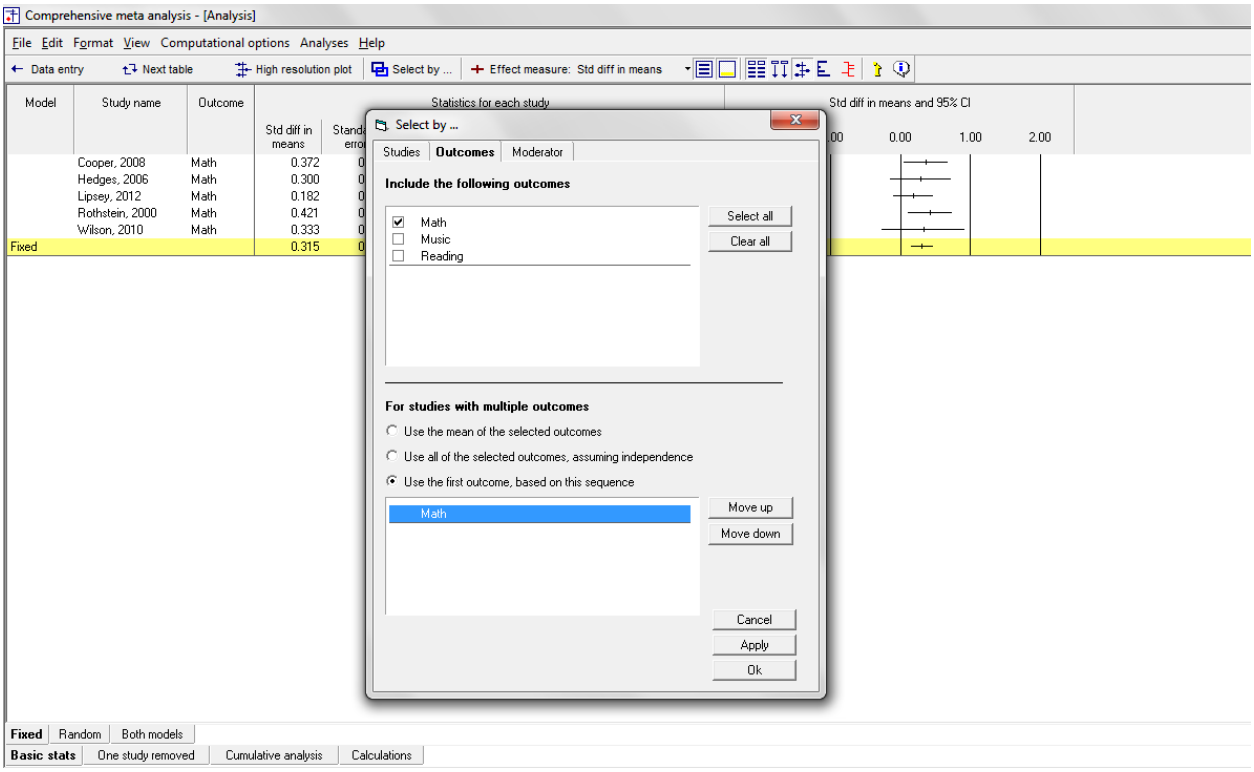


We can run an analysis for math only (that is, selecting math for studies that report an effect size for math, and omitting studies that do not)

Right-click on the Outcome column and click [Select by outcome]

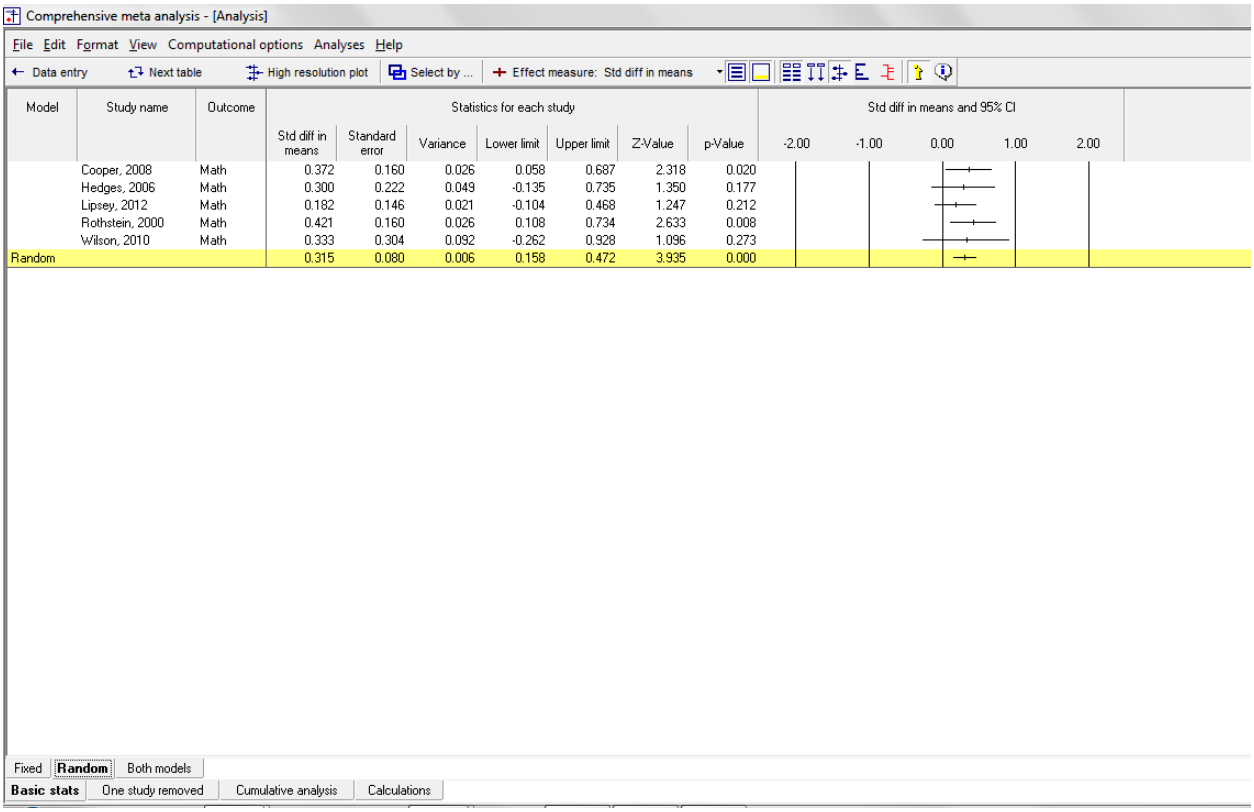


Select Math


Comprehensive meta analysis - [Analysis]
File Edit Format View Computational options Analyses Help
Data entry
Next table
High resolution plot
Select by ...
Effect measure: Std diff in means
Model
Study name
Outcome
Statistics for each study
Std diff in means
Std diff in means and 95% CI
Cooper, 2008 Math 0.372
Hedges, 2006 Math 0.300
Lipsey, 2012 Math 0.182
Rothstein, 2000 Math 0.421
Wilson, 2010 Math 0.333
Fixed 0.315
Select by ...
Studies
Outcomes
Moderator
Include the following outcomes
Math
Music
Reading
Select all
Clear all
For studies with multiple outcomes
Use the mean of the selected outcomes
Use all of the selected outcomes, assuming independence
Use the first outcome, based on this sequence
Math
Move up
Move down
Cancel
Apply
Ok
Fixed
Random
Both models
Basic stats
One study removed
Cumulative analysis
Calculations

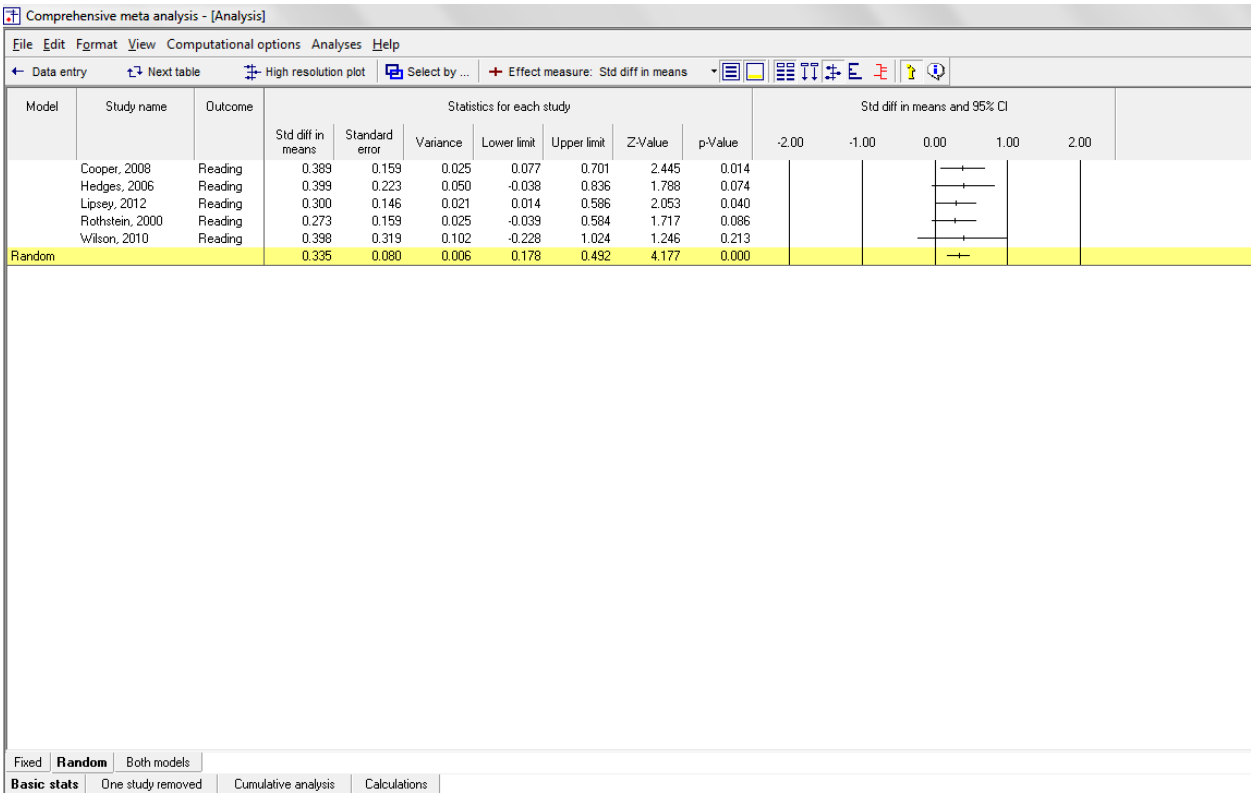
The program shows an analysis for Math.

Note that the variance for the summary effect is 0.006



Follow the same steps to run an analysis for Reading

Note that the variance for the summary effect is 0.006

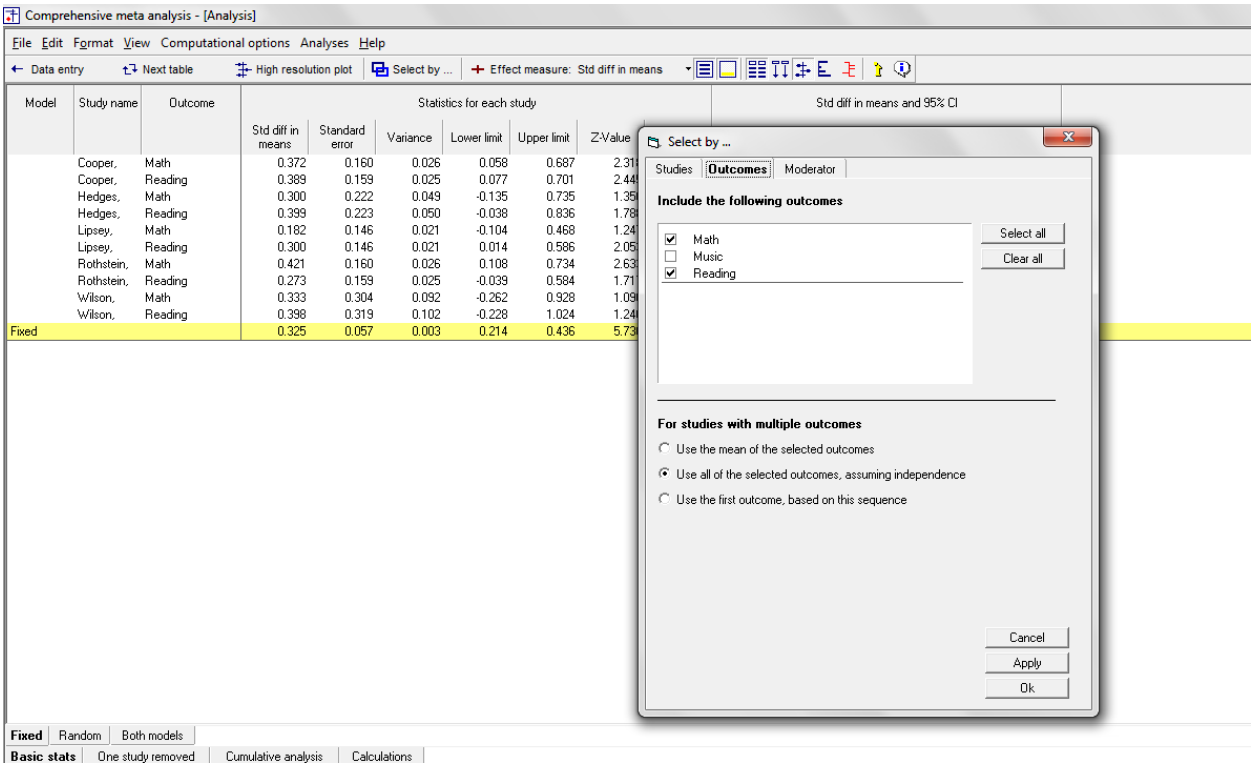


Suppose we want to run an analysis for math *and* for reading

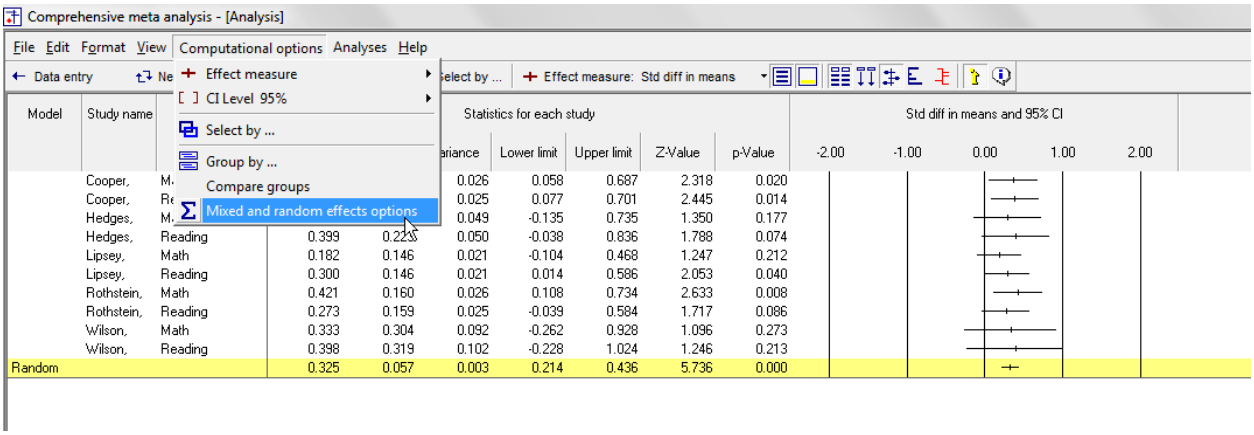
- Check Math
- Check Reading
- Uncheck Music

- Select Use all of the selected outcomes, assuming independence

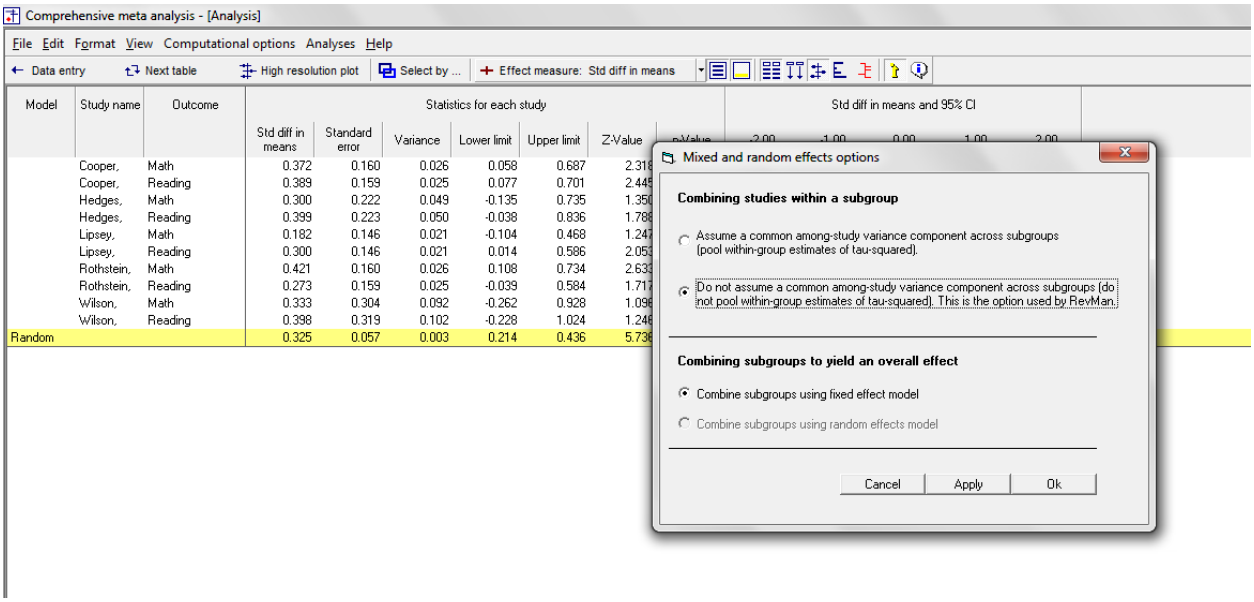
As we shall see momentarily, this analysis, which includes information from both math and reading, is incorrect. We need to split this into two separate analyses.



Select Computational options > Mixed and random effects options

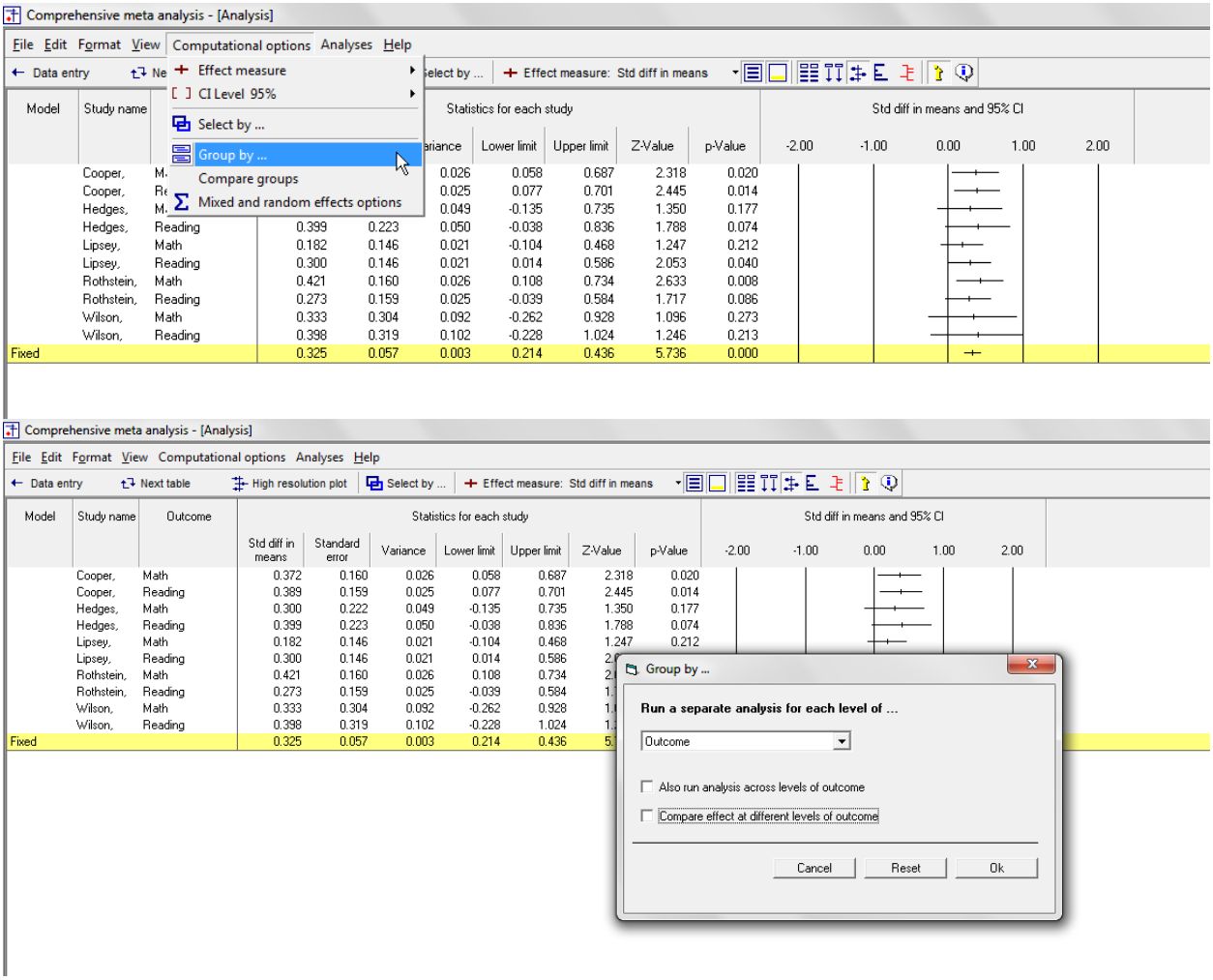


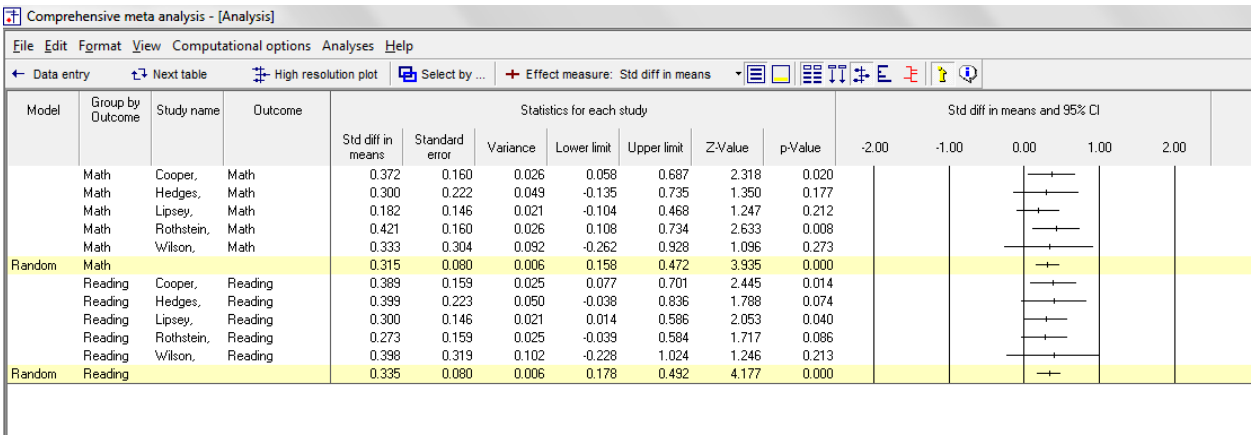
Select “Do not assume a common among-study variance”



Select Computational options > Group by > Outcome

Leave the two check-boxes unchecked





Model	Group by Outcome	Study name	Outcome	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Math	Cooper,	Math	0.372	0.160	0.026	0.058	0.687	2.318	0.020
	Math	Hedges,	Math	0.300	0.222	0.049	-0.135	0.735	1.350	0.177
	Math	Lipsey,	Math	0.182	0.146	0.021	-0.104	0.468	1.247	0.212
	Math	Rothstein,	Math	0.421	0.160	0.026	0.108	0.734	2.633	0.008
	Math	Wilson,	Math	0.333	0.304	0.092	-0.262	0.928	1.096	0.273
Random	Math			0.315	0.080	0.006	0.158	0.472	3.935	0.000
	Reading	Cooper,	Reading	0.389	0.159	0.025	0.077	0.701	2.445	0.014
	Reading	Hedges,	Reading	0.399	0.223	0.050	-0.038	0.836	1.788	0.074
	Reading	Lipsey,	Reading	0.300	0.146	0.021	0.014	0.586	2.053	0.040
	Reading	Rothstein,	Reading	0.273	0.159	0.025	-0.039	0.584	1.717	0.086
	Reading	Wilson,	Reading	0.398	0.319	0.102	-0.228	1.024	1.246	0.213
Random	Reading			0.335	0.080	0.006	0.178	0.492	4.177	0.000

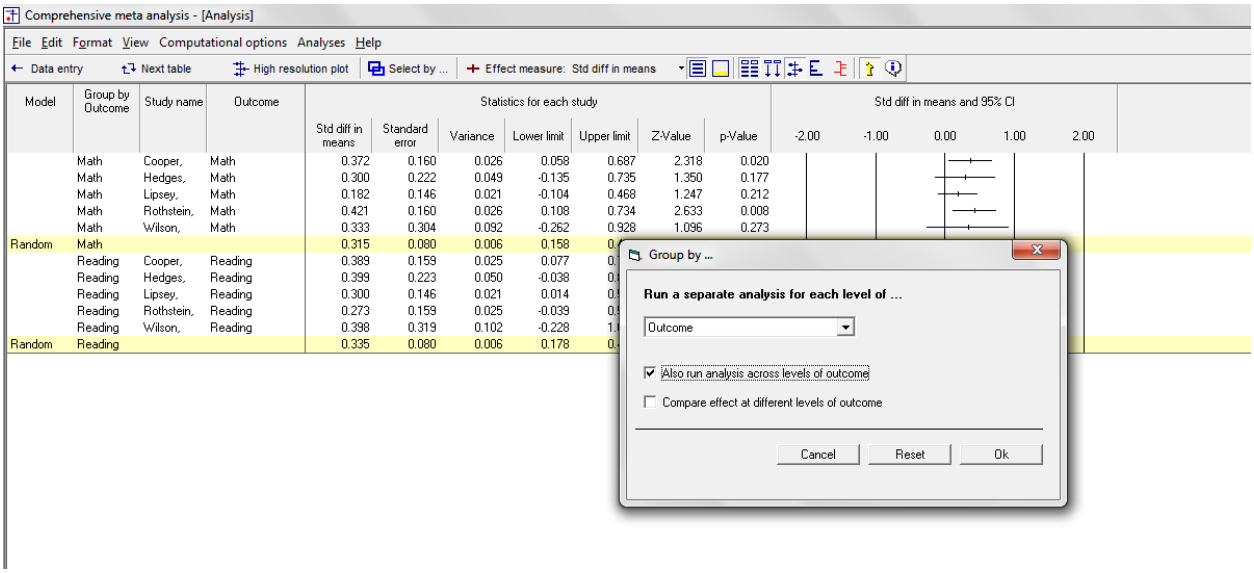
The analysis for math is the same as the one we saw before, with a variance of 0.006
The analysis for reading is the same as the one we saw before, with a variance of 0.006

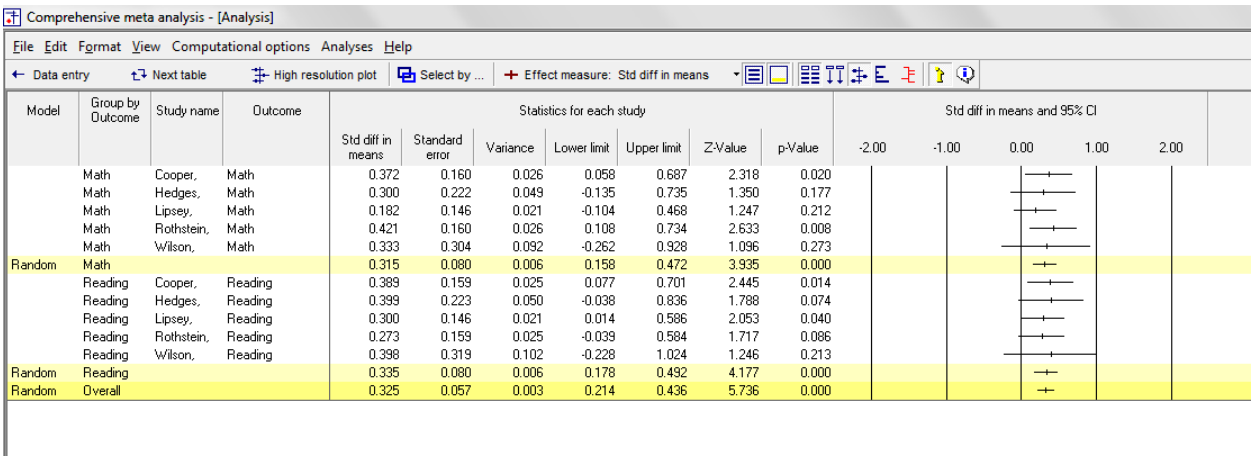
Each of these analyses is valid, as the variance is based on the actual number of students in the studies.

However, consider what happens if we also compute an overall effect size

Click Computational options > Group by

Add a check-mark as shown





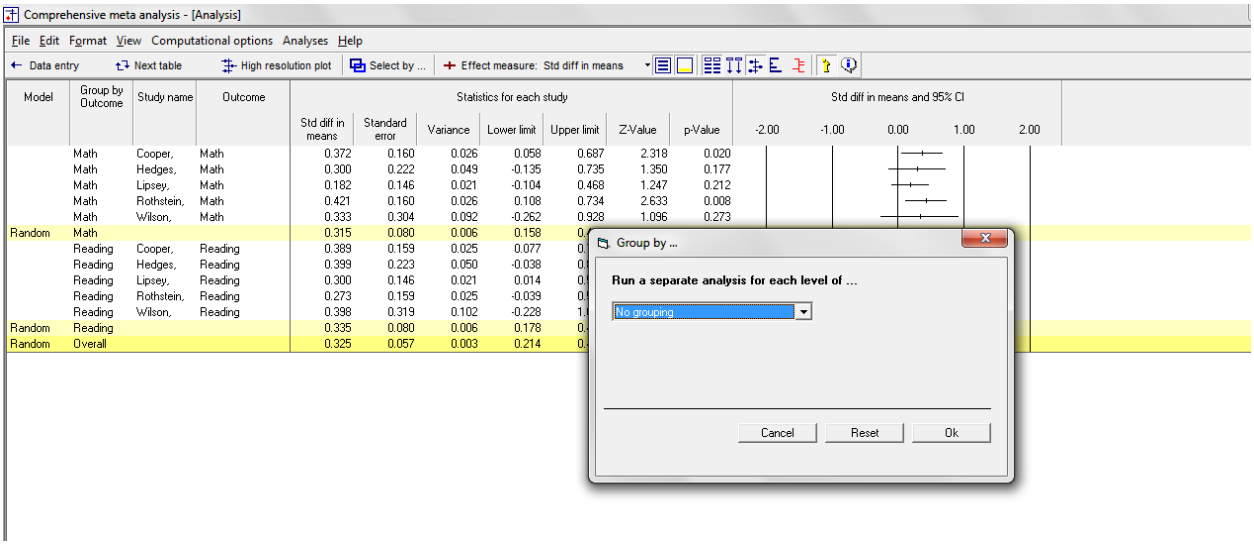
Model	Group by Outcome	Study name	Outcome	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Math	Cooper,	Math	0.372	0.160	0.026	0.058	0.687	2.318	0.020
	Math	Hedges,	Math	0.300	0.222	0.049	-0.135	0.735	1.350	0.177
	Math	Lipsey,	Math	0.182	0.146	0.021	-0.104	0.468	1.247	0.212
	Math	Rothstein,	Math	0.421	0.160	0.026	0.108	0.734	2.633	0.008
	Math	Wilson,	Math	0.333	0.304	0.092	-0.262	0.928	1.096	0.273
Random	Math			0.315	0.080	0.006	0.158	0.472	3.935	0.000
	Reading	Cooper,	Reading	0.389	0.159	0.025	0.077	0.701	2.445	0.014
	Reading	Hedges,	Reading	0.399	0.223	0.050	-0.038	0.836	1.788	0.074
	Reading	Lipsey,	Reading	0.300	0.146	0.021	0.014	0.586	2.053	0.040
	Reading	Rothstein,	Reading	0.273	0.159	0.025	-0.039	0.584	1.717	0.086
	Reading	Wilson,	Reading	0.398	0.319	0.102	-0.228	1.024	1.246	0.213
Random	Reading			0.335	0.080	0.006	0.178	0.492	4.177	0.000
Random	Overall			0.325	0.057	0.003	0.214	0.436	5.736	0.000

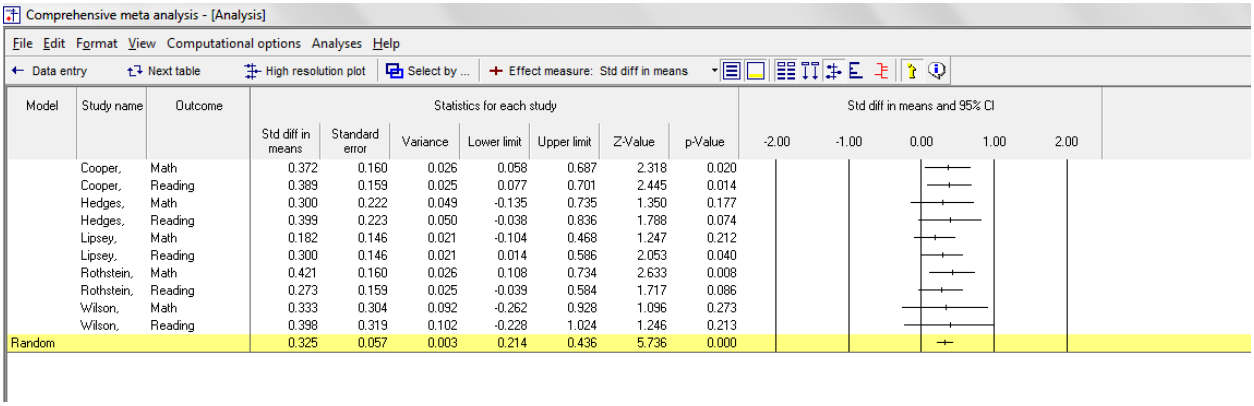
The program now computes the overall effect size. Where the variance for reading was 0.006 and the variance for math was 0.006, the variance for the overall effect is shown as 0.003.

This would be the correct value if the math studies and the reading studies were based on different sets of students, and (it follows) the correlation between the two effect sizes was zero. Indeed, this is the assumption that we made when we said "Assuming independence". However, it's very unlikely that this assumption is valid. To the extent that the true correlation us greater than 0.0, the information provided by math will overlap with the information provided by reading, and the true variance will be greater than 0.003. In the extreme, if the actual correlation is 1.0, the true variance will be 0.006.

As we see here, when we assume independence the program assumes the correlation between effect sizes for math and reading is 0.0. We can also tell the program NOT to treat these as independent, but rather to compute a composite score for each study (using the mean of math and reading), assuming that the correlation between them is 1.0.

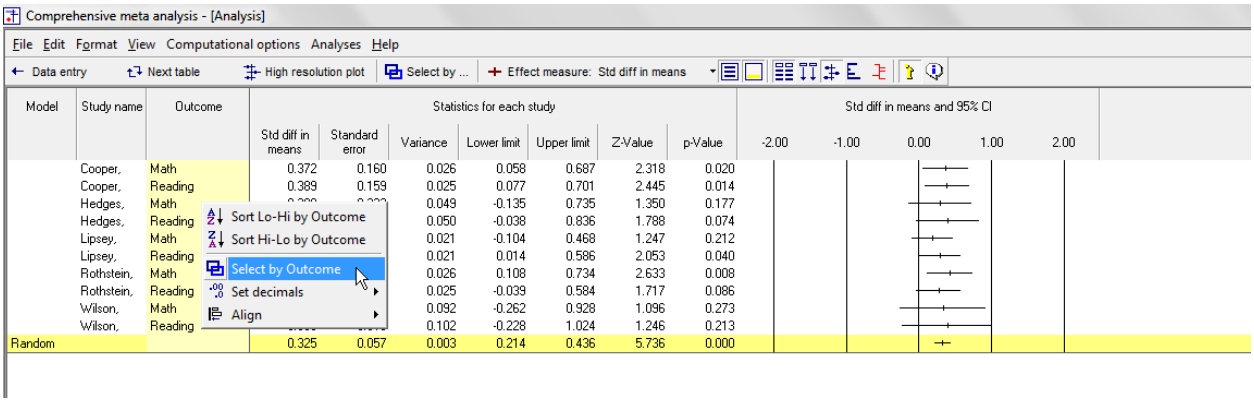
First, turn off grouping





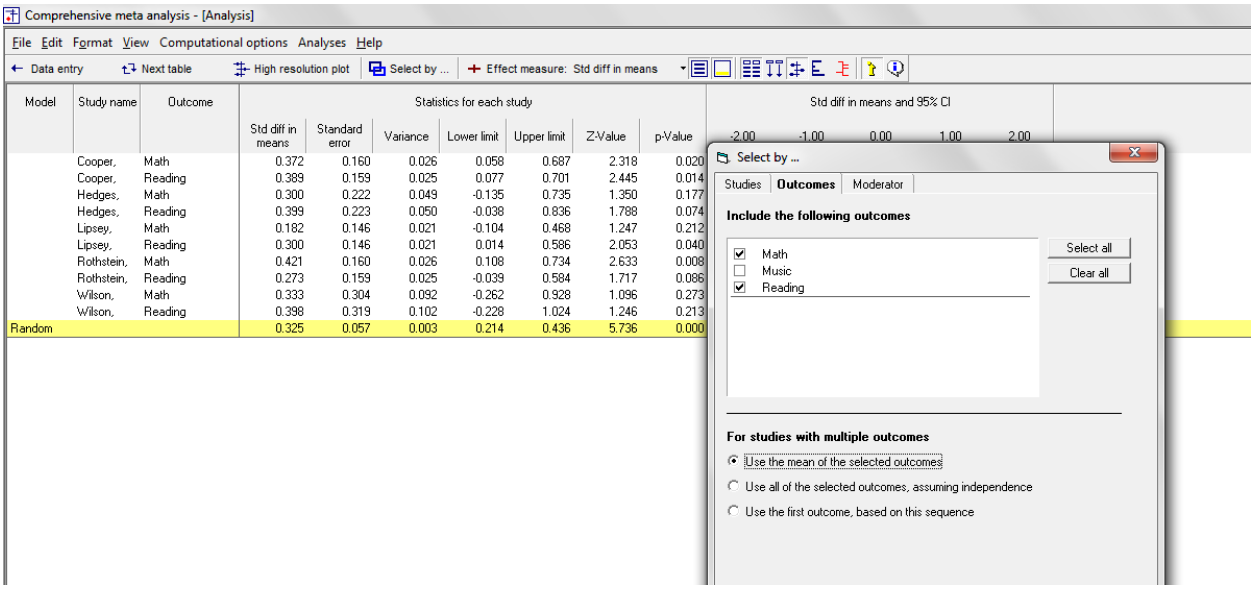
We see that the variance, based on a correlation of zero between effects for math and effects for reading, is still 0.003

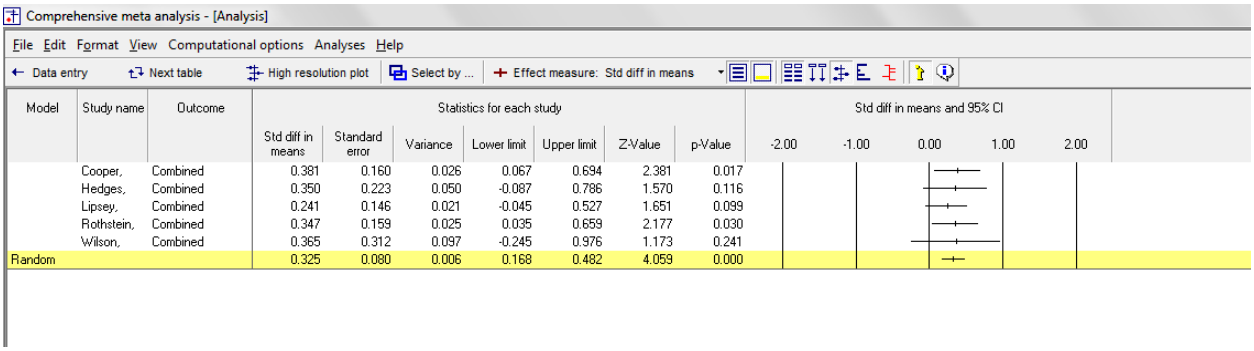
Click Select by Outcome

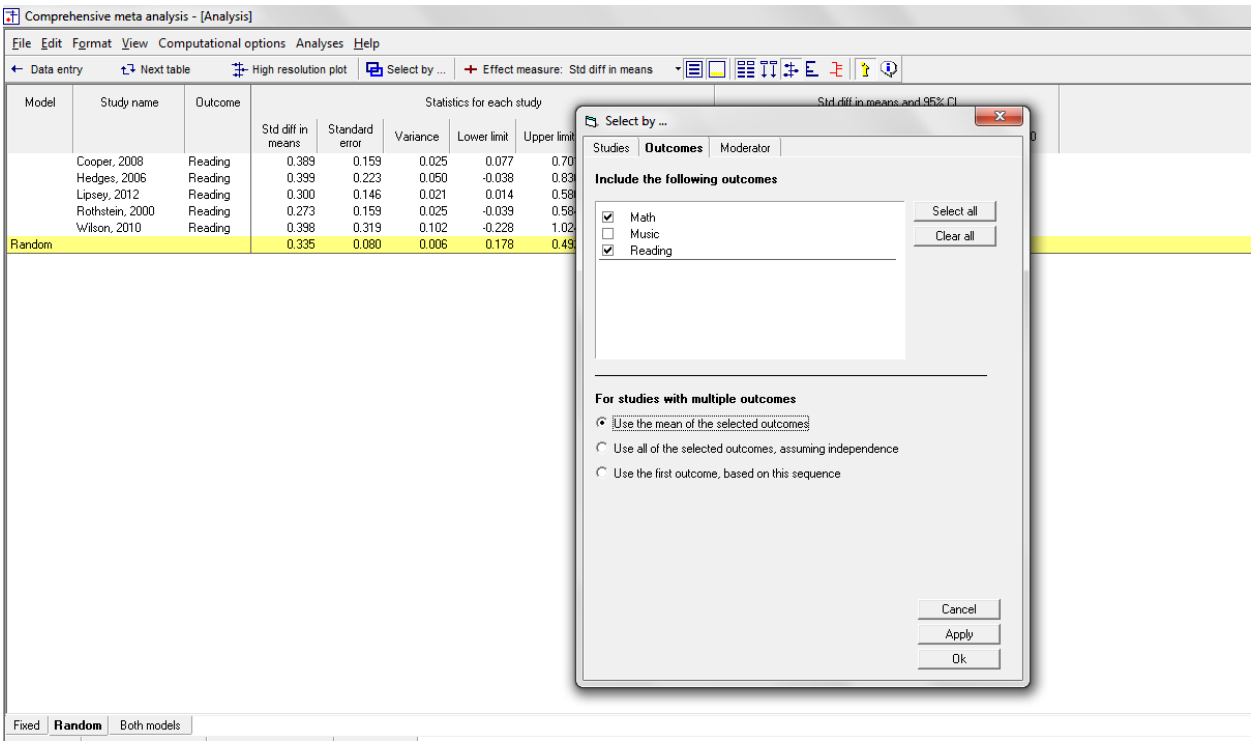


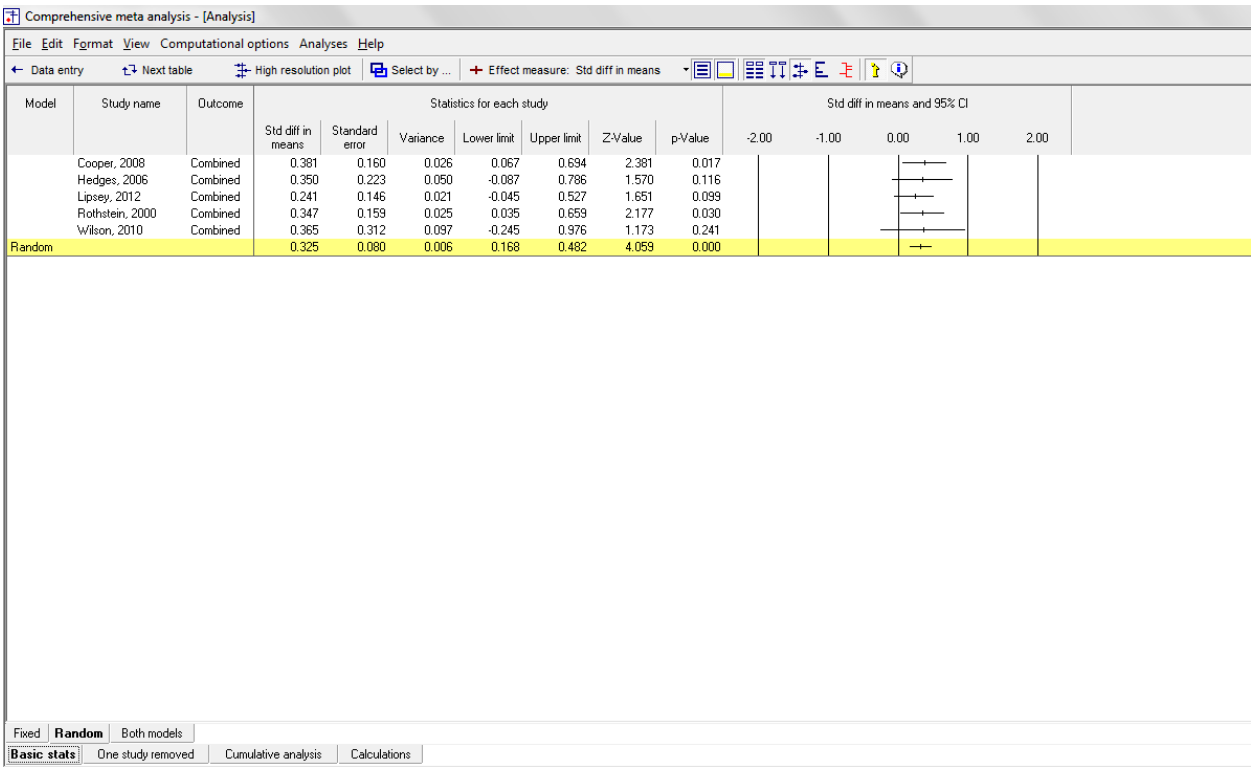
Check math
Check reading
Un-check Music

Select Use the mean of the selected outcomes




Comprehensive meta analysis - [Analysis]
File Edit Format View Computational options Analyses Help
Data entry
Next table
High resolution plot
Select by ...
Effect measure: Std diff in means
Model
Study name
Outcome
Statistics for each study
Std diff in means
Standard error
Variance
Lower limit
Upper limit
Z-Value
p-Value
Std diff in means and 95% CI
-2.00
-1.00
0.00
1.00
2.00
Cooper, Combined 0.381 0.160 0.026 0.067 0.694 2.381 0.017
Hedges, Combined 0.350 0.223 0.050 -0.087 0.786 1.570 0.116
Lipsey, Combined 0.241 0.146 0.021 -0.045 0.527 1.651 0.099
Rothstein, Combined 0.347 0.159 0.025 0.035 0.659 2.177 0.030
Wilson, Combined 0.365 0.312 0.097 -0.245 0.976 1.173 0.241
Random 0.325 0.080 0.006 0.168 0.482 4.059 0.000


Comprehensive meta analysis - [Analysis]
File Edit Format View Computational options Analyses Help
Data entry
Next table
High resolution plot
Select by ...
Effect measure: Std diff in means
Model
Study name
Outcome
Statistics for each study
Std diff in means
Standard error
Variance
Lower limit
Upper limit
Cooper, 2008 Reading 0.389 0.159 0.025 0.077
Hedges, 2006 Reading 0.399 0.223 0.050 -0.038
Lipsey, 2012 Reading 0.300 0.146 0.021 0.014
Rothstein, 2000 Reading 0.273 0.159 0.025 -0.039
Wilson, 2010 Reading 0.398 0.319 0.102 -0.228
Random 0.335 0.080 0.006 0.178
Select by ...
Studies
Outcomes
Moderator
Include the following outcomes
Math
Music
Reading
Select all
Clear all
For studies with multiple outcomes
Use the mean of the selected outcomes
Use all of the selected outcomes, assuming independence
Use the first outcome, based on this sequence
Cancel
Apply
Ok
Fixed
Random
Both models



- The program computes a composite score for each study using the mean of reading and math
- The program assumes that the correlation between reading and math is 1.0, and so the variance of the composite is the same as the variance of either outcome alone
- Therefore, the variance of the summary score is still 0.006

In sum,

If we tell the program to treat effect size for math and reading as independent, the program assumes the correlation between them is 0, which over-estimates the precision of the summary effect (since the correlation is probably higher than 0).

If we tell the program to form a composite for math and reading, the program assumes the correlation between them is 1.0, which under-estimates the precision of the summary effect (since the correlation is probably less than 1.0).

Between the two, it's probably better to use the composite approach. This could be considered the more conservative approach in the sense that it under-estimates the precision.

Also, this approach is likely to yield a pretty good estimate of the correct variance if most studies contribute only one effect size (and a few contribute two), and/or the actual correlation is near 1.0. For example, this would be the case if the different outcomes are scores on various math tests, where some schools use A, others B, others C, others A and B, others B and C, and so on.

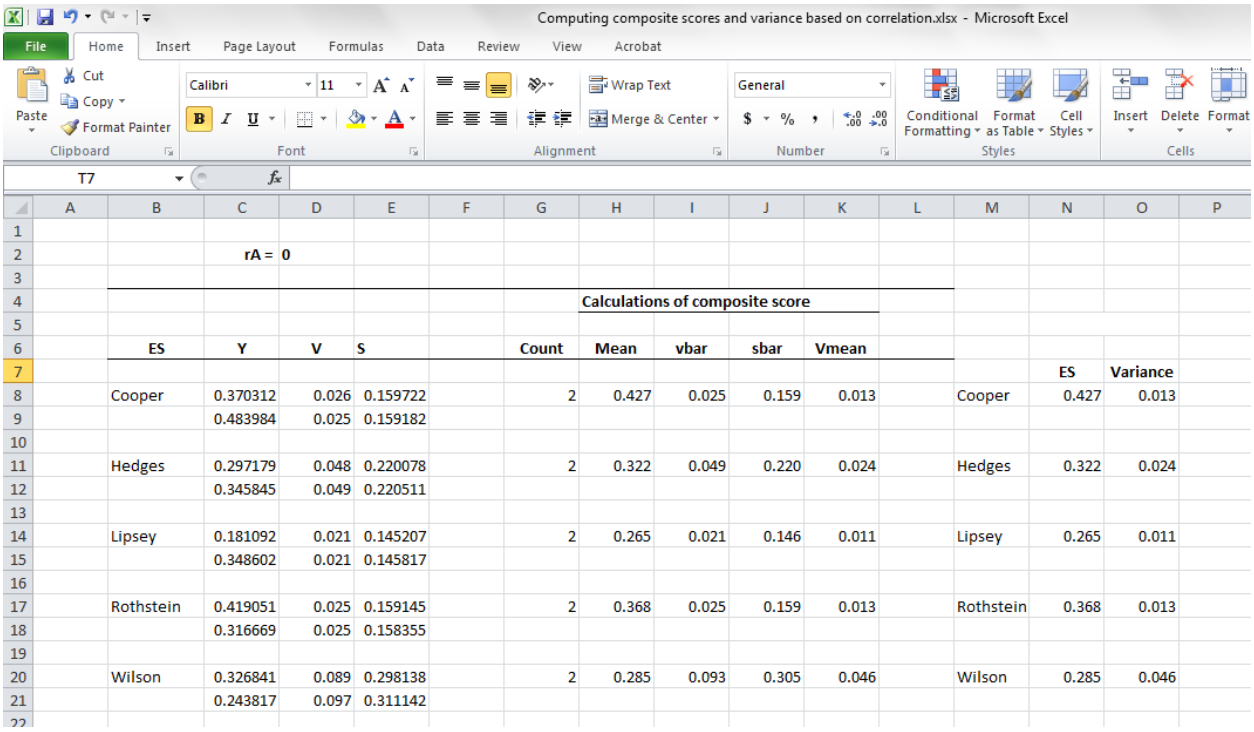
However, there are cases where we want to get the most precise estimate possible for the variance. And, if studies contribute more than two effects and we treat the correlation as 1.0, we will be seriously underestimating the precision of the summary effect size.

In these cases we can step outside CMA, compute composite effects with a variance based on any correlation, and then copy these values back into CMA

While we may not know the actual correlation, this process allows us to use correlations that are more plausible than 0 or 1. For example, if we expect that the correlation falls in the range of 0.50 to 0.80 we may elect to use 0.80 (which yields the highest estimate of the variance), or perhaps 0.75 (which is near the upper end of the range.

The procedure for computing the composite score and variance is as follows

Open the spreadsheet Computing composite score and variance



Computing composite scores and variance based on correlation.xlsx - Microsoft Excel

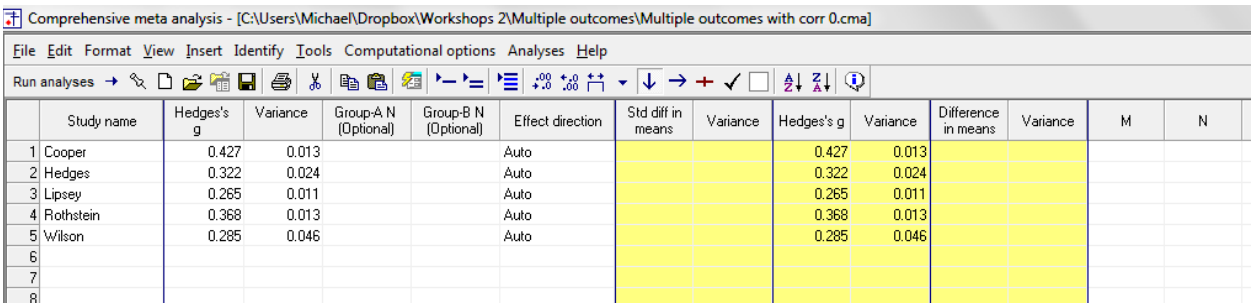
rA = 0

Calculations of composite score

	ES	Y	V	S	Count	Mean	vbar	sbar	Vmean
	Cooper	0.370312	0.026	0.159722	2	0.427	0.025	0.159	0.013
		0.483984	0.025	0.159182					
	Hedges	0.297179	0.048	0.220078	2	0.322	0.049	0.220	0.024
		0.345845	0.049	0.220511					
	Lipsey	0.181092	0.021	0.145207	2	0.265	0.021	0.146	0.011
		0.348602	0.021	0.145817					
	Rothstein	0.419051	0.025	0.159145	2	0.368	0.025	0.159	0.013
		0.316669	0.025	0.158355					
	Wilson	0.326841	0.089	0.298138	2	0.285	0.093	0.305	0.046
		0.243817	0.097	0.311142					

	ES	Variance
Cooper	0.427	0.013
Hedges	0.322	0.024
Lipsey	0.265	0.011
Rothstein	0.368	0.013
Wilson	0.285	0.046

- Enter the correlation between the two effect sizes in cell D2 (Here, 0.0)
- Copy the effect size and variance for each study from CMA to Excel, in columns C and D
- Start a new spreadsheet in CMA and copy the data from columns N and O

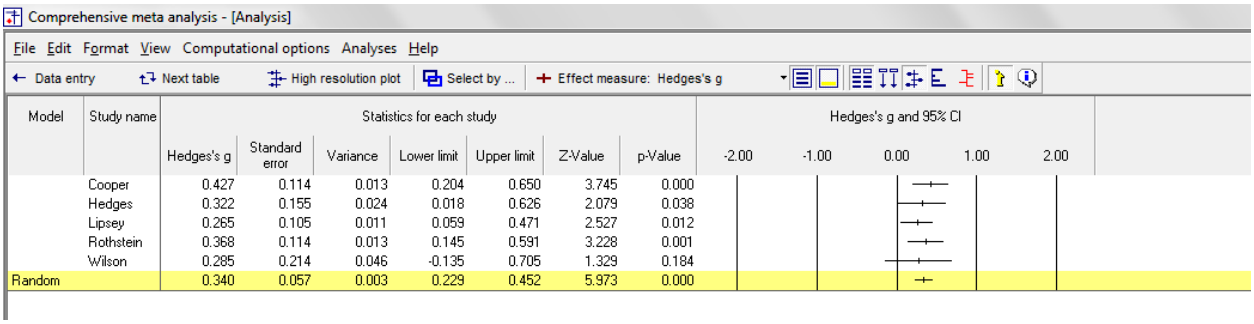


Comprehensive meta analysis - [C:\Users\Michael\Dropbox\Workshops 2\Multiple outcomes\Multiple outcomes with corr 0.cma]

File Edit Format View Insert Identify Tools Computational options Analyses Help

Run analyses

	Study name	Hedges's g	Variance	Group-A N (Optional)	Group-B N (Optional)	Effect direction	Std diff in means	Variance	Hedges's g	Variance	Difference in means	Variance	M	N
1	Cooper	0.427	0.013			Auto			0.427	0.013				
2	Hedges	0.322	0.024			Auto			0.322	0.024				
3	Lipsey	0.265	0.011			Auto			0.265	0.011				
4	Rothstein	0.368	0.013			Auto			0.368	0.013				
5	Wilson	0.285	0.046			Auto			0.285	0.046				
6														
7														
8														



Comprehensive meta analysis - [Analysis]

File Edit Format View Computational options Analyses Help

Data entry | Next table | High resolution plot | Select by ... | Effect measure: Hedges's g

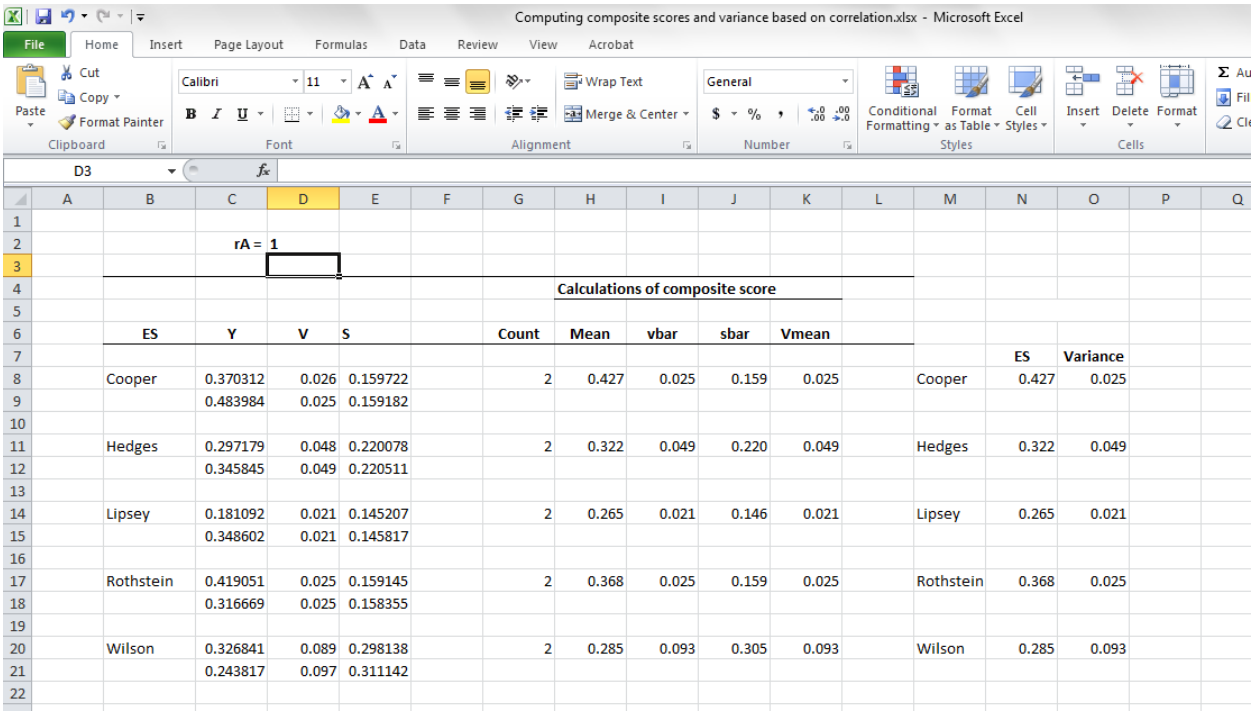
Model	Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Cooper	0.427	0.114	0.013	0.204	0.650	3.745	0.000
	Hedges	0.322	0.155	0.024	0.018	0.626	2.079	0.038
	Lipsey	0.265	0.105	0.011	0.059	0.471	2.527	0.012
	Rothstein	0.368	0.114	0.013	0.145	0.591	3.228	0.001
	Wilson	0.285	0.214	0.046	-0.135	0.705	1.329	0.184
Random		0.340	0.057	0.003	0.229	0.452	5.973	0.000

Statistics for each study

Hedges's g and 95% CI -2.00 -1.00 0.00 1.00 2.00

Here, the correlation was 0.0 and the variance is 0.003

Open the spreadsheet Computing composite score and variance



Computing composite scores and variance based on correlation.xlsx - Microsoft Excel

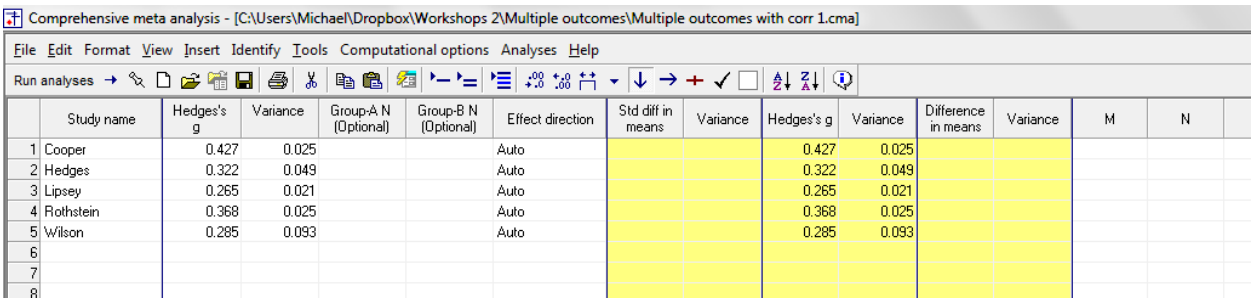
rA = 1

Calculations of composite score

	ES	Y	V	S	Count	Mean	vbar	sbar	Vmean
	Cooper	0.370312	0.026	0.159722	2	0.427	0.025	0.159	0.025
		0.483984	0.025	0.159182					
	Hedges	0.297179	0.048	0.220078	2	0.322	0.049	0.220	0.049
		0.345845	0.049	0.220511					
	Lipsey	0.181092	0.021	0.145207	2	0.265	0.021	0.146	0.021
		0.348602	0.021	0.145817					
	Rothstein	0.419051	0.025	0.159145	2	0.368	0.025	0.159	0.025
		0.316669	0.025	0.158355					
	Wilson	0.326841	0.089	0.298138	2	0.285	0.093	0.305	0.093
		0.243817	0.097	0.311142					

	ES	Variance
Cooper	0.427	0.025
Hedges	0.322	0.049
Lipsey	0.265	0.021
Rothstein	0.368	0.025
Wilson	0.285	0.093

- Enter the correlation between the two effect sizes in cell D2 (Here, 1.0)
- Copy the effect size and variance for each study from CMA to Excel, in columns C and D
- Start a new spreadsheet in CMA and copy the data from columns N and O

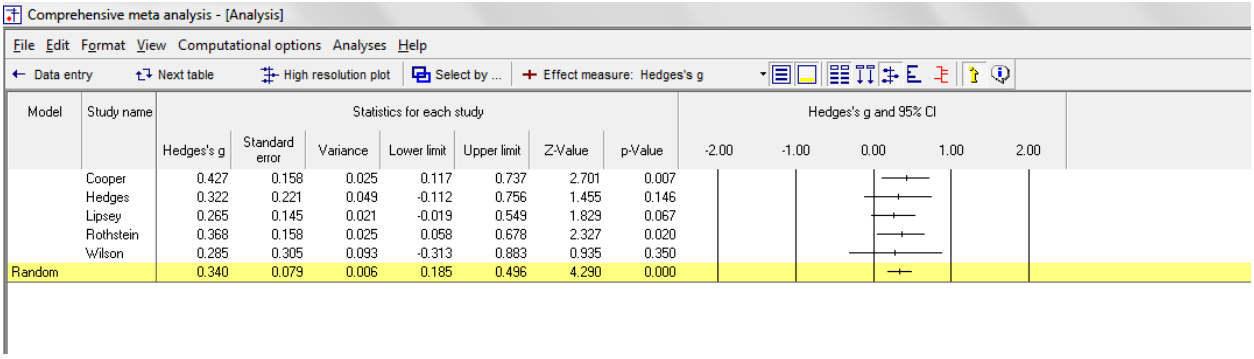


Comprehensive meta analysis - [C:\Users\Michael\Dropbox\Workshops 2\Multiple outcomes\Multiple outcomes with corr 1.cma]

File Edit Format View Insert Identify Tools Computational options Analyses Help

Run analyses

	Study name	Hedges's g	Variance	Group-A N (Optional)	Group-B N (Optional)	Effect direction	Std diff in means	Variance	Hedges's g	Variance	Difference in means	Variance	M	N
1	Cooper	0.427	0.025			Auto			0.427	0.025				
2	Hedges	0.322	0.049			Auto			0.322	0.049				
3	Lipsey	0.265	0.021			Auto			0.265	0.021				
4	Rothstein	0.368	0.025			Auto			0.368	0.025				
5	Wilson	0.285	0.093			Auto			0.285	0.093				
6														
7														
8														



Comprehensive meta analysis - [Analysis]

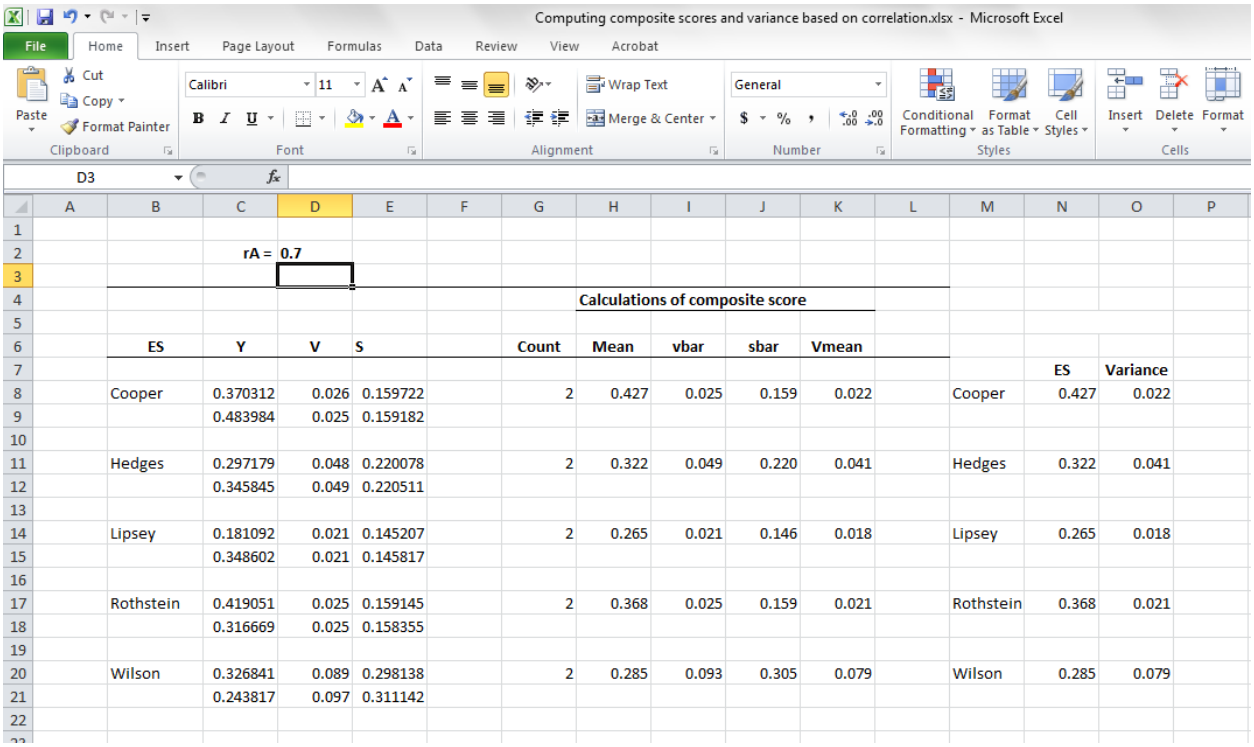
File Edit Format View Computational options Analyses Help

Data entry | Next table | High resolution plot | Select by ... | Effect measure: Hedges's g

Model	Study name	Statistics for each study: Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Hedges's g and 95% CI: -2.00	-1.00	0.00	1.00	2.00
	Cooper	0.427	0.158	0.025	0.117	0.737	2.701	0.007					
	Hedges	0.322	0.221	0.049	-0.112	0.756	1.455	0.146					
	Lipsey	0.265	0.145	0.021	-0.019	0.549	1.829	0.067					
	Rothstein	0.368	0.158	0.025	0.058	0.678	2.327	0.020					
	Wilson	0.285	0.305	0.093	-0.313	0.883	0.935	0.350					
Random		0.340	0.079	0.006	0.185	0.496	4.290	0.000					

Here, the correlation was 1.0 and the variance is 0.006

Open the spreadsheet Computing composite score and variance



Computing composite scores and variance based on correlation.xlsx - Microsoft Excel

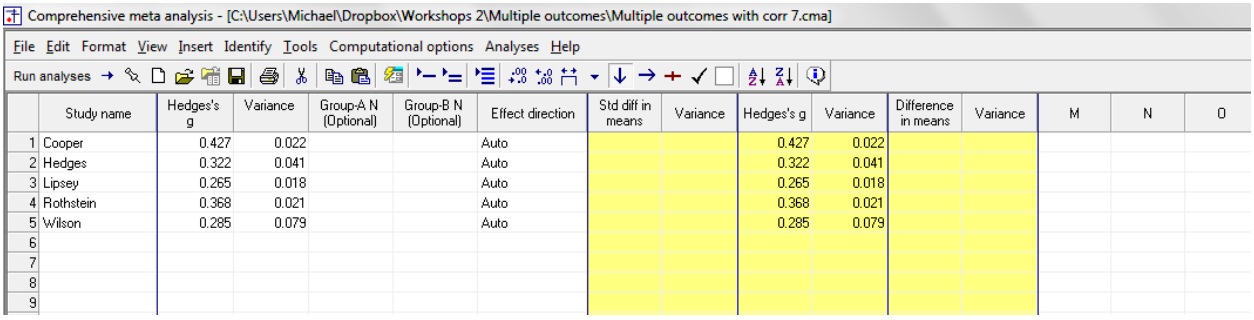
rA = 0.7

Calculations of composite score

	ES	Y	V	S	Count	Mean	vbar	sbar	Vmean
	Cooper	0.370312	0.026	0.159722	2	0.427	0.025	0.159	0.022
		0.483984	0.025	0.159182					
	Hedges	0.297179	0.048	0.220078	2	0.322	0.049	0.220	0.041
		0.345845	0.049	0.220511					
	Lipsey	0.181092	0.021	0.145207	2	0.265	0.021	0.146	0.018
		0.348602	0.021	0.145817					
	Rothstein	0.419051	0.025	0.159145	2	0.368	0.025	0.159	0.021
		0.316669	0.025	0.158355					
	Wilson	0.326841	0.089	0.298138	2	0.285	0.093	0.305	0.079
		0.243817	0.097	0.311142					

	ES	Variance
Cooper	0.427	0.022
Hedges	0.322	0.041
Lipsey	0.265	0.018
Rothstein	0.368	0.021
Wilson	0.285	0.079

- Enter the correlation between the two effect sizes in cell D2 (Here, 0.7)
- Copy the effect size and variance for each study from CMA to Excel, in columns C and D
- Start a new spreadsheet in CMA and copy the data from columns N and O



Comprehensive meta analysis - [C:\Users\Michael\Dropbox\Workshops 2\Multiple outcomes\Multiple outcomes with corr 7.cma]

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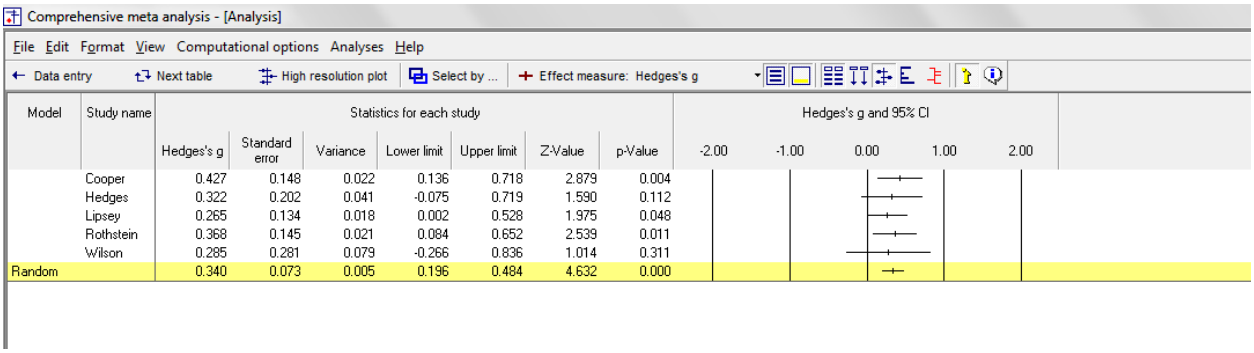
Run analyses

	Study name	Hedges's g	Variance	Group A N (Optional)	Group B N (Optional)	Effect direction	Std diff in means	Variance	Hedges's g	Variance	Difference in means	Variance	M	N	O
1	Cooper	0.427	0.022			Auto			0.427	0.022					
2	Hedges	0.322	0.041			Auto			0.322	0.041					
3	Lipsey	0.265	0.018			Auto			0.265	0.018					
4	Rothstein	0.368	0.021			Auto			0.368	0.021					
5	Wilson	0.285	0.079			Auto			0.285	0.079					
6															
7															
8															
9															



Comprehensive meta analysis - [Analysis]

File Edit Format View Computational options Analyses Help

Data entry | Next table | High resolution plot | Select by ... | Effect measure: Hedges's g

Model	Study name	Statistics for each study: Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Hedges's g and 95% CI: -2.00	-1.00	0.00	1.00	2.00
	Cooper	0.427	0.148	0.022	0.136	0.718	2.879	0.004					
	Hedges	0.322	0.202	0.041	-0.075	0.719	1.590	0.112					
	Lipsey	0.265	0.134	0.018	0.002	0.528	1.975	0.048					
	Rothstein	0.368	0.145	0.021	0.084	0.652	2.539	0.011					
	Wilson	0.285	0.281	0.079	-0.266	0.836	1.014	0.311					
Random		0.340	0.073	0.005	0.196	0.484	4.632	0.000					

Here, the correlation was 1.0 and the variance is 0.005

So it turns out in this case that the variance was not too much larger if we assumed a correlation of 1.0 rather than 0.70, but (as outlined earlier) this will not always be the case.

A similar situation exists if we want to assess the difference between effect sizes for math and reading. We would assume independence, group by outcome, and test the difference.

However, there is a critical difference here. When we compute an overall effect, the higher correlation yields largest variance for the overall effect. By contrast, when we compute a difference, the lower correlation yield the largest variance for the difference.

Thus, for computing an overall effect the composite (with a correlation of 1.0) is the "conservative" estimate. By contrast, for the difference, "Assuming independence" is the "conservative" estimate.