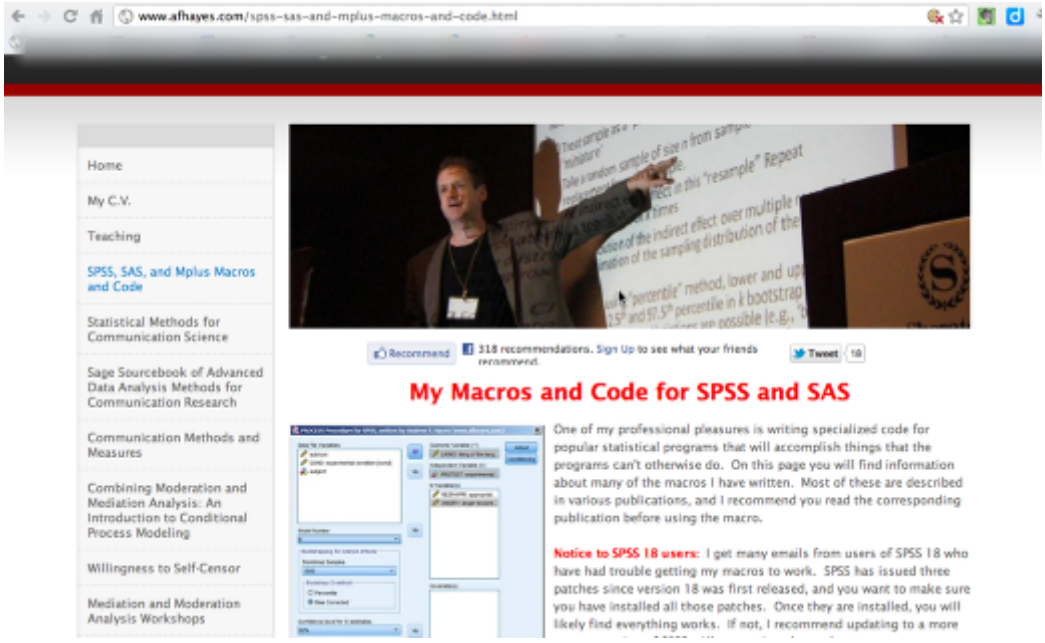
The macros used in this tip sheet can be found at the following website

http://www.afhayes.com/spss-sas-and-mplus-macros-and-code.html

To fully understand this approach you should also read the accompanying paper:

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. Behavior Research Methods, 40, 879-891. Link to PDF on Hayes website



Also see Hayes's Facebook page

For this example we will use the INDIRECT Macro

Download the SPSS macro to your computer
You should also download the documentation (Indirect.pdf) for additional information
There is another tipsheet for simple mediation models HERE

INDIRECT

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. ***Behavior Research Methods, 40,*** **879-891.** PDF.

This macro for SPSS and SAS estimates the path coefficients in a multiple mediator model and generates bootstrap confidence intervals (percentile, bias-corrected, and bias-corrected and accelerated) for total and specific indirect effects of *X* on *Y* through a one or more mediator variable(s) *M*. This is macro is far superior to SOBEL, as it allows for more than one mediator and adjusts all paths for the potential influence of covariates not proposed to be mediators in the model. Since the macro was originally published, many improvements have been made to the SPSS version, including the ability to estimate models with dichotomous outcomes.

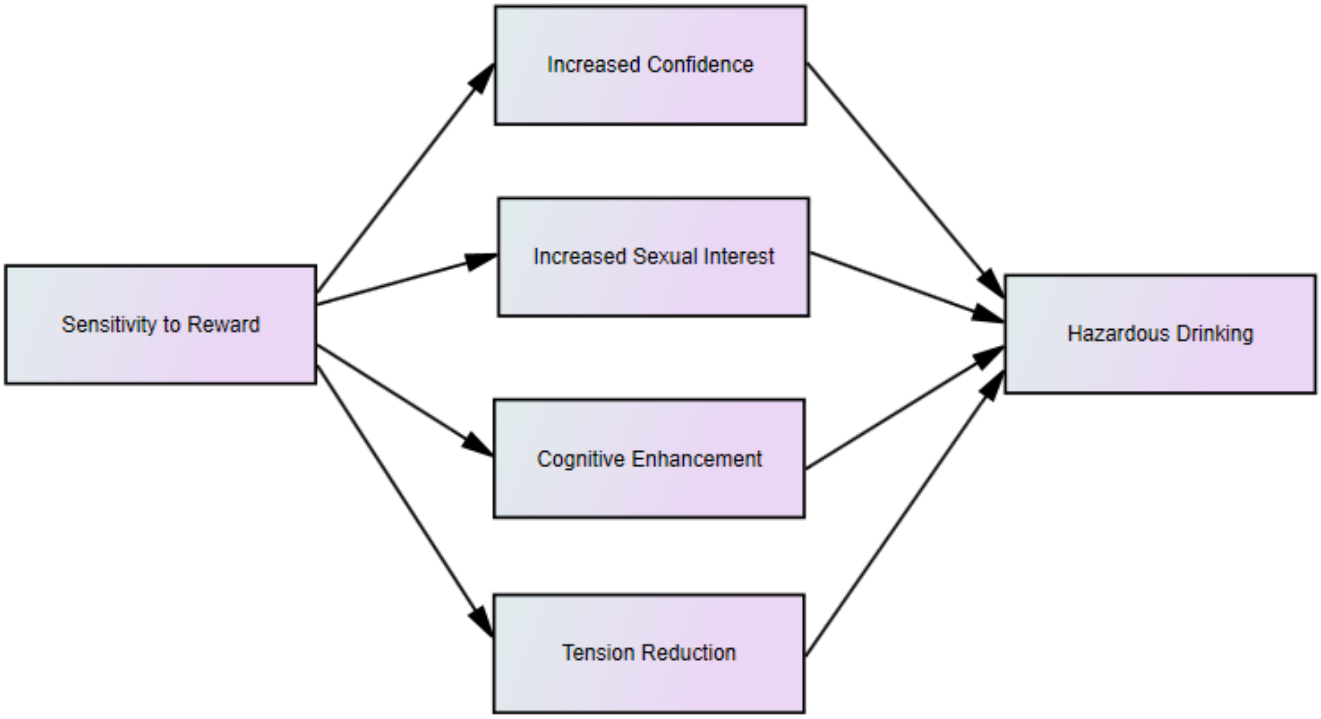
There have been some improvements to the SPSS version of INDIRECT since the 2008 paper was published. Among the new features include **the ability to estimate models with a dichotomous outcome (*Y*) variable** and the implementation of a faster algorithm for generating bootstrap confidence intervals that greatly speeds up the generation of output.

Please read the download instructions at the top of this page.

SPSS Version
Documentation: indirect.pdf
Macro: indirect.sps
Script: indirect.sbs
Custom Dialog: indirect.spd

Let's test this model

In this hypothesised model (based on a subsample of real data) the effect of the personality trait of Reward Sensitivity (measured using the Sensitivity to Reward scale) on Hazardous Drinking (measured using the AUDIT) occurs via Positive Alcohol Expectancies, namely the expectation that drinking increases ones confidence, increases sexual interest, enhances cognitive functioning and reduces tension (measured using the Drinking Expectancy Questionnaire). We want to test whether the indirect effect occurs for the whole model (e.g., global positive expectancies of drinking) and/or specific expectancies.

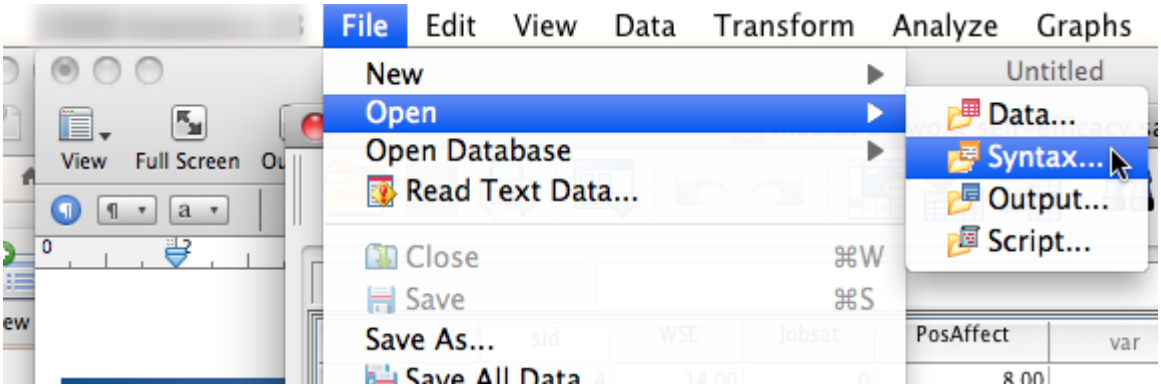


The dataset can be accessed HERE
Note the variable names that map onto the SPSS file

ID	sex	age	SR	Confidence	Sex_Interest	Cog_Enhance	Tension	HazDrink
1.00	1	21	17.00	58.00	15.00	3.00	15.00	28.00
2.00	0	23	14.00	47.00	14.00	7.00	9.00	11.00
3.00	1	18	10.00	43.00	9.00	6.00	6.00	7.00
5.00	1	19	10.00	33.00	9.00	9.00	8.00	3.00
6.00	1	17	8.00	41.00	11.00	6.00	11.00	1.00
7.00	1	35	14.00	43.00	13.00	8.00	12.00	16.00
8.00	1	17	8.00	45.00	11.00	7.00	8.00	2.00
9.00	0	21	12.00	48.00	13.00	4.00	7.00	17.00
10.00	1	19	17.00	51.00	15.00	5.00	14.00	24.00
11.00	0	18	13.00	42.00	12.00	8.00	7.00	12.00
12.00	1	22	14.00	28.00	9.00	7.00	5.00	1.00
13.00	1	20	15.00	31.00	9.00	7.00	5.00	2.00
14.00	1	20	4.00	27.00	5.00	10.00	5.00	1.00
15.00	0	18	13.00	51.00	12.00	3.00	9.00	13.00
16.00	1	20	7.00	48.00	13.00	4.00	10.00	14.00
17.00	1	18	13.00	39.00	7.00	7.00	4.00	3.00

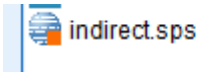
1) Run the Macro (Indirect)

Macros are very similar to syntax files and are run as such:
Open the file via the "Open Syntax" option

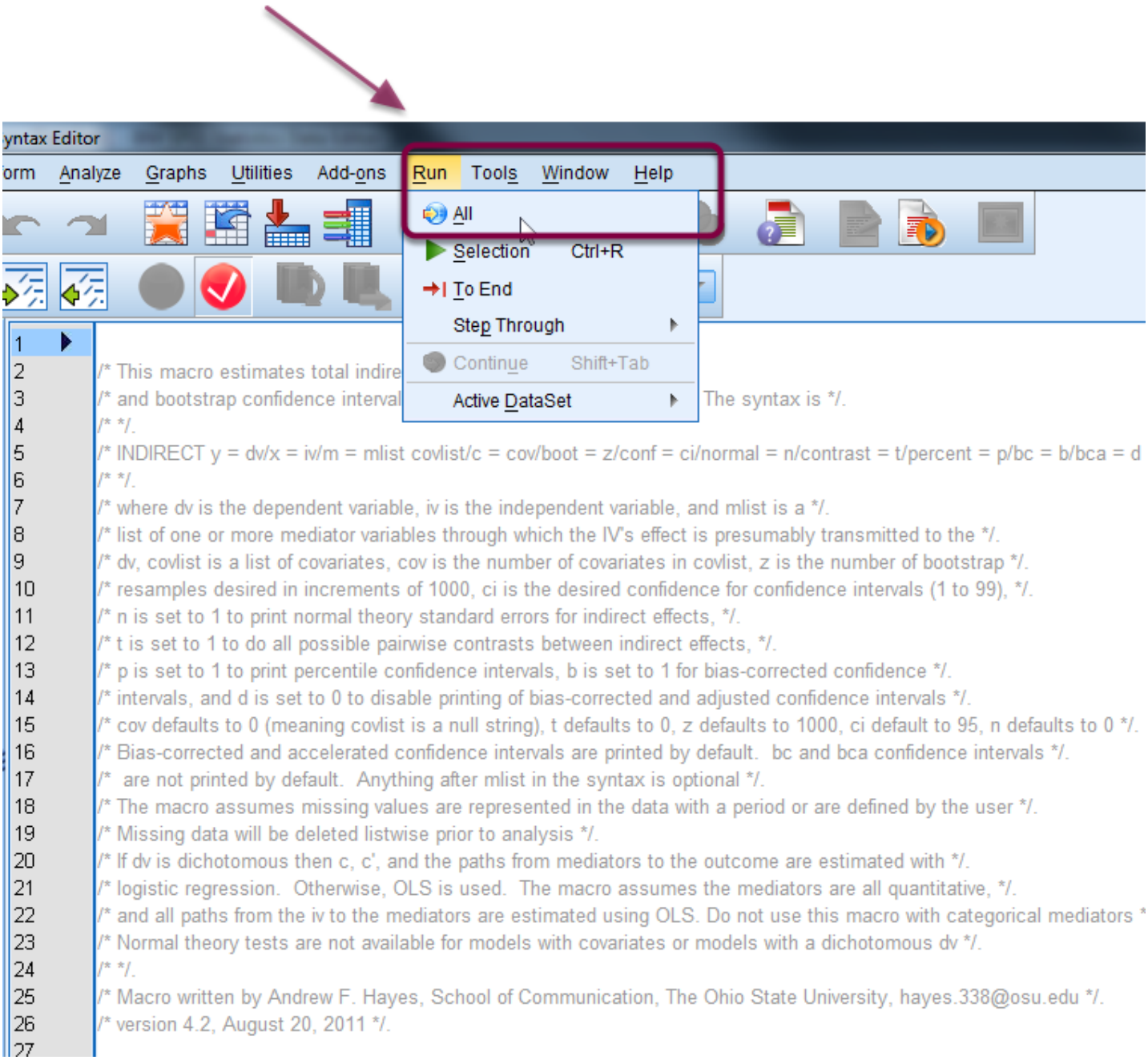


Make sure to select the file "indirect.SPS"

This is the file you downloaded from the Hayes website



Select "Run...All"
This activates the macro (which runs in the background)
You can close the macro file if you wish - this will stay in the background until you either restart SPSS or load a different macro



2) Set up your model in another syntax file

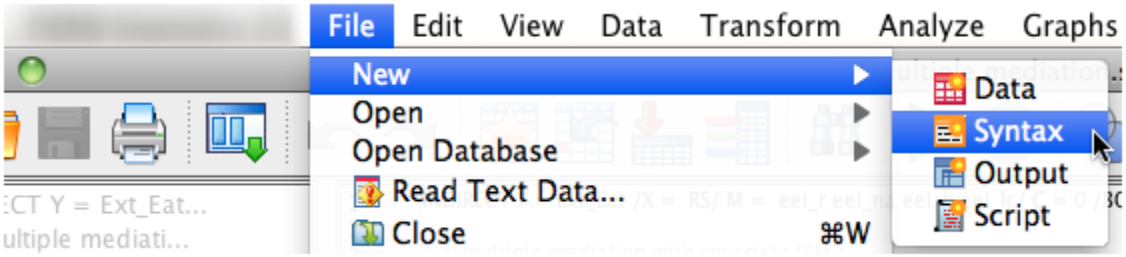
In this step you need to tell the macro which of your variables are the IV, DV and Mediators.
To do this you need to create a new syntax file and set up your model using this template:

INDIRECT Y = DV/X = IV/M = MV1 MV2...MVk/CONTRAST = 1/CONF = 95/PERCENT = 1/ BOOT = 5000.

This is the syntax for the example model:

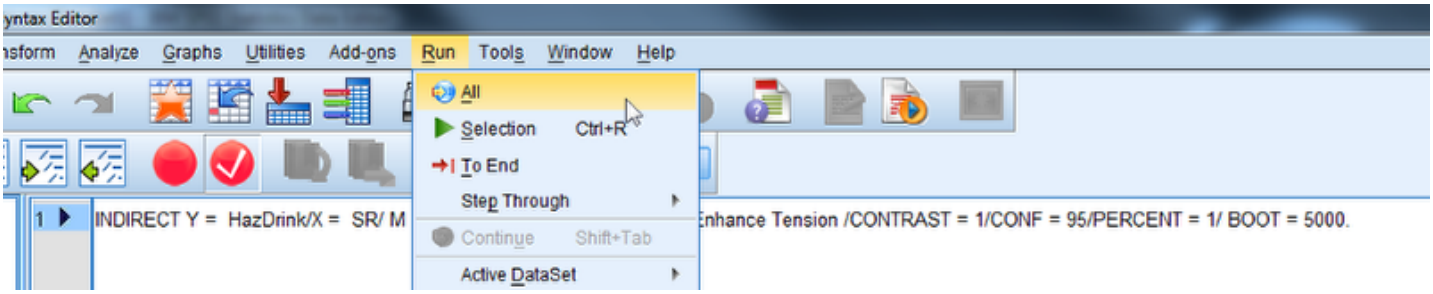
INDIRECT Y = HazDrink/X = SR/ M = Confidence Sex_Interest Cog_Enhance Tension /CONTRAST = 1/CONF = 95/PERCENT = 1/ BOOT = 5000.

Note, that the syntax can be set to test the indirect effects using the Sobel test (not recommended) and/or Bias-corrected CIs (recommended). This example is set to calculate 95% Bias-corrected CIs



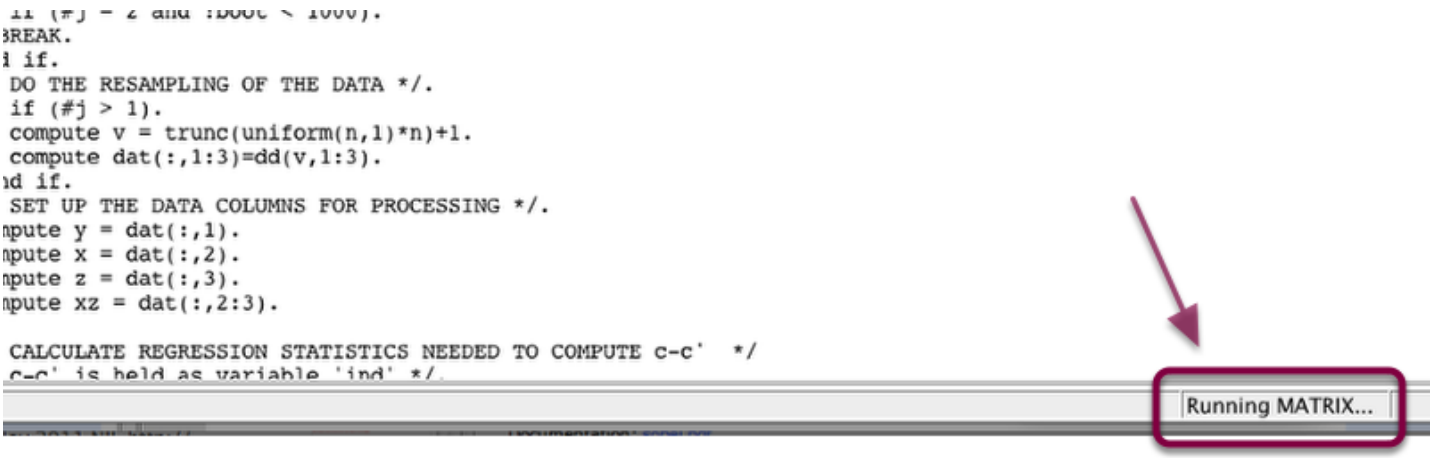
Run this syntax

Note the "boot = 5000"
This is the part of the syntax that tells SPSS to draw 5000 sample indirect effects (with replacement) using your sample data as the "population" of possible indirect effects



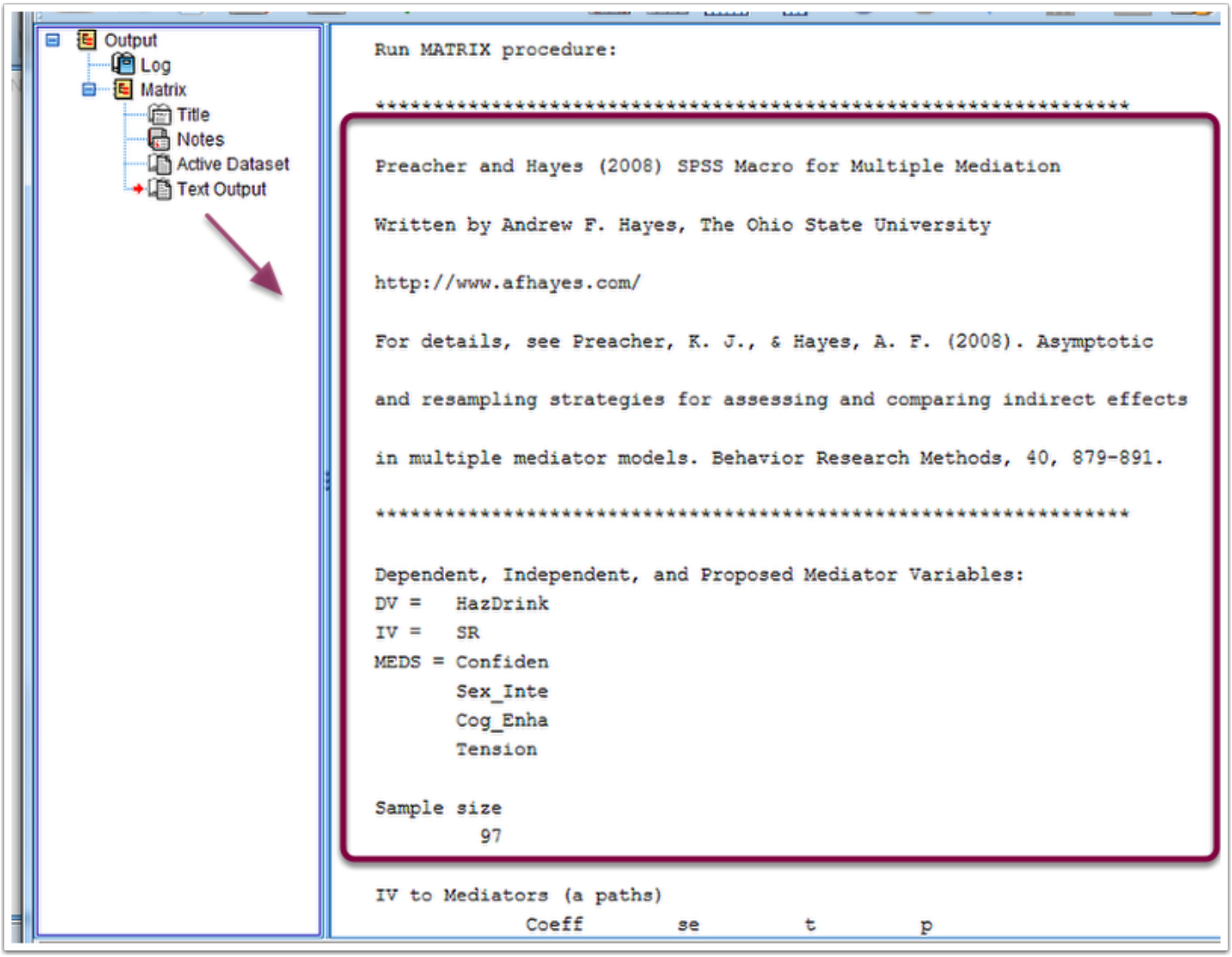
The macro will now run to test your model

Note. This can take a little while as this is performing rather complex equations
To check if the program is still running you will see a little "Running MATRIX" in the bottom right



3). Interpret the output

By default the initial macro will be recorded in the output file (ignore this and scroll to the bottom of the output file)



Total and Direct Effects output

This part of the output provides the significance tests of the DIRECT EFFECTS :

1) "a" path (IV to MedVs)
- the path from SR to Confidence Expectancy is significant p = .0234
- the path from SR to Sexual Interest Expectancy is significant p = .0093
- the path from SR to Cognitive Enhancement is not significant p = .9088
- the path from SR to Confidence Expectancy is not significant p = .5882

2) "b" path (MedVs to DV, controlling for the IV)
- the path from Confidence Expectancy to HazDrink is significant p = .0001
- the path from Sexual Interest Expectancy to HazDrink is not significant p = .1775
- the path from Cognitive Enhancement to HazDrink is not significant p = .7888
- the path from Confidence Expectancy to HazDrink is significant p = .0072

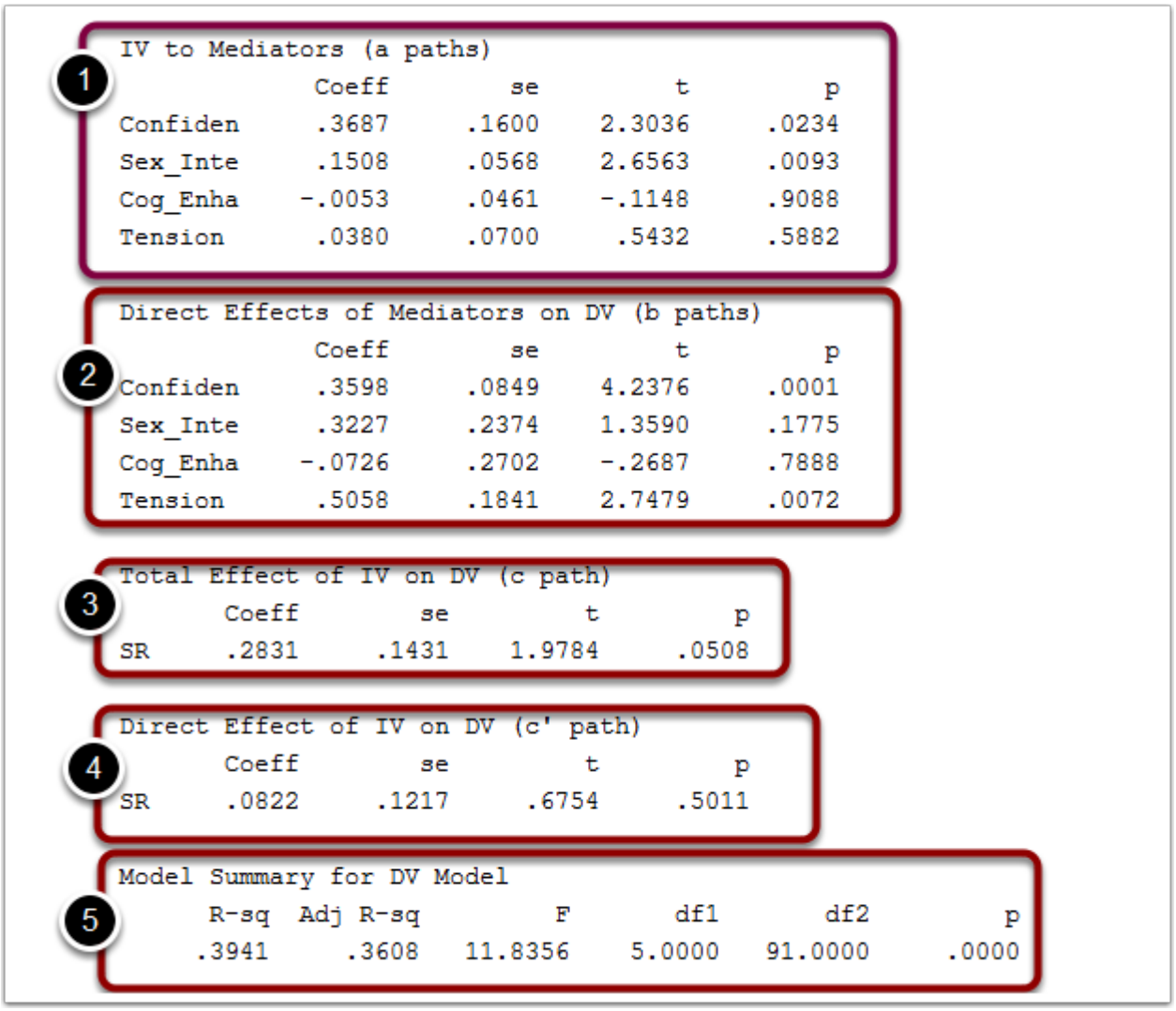
3) "c" path (IV to DV without the MedVs, aka the Total effect) - in this example not significant (just) p = .0508

4) "c' " path (IV to DV, controlling for the MedVs, aka the Direct effect) - in this example non-significant p = .5159

5) R square = .3941 is the amount of variance in the DV (i.e., Hazardous drinking) accounted from by the IV and MedVs

So, this model has met all the criteria for mediation according to Baron and Kenny (1986) - although note that the IV-DV total effect criteria is no longer necessary (see related papers at the end of this tipsheet)

Note - These coefficients are the **Unstandardised weights**



1

IV to Mediators (a paths)

	Coeff	se	t	p
Confiden	.3687	.1600	2.3036	.0234
Sex_Inte	.1508	.0568	2.6563	.0093
Cog_Enha	-.0053	.0461	-.1148	.9088
Tension	.0380	.0700	.5432	.5882

2

Direct Effects of Mediators on DV (b paths)

	Coeff	se	t	p
Confiden	.3598	.0849	4.2376	.0001
Sex_Inte	.3227	.2374	1.3590	.1775
Cog_Enha	-.0726	.2702	-.2687	.7888
Tension	.5058	.1841	2.7479	.0072

3

Total Effect of IV on DV (c path)

	Coeff	se	t	p
SR	.2831	.1431	1.9784	.0508

4

Direct Effect of IV on DV (c' path)

	Coeff	se	t	p
SR	.0822	.1217	.6754	.5011

5

Model Summary for DV Model

R-sq	Adj R-sq	F	df1	df2	p
.3941	.3608	11.8356	5.0000	91.0000	.0000

INDIRECT effects output

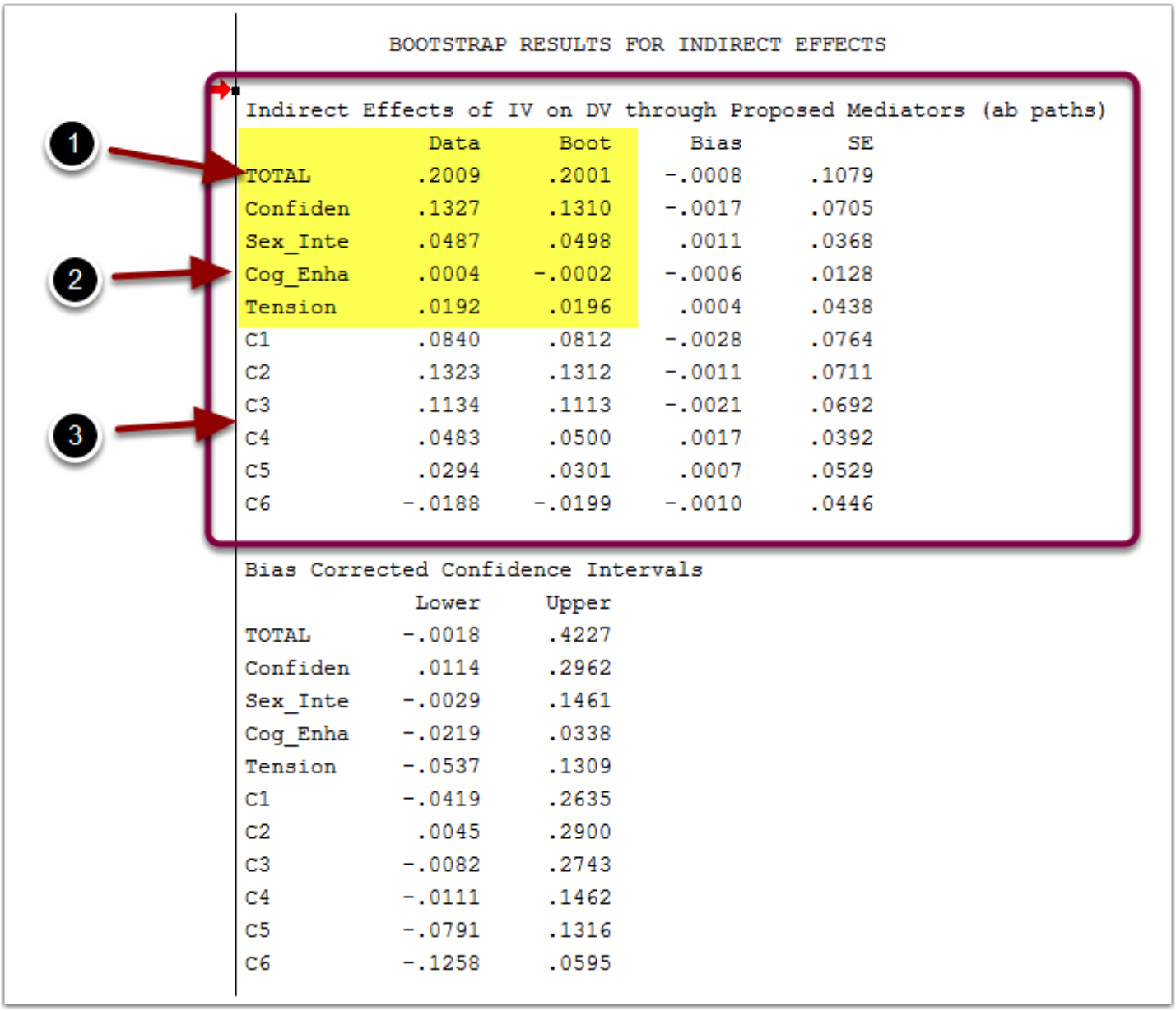
The output provides the indirect effects (simply path a X path b) for the Total effect and each mediator

1) Provides the indirect effect for ALL the Mediators as a group

2) Provides the indirect effect of EACH mediator (controlling for the other mediators)

3) C1 to C6 are the contrasts of the four indirect effects against the others (tests whether one or more of the indirect effects are stronger than the others)

Note: The "Boot" column is the estimate of the mean true indirect effect in the underlying population (this is usually very close to the indirect effect calculated from the sample data). The parameter more of interest is the standard error of the indirect effect (which skewed as we are calculating the standard error of a cross-product - a*b.) So, we next examine the confidence intervals that provide a range of possible true indirect effects in the population.



BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)

	Data	Boot	Bias	SE
TOTAL	.2009	.2001	-.0008	.1079
Confiden	.1327	.1310	-.0017	.0705
Sex_Inte	.0487	.0498	.0011	.0368
Cog_Enha	.0004	-.0002	-.0006	.0128
Tension	.0192	.0196	.0004	.0438
C1	.0840	.0812	-.0028	.0764
C2	.1323	.1312	-.0011	.0711
C3	.1134	.1113	-.0021	.0692
C4	.0483	.0500	.0017	.0392
C5	.0294	.0301	.0007	.0529
C6	-.0188	-.0199	-.0010	.0446

Bias Corrected Confidence Intervals

	Lower	Upper
TOTAL	-.0018	.4227
Confiden	.0114	.2962
Sex_Inte	-.0029	.1461
Cog_Enha	-.0219	.0338
Tension	-.0537	.1309
C1	-.0419	.2635
C2	.0045	.2900
C3	-.0082	.2743
C4	-.0111	.1462
C5	-.0791	.1316
C6	-.1258	.0595

Bootstrapped tests of the INDIRECT effects

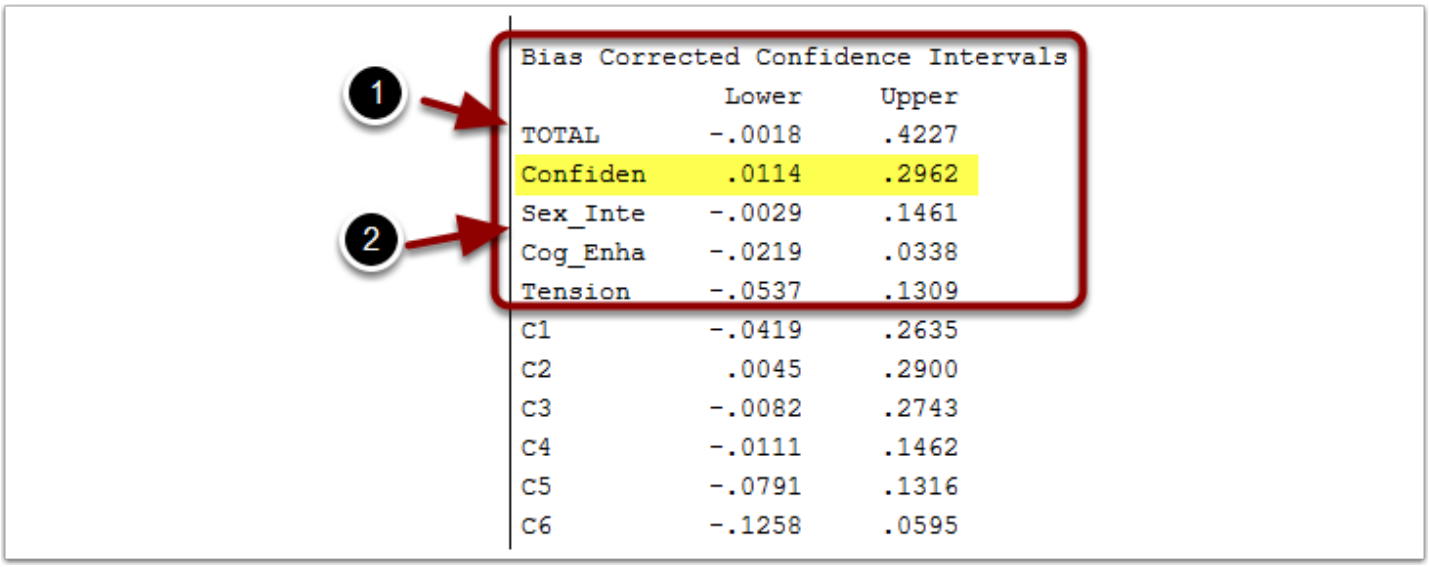
The output provides the 95% Bias corrected bootstrapped confidence interval

Here we are looking to see if ZERO (0) lies within the interval range
Note that LL = Lower Limit (or the lower boundary) and UL = Upper Limit (or upper boundary) of the Confidence interval.
Essentially we are asking whether it is possible (with 95% confidence) that the TRUE indirect effect would be ZERO (basically, no mediation).

1) Total effect
In this case the TRUE TOTAL indirect effect is 95% likely to range from -.0018 to .4227 - the estimated effect is .2001 (lying in between these two values)
If (as in this case) zero does occur between the LL and the UL then we can conclude that the TOTAL indirect effect is not significant

2) Individual mediator indirect effects
In this case the TRUE indirect effect VIA CONFIDENCE is 95% likely to range from 0114 to .2962 - the estimated effect is .1310 (lying in between these two values)
If (as in this case) zero does NOT occur between the LL and the UL then we can conclude that the indirect effect for this mediator is significant
Looking at the remaining mediators we can see that all of them have CIs that include ZERO and therefore are not significant

Note: these estimates will change each time the syntax is run due to the bootstrapping procedure using different random samples from the sample.



Bias Corrected Confidence Intervals		
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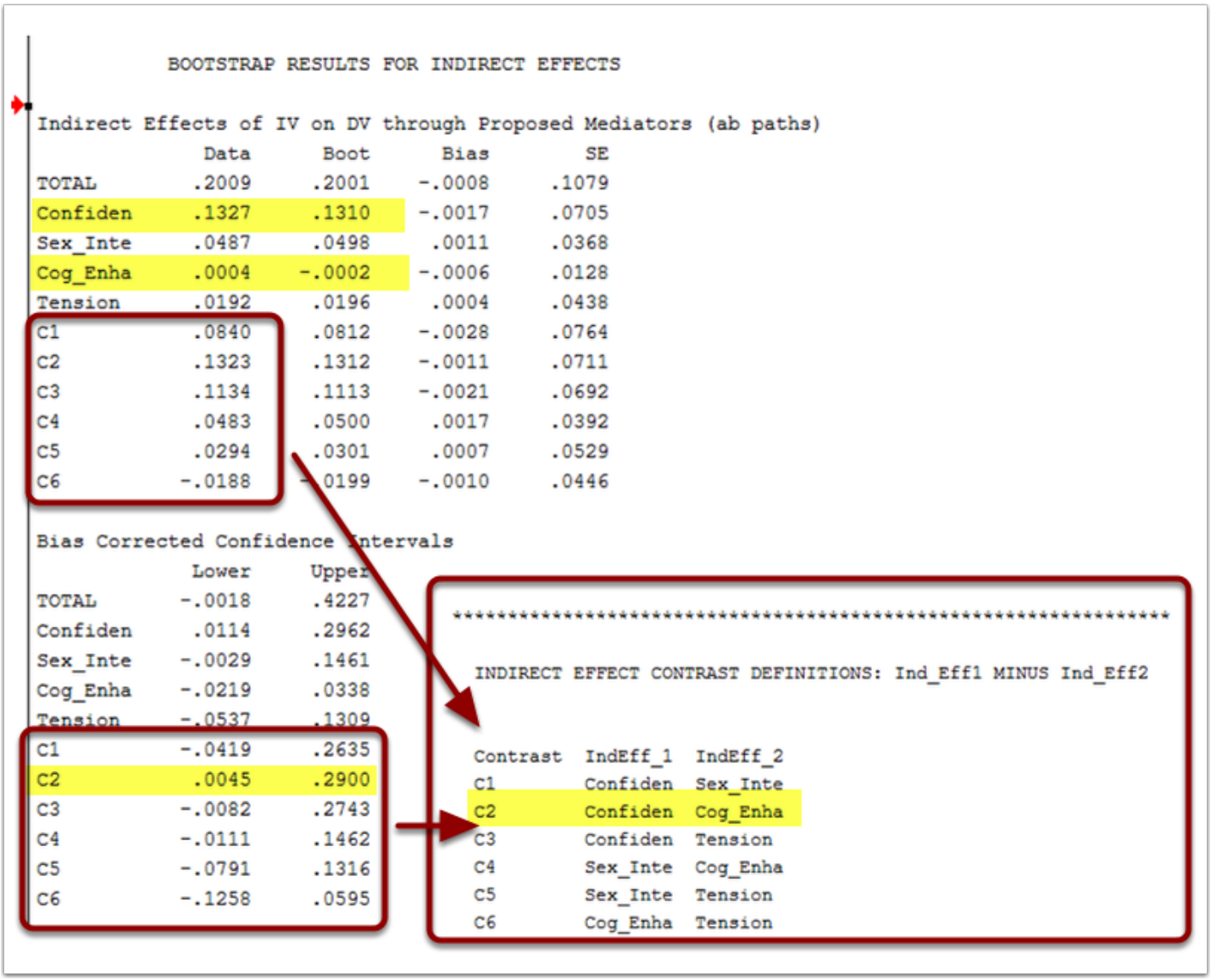
C2	.0045	.2900
C3	-.0082	.2743
C4	-.0111	.1462
C5	-.0791	.1316
C6	-.1258	.0595

Comparing the strength of indirect effects

Finally we can compare the strength of the individual indirect effects against each other.
In this case there are six possible pairwise contrasts between the four indirect effects. These are specified at the very end of the output.
Again, CIs that DO NOT contain ZERO represent significant contrasts. In this case, only C2 indicates significant differences in the strength of the indirect effects. The indirect effect via CONFIDENCE is greater than the effect via COGNITIVE ENHANCEMENT

It should be noted that the sam[ple in this dataset is small (*n* = 97) and thus the power to detect significant contrasts is low.



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Confiden	.0114	.2962
Sex_Inte	-.0029	.1461
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C1	-.0419	.2635
C2	.0045	.2900
C3	-.0082	.2743
C4	-.0111	.1462
C5	-.0791	.1316
C6	-.1258	.0595

****

INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2

Contrast	IndEff_1	IndEff_2
C1	Confiden	Sex_Inte
C2	Confiden	Cog_Enha
C3	Confiden	Tension
C4	Sex_Inte	Cog_Enha
C5	Sex_Inte	Tension
C6	Cog_Enha	Tension

Interpretation

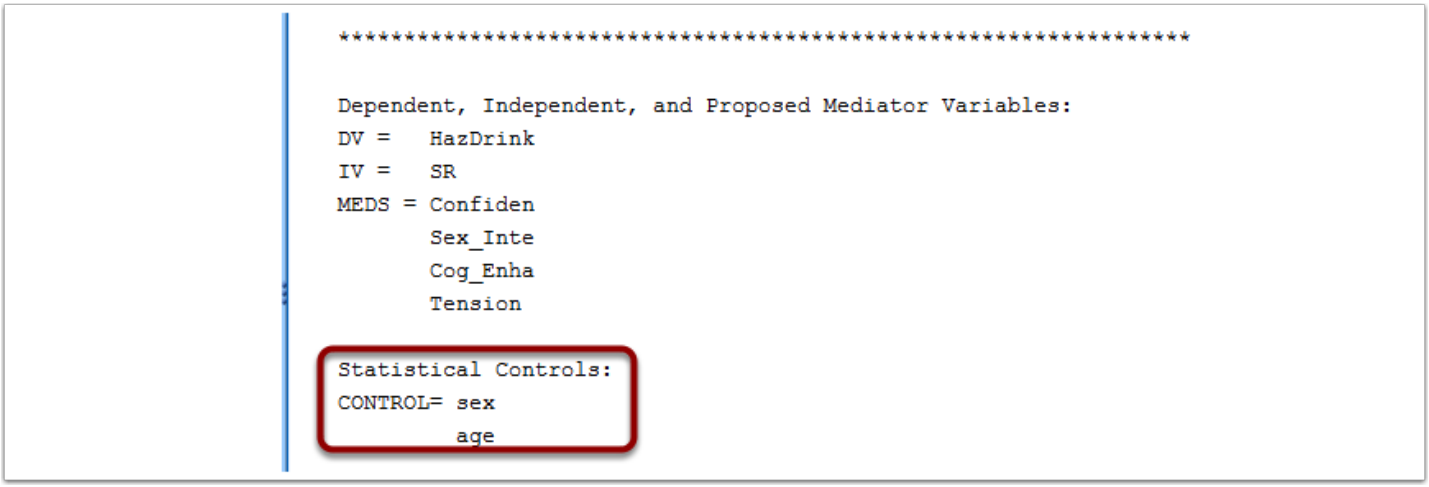
We can conclude that only CONFIDENCE mediates the effect of Reward Sensitivity on Hazardous Drinking.
The reader should note that the TOTAL indirect effect was not significant and is referred to the original paper for a discussion of interpreting individual indirect effects in the absence of a significant total effect.

Additional Issues: Adding covariates

You can also include covariates by adding them to the model syntax like so (I've highlighted the extra syntax in BOLD:

INDIRECT Y = HazDrink/X = SR/ M = Confidence Sex_Interest Cog_Enhance Tension **sex age/C = 2**/CONTRAST = 1/CONF = 95/PERCENT = 1/ BOOT = 5000.

This part of the syntax has now added the two covariates of interest "sex" and "age" and then told the INDIRECT macro that the last two variables in the model are covariates (not Mediating Vars). As such, all covariates must be added to the end of the variable list. You can see this in the output created from this syntax (don't forget that you need to have run the INDIRECT.SPS macro first)



```
************************************************************************

Dependent, Independent, and Proposed Mediator Variables:
DV =   HazDrink
IV =   SR
MEDS = Confiden
       Sex_Inte
       Cog_Enha
       Tension

Statistical Controls:
CONTROL= sex
         age
```

There's no effect of either covariate on the DV so possibly best not to include in the model (lose degrees of freedom - and thus power - if leave them in). I only include covariates if there are associated with the DV

```
Partial Effect of Control Variables on DV
        Coeff         se          t          p
sex    -.0125     1.5984     -.0078     .9938
age    -.1203      .1103    -1.0911     .2782
```

There's also very little change to our previous results or interpretation

BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)

	Data	Boot	Bias	SE
TOTAL	.2009	.2001	-.0008	.1079
Confiden	.1327	.1310	-.0017	.0705
Sex_Inte	.0487	.0498	.0011	.0368
Cog_Enha	.0004	-.0002	-.0006	.0128
Tension	.0192	.0196	.0004	.0438
C1	.0840	.0812	-.0028	.0764
C2	.1323	.1312	-.0011	.0711
C3	.1134	.1113	-.0021	.0692
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C5	.0294	.0301	.0007	.0529
C6	-.0188	-.0199	-.0010	.0446

Bias Corrected Confidence Intervals

	Lower	Upper
TOTAL	-.0018	.4227
Confiden	.0114	.2962
Sex_Inte	-.0029	.1461
Cog_Enha	-.0219	.0338
Tension	-.0537	.1309
C1	-.0419	.2635
C2	.0045	.2900
C3	-.0082	.2743
C4	-.0111	.1462
C5	-.0791	.1316
C6	-.1258	.0595

Results including covariates

Indirect Effects of IV on DV through Proposed Mediators

	Data	Boot	Bias	SE
TOTAL	.1989	.1975	-.0014	.1098
Confiden	.1202	.1193	-.0010	.0677
Sex_Inte	.0553	.0557	.0004	.0378
Cog_Enha	.0002	-.0006	-.0009	.0127
Tension	.0231	.0232	.0000	.0456
C1	.0649	.0636	-.0014	.0738
C2	.1200	.1199	-.0001	.0683
C3	.0971	.0961	-.0010	.0634
C4	.0551	.0563	.0013	.0405
C5	.0322	.0326	.0004	.0544
C6	-.0229	-.0238	-.0009	.0467

Bias Corrected Confidence Intervals

	Lower	Upper
TOTAL	-.0080	.4176
Confiden	.0120	.2815
Sex_Inte	.0025	.1554
Cog_Enha	-.0237	.0300
Tension	-.0570	.1306
C1	-.0600	.2415
C2	.0068	.2777
C3	-.0131	.2414
C4	-.0061	.1577
C5	-.0875	.1329
C6	-.1258	.0638

Additional Issues: Using a Drop-down menu style script

The alternative approach to writing syntax for this specific macro is to use the very user-friendly "Script" provided on the Hayes website

INDIRECT

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. ***Behavior Research Methods, 40,*** **879-891.** PDF.

This macro for SPSS and SAS estimates the path coefficients in a multiple mediator model and generates bootstrap confidence intervals (percentile, bias-corrected, and bias-corrected and accelerated) for total and specific indirect effects of *X* on *Y* through a one or more mediator variable(s) *M*. This is macro is far superior to SOBEL, as it allows for more than one mediator and adjusts all paths for the potential influence of covariates not proposed to be mediators in the model. Since the macro was originally published, many improvements have been made to the SPSS version, including the ability to estimate models with dichotomous outcomes.

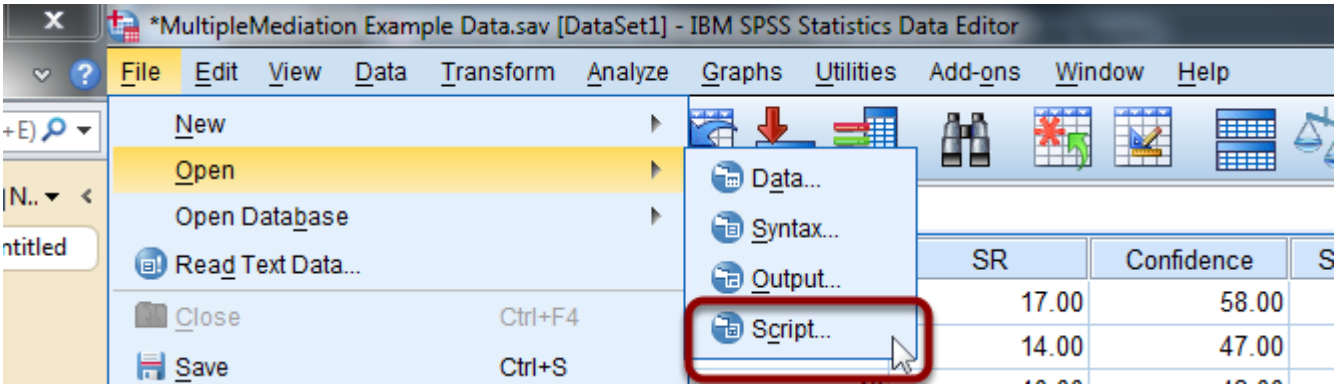
There have been some improvements to the SPSS version of INDIRECT since the 2008 paper was published. Among the new features include **the ability to estimate models with a dichotomous outcome (*Y*) variable** and the implementation of a faster algorithm for generating bootstrap confidence intervals that greatly speeds up the generation of output.

Please read the download instructions at the top of this page.

SPSS Version
Documentation: indirect.pdf
Macro: indirect.sps
Script: indirect.sbs
Custom Dialog: indirect.spd

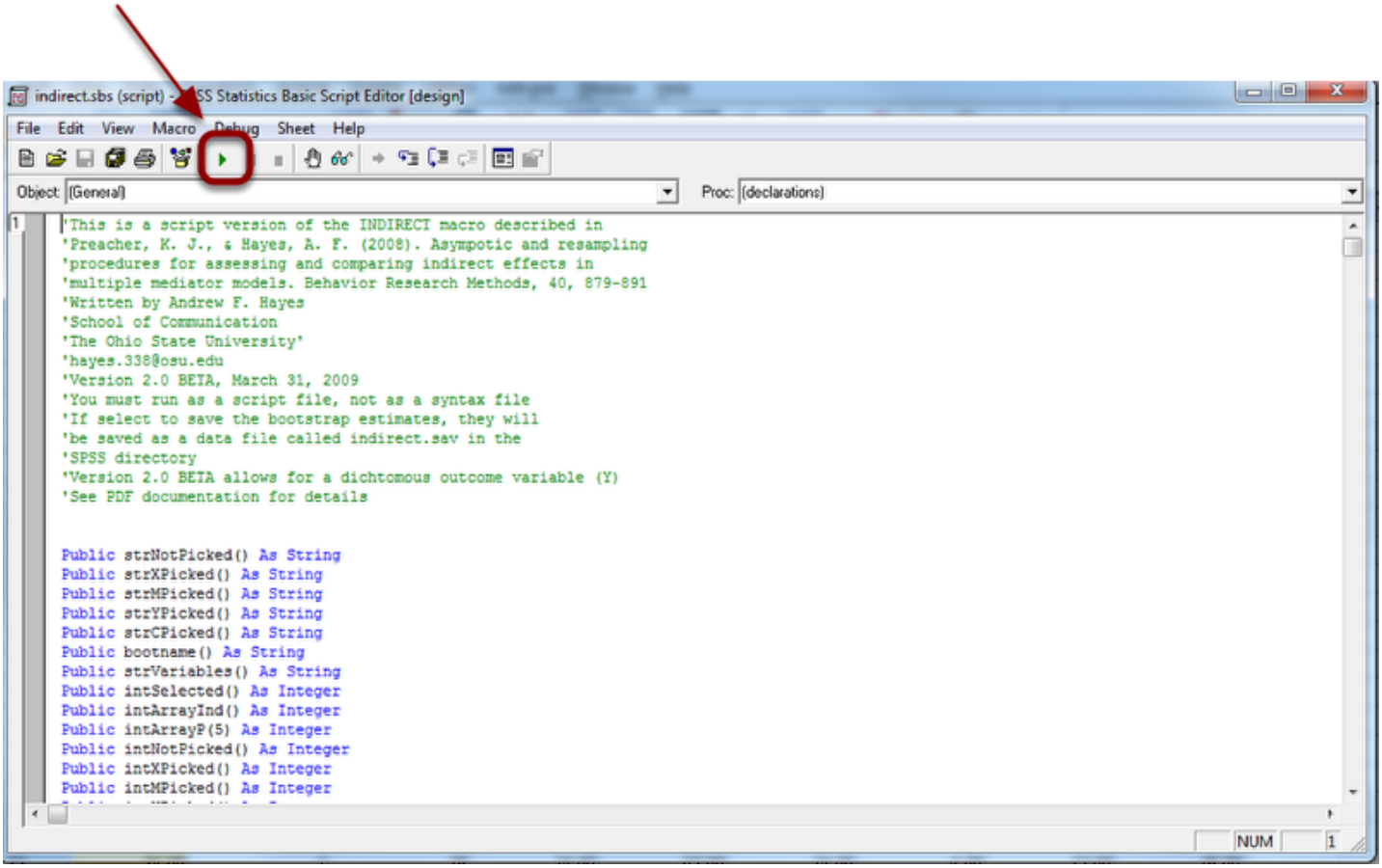
Run the SCRIPT (Indirect)

Open the file (Indirect.sbs) via the "Open Script" option



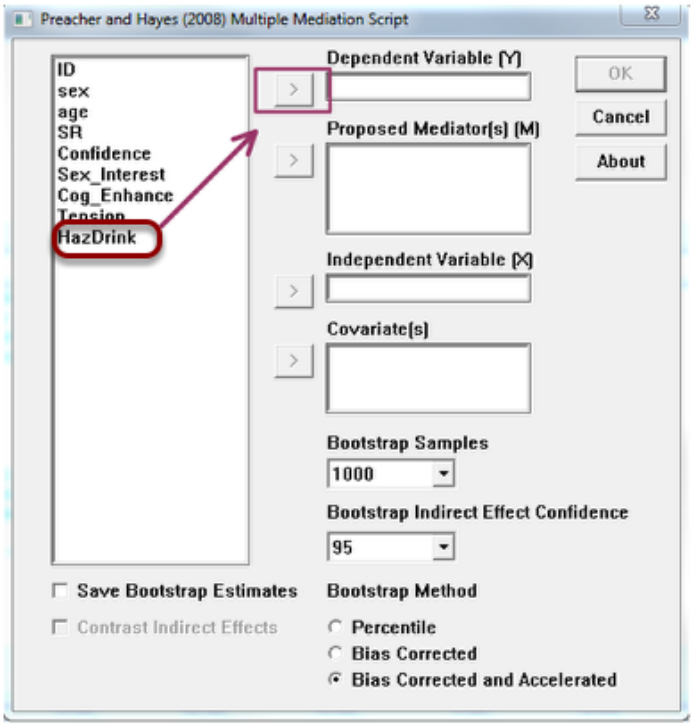
This will open another window to run the script

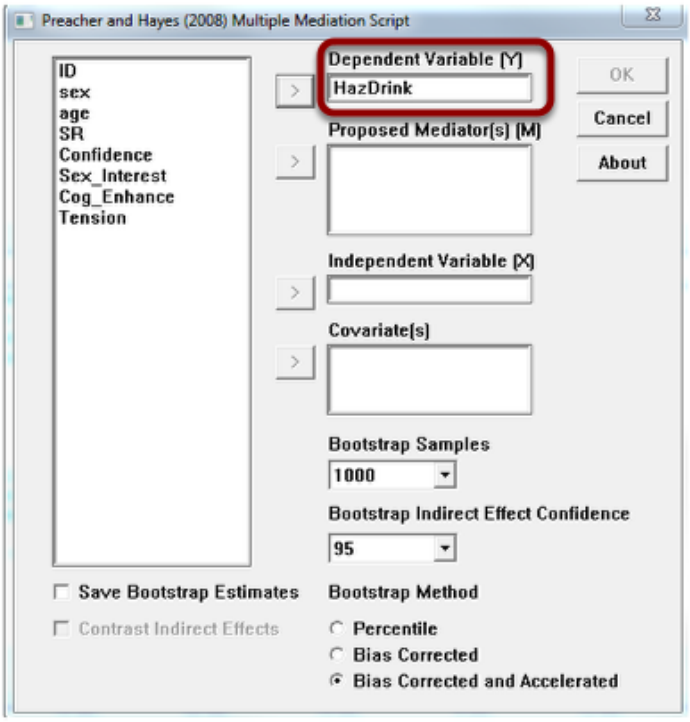
Simply press the "Run" button



Now you can enter all your variables of interest

Just add the relevant variables from the variable list by clicking on the variable name and then the ">" button at the appropriate box. E.g., below we have added the Hazardous Drinking variable to the DV (Y) box





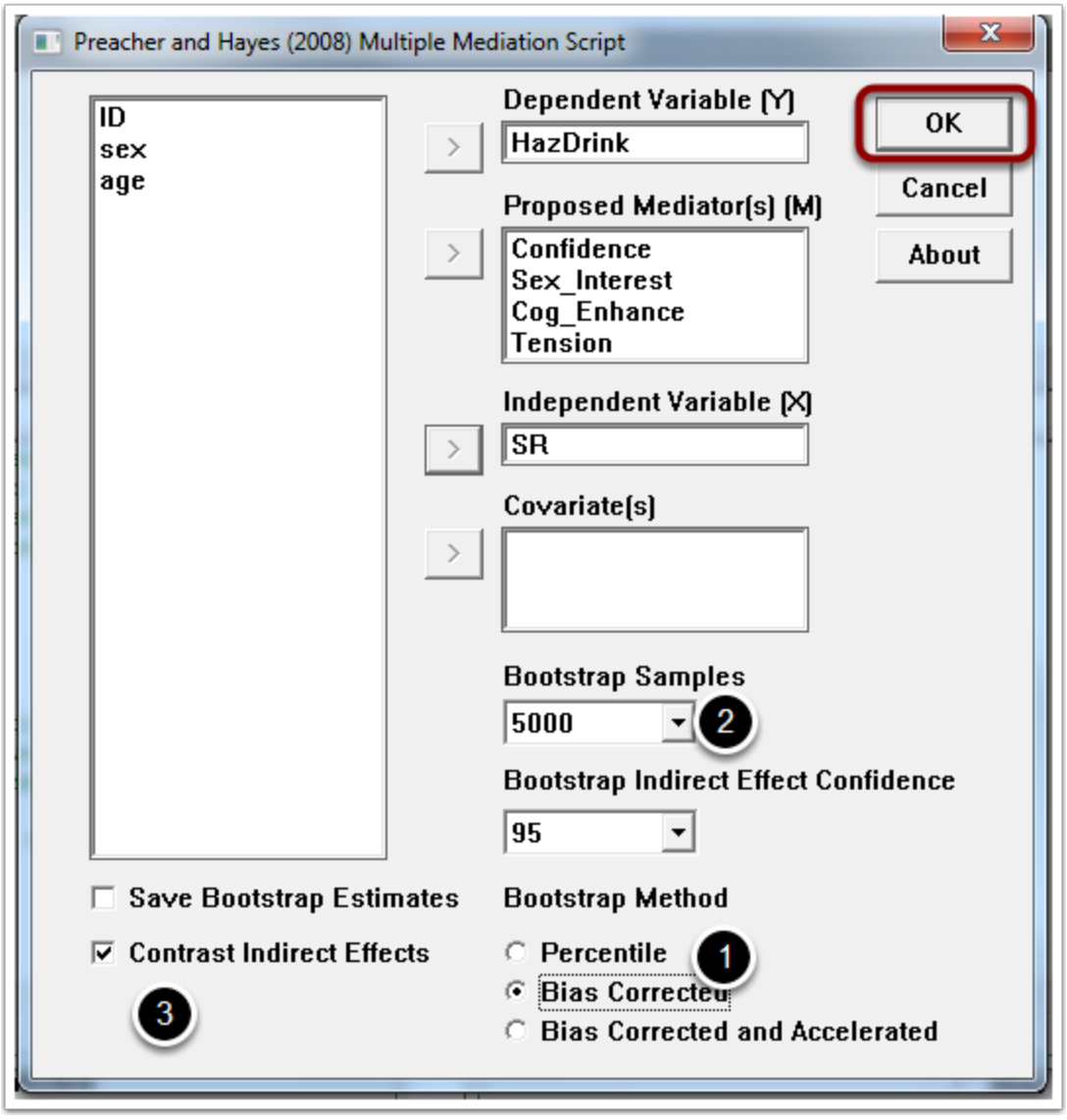
Then choose the relevant options

Now, all the variables have been entered and I have (for consistency) asked for:
(1) The Bias Corrected estimates
(2) 5000 bootstraps
(3) Contrasts of the Indirect effects

And click OK

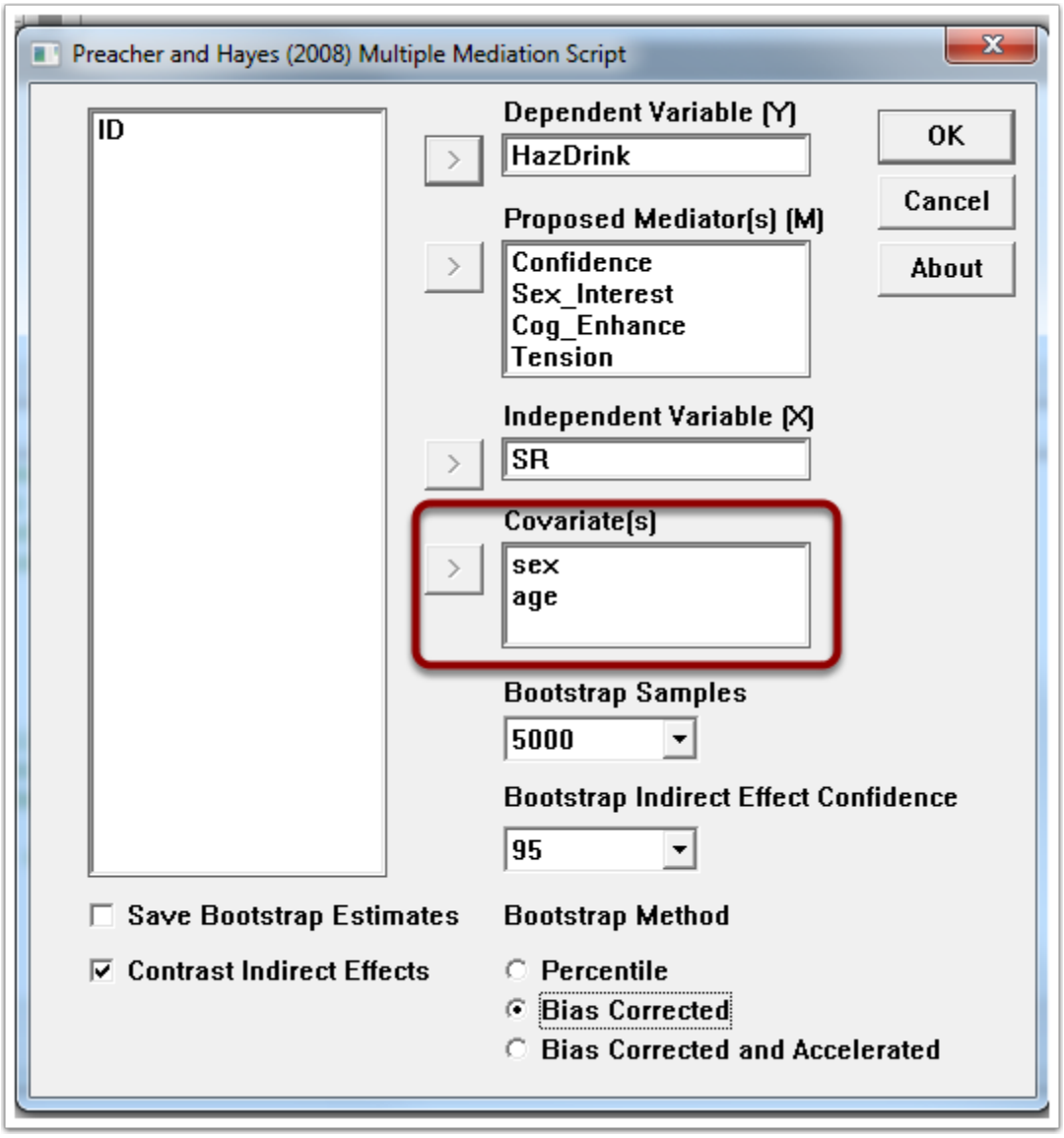
My output is identical to that presented earlier with two exceptions:

1) By default the "Normal Theory Tests for Indirect Effects" are automatically included (these are just the Sobel tests that I could have asked for in the syntax version if I wanted. However, there is much debate re: power of the Sobel, esp with small samples)
2) Because the bootstrapped estimates are re-estimated each time, these will be slightly different each time the macro is run



With Covariates

and again, covariates are easily entered



Caveats

Note that limitations of this macro from the documentation and other suggested macros such as the new PROCESS macro at the Hayes site.

- The variables in `mvlist` must be a quantitative variables and are assumed to have at least interval-level measurement properties. `xvar`, `dvar`, and variables in `covlist` can be dichotomous or quantitative with interval-level properties. **INDIRECT should not be used with a dichotomous mediator.**
- When bootstrapping is enabled, the bootstrap samples are saved to an SPSS data file called "indirect.sav", typically in the SPSS root directory, although the exact location will vary from machine to machine depending on how the SPSS program was installed.
- A case will be deleted from the analysis if missing on any of the variables in the model.

Summary

This tipsheet has run through using the Preacher and Hayes (2008) Indirect macro for testing multiple mediation models with manifest variables using either SPSS Syntax or the more user-friendly SPSS Script. Covariates can also be used with this macro, as can dichotomous DVs (not addressed in this tipsheet).
For those wishing to include multiple IVs, DVs and/or latent variables should consider using a software package that allow Structural Equation Models such as MPlus, STATA, AMOS. Lisrel etc

Those wishing more information on this macro and/or mediation etc are advised to refer to the Hayes website or the Facebook mediation website.

Please note that the creator of this tipsheet is not associated with the developers of the macros and is unable to provide additional advice on the macro or issues related with mediation or other analyses.

Associated references

Hayes, A. F. (2009). Beyond Baron and Kenny: Statistical Mediation Analysis in the New Millennium. *Communication Monographs, 76*(4), 408-420. doi: 10.1080/03637750903310360

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, and Computers, 36*, 717-731.

Shrout, P. E., & Bolger, N. (2002). Mediation in experimental and nonexperimental studies: New procedures and recommendations. *Psychological Methods, 7*(4), 422-445.

MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods, 7*(1), 83-104.