This tipsheet was created by Natalie J. Loxton (Griffith University, Australia)

This tipsheet was created to assist students and colleagues at Griffith University and The University of Queensland but is freely available to anyone interested in using this macro.

However, 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.

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

NOTE: This tipsheet uses PROCESS Ver 2

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

http://www.processmacro.org

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

Hayes, A. F. (2013). *Introduction to Mediation, Moderation, and Conditional Process Analysis : A Regression-Based Approach*. New York: Guilford Press.

Also check the latest state of the union regarding the use of bias-corrected estimates etc: Hayes, A. F., & Scharkow, M. (2013). The relative trustworthiness of inferential tests of the indirect effect in statistical mediation analysis: Does method really matter? *Psychological Science, 24,* 1918-1927

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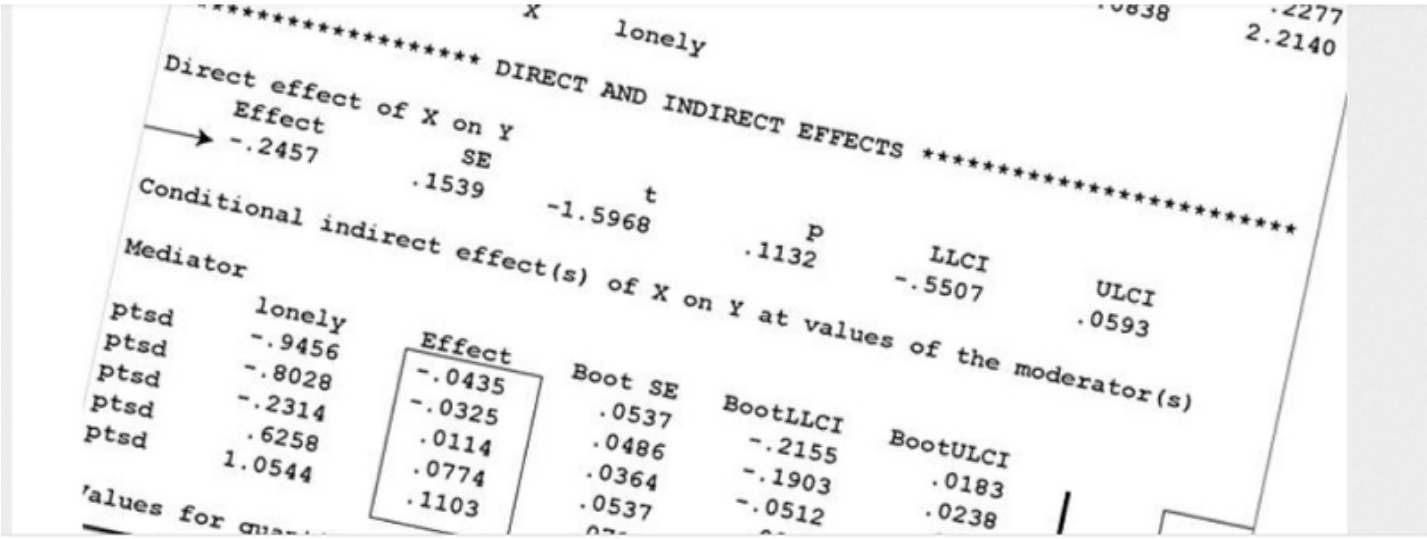
The PROCESS macro for SPSS and SAS



```
                    X          lonely                                    .0838     .2277
                                                                                   2.2140
********************* DIRECT AND INDIRECT EFFECTS *************************
Direct effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
    -.2457      .1539    -1.5968      .1132     -.5507      .0593

Conditional indirect effect(s) of X on Y at values of the moderator(s)
Mediator
                lonely     Effect   Boot SE  BootLLCI  BootULCI
ptsd            -.9456    -.0435     .0537    -.2155     .0183
ptsd            -.8028    -.0325     .0486    -.1903     .0238
ptsd            -.2314     .0114     .0364    -.0512
ptsd             .6258     .0774     .0537
                1.0544     .1103
Values for qua
```

PROCESS is an easy to use add-on for SPSS and SAS for statistical mediation, moderation, and conditional process analysis. The use of **PROCESS** is described and documented in *Introduction to Mediation, Moderation, and Conditional Process Analysis*, published by The Guilford Press.

For this example we will use the PROCESS Macro

PROCESS includes a host (76 in fact) of testable models. In this tipsheet we will just test the simpler moderated mediation model.

Download the PROCESS zip files to your computer directly from http://www.processmacro.org (this was updated in Jun 2016). Will be updated in 2017.

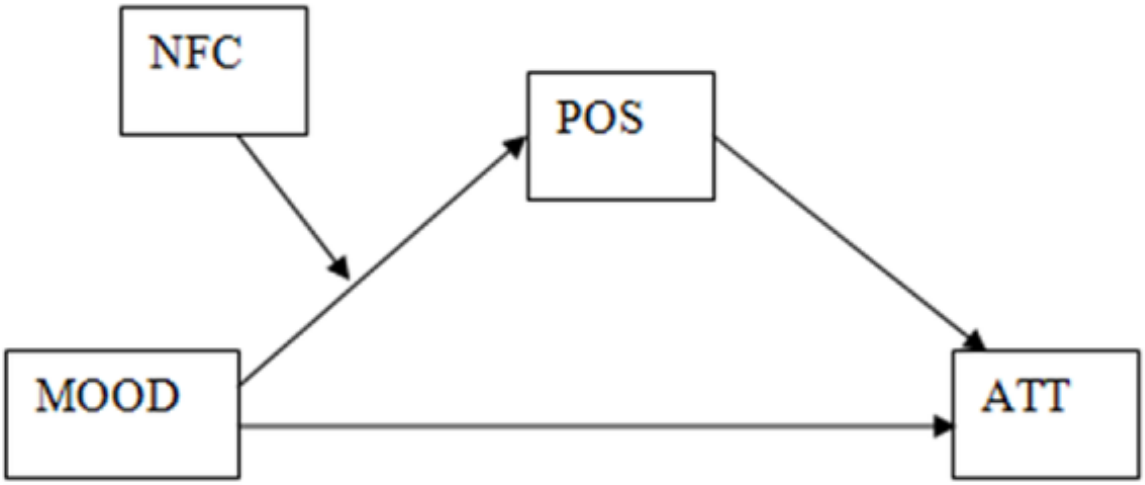
I would suggest downloading directly each time you use the macro (if you only use it every now and then) as it is frequently updated (unlike this tipsheet)

Let's test this model

This model comes from a very good paper on moderated mediation and mediated moderation:

> Muller, D., Judd, C. M., & Yzerbyt, V. Y. (2005). When moderation is mediated and mediation is moderated. *Journal of Personality and Social Psychology, 89*(6), 852-863. Refer to this paper for the background to this model.
>
> This model is a **MODERATED MEDIATION model**

In this example the indirect effect of MOOD on ATT (Attitude) via POS (Positive Thoughts) is moderated by NFC (Need for Cognition)



The (hypothetical) dataset created by Muller et al. can be accessed HERE

Don't worry about the -1 for the MOOD variable. This is a dichotmous variable. While you could use "dummy coding", sometimes it's better to use "effect coding".

File Edit View Data Transform Analyze Direct Marketing Graphs Utilities

1 : ATT 18.5455

	OBS	MOOD	NFC	POS	ATT	var	var	var
1	1	-1	3.07579	6.25	18.5455			
2	2	-1	2.59489	-5.07	-16.9684			
3	3	-1	-1.00952	.93	-5.9578			
4	4	-1	-.43824	2.87	-7.2256			
5	5	-1	.21788	-16.56	-26.7000			
6	6	-1	.43842	-13.14	-24.1241			
7	7	-1	-1.09646	-.95	-28.0378			
8	8	-1	-.57737	-13.77	-9.4845			
9	9	-1	1.75978	-5.82	10.8746			
10	10	-1	-.42134	.33	18.2762			
11	11	-1	2.79577	-.91	8.8336			
12	12	-1	.17257	.61	-12.8959			
13	13	-1	-.74219	1.44	.3409			
14	14	-1	.89686	-8.31	-28.3586			

1) Set up and run the model

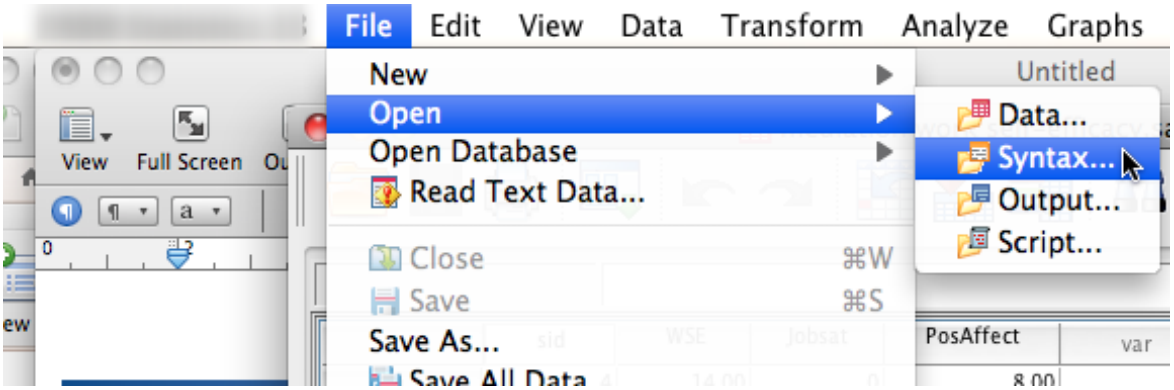
First - we will run this model using the SYNTAX approach

While this is a bit more work than the dropdown windows approach (see below), this allows you to keep a record of your analysis. The dropdown windows do not allow you to "paste" to syntax (yet).

Using the syntax version of the macro

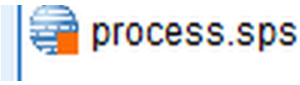
Macros are very similar to syntax files and are run as such:

Open the file via the "Open Syntax" option



Make sure to select the file "process.SPS"

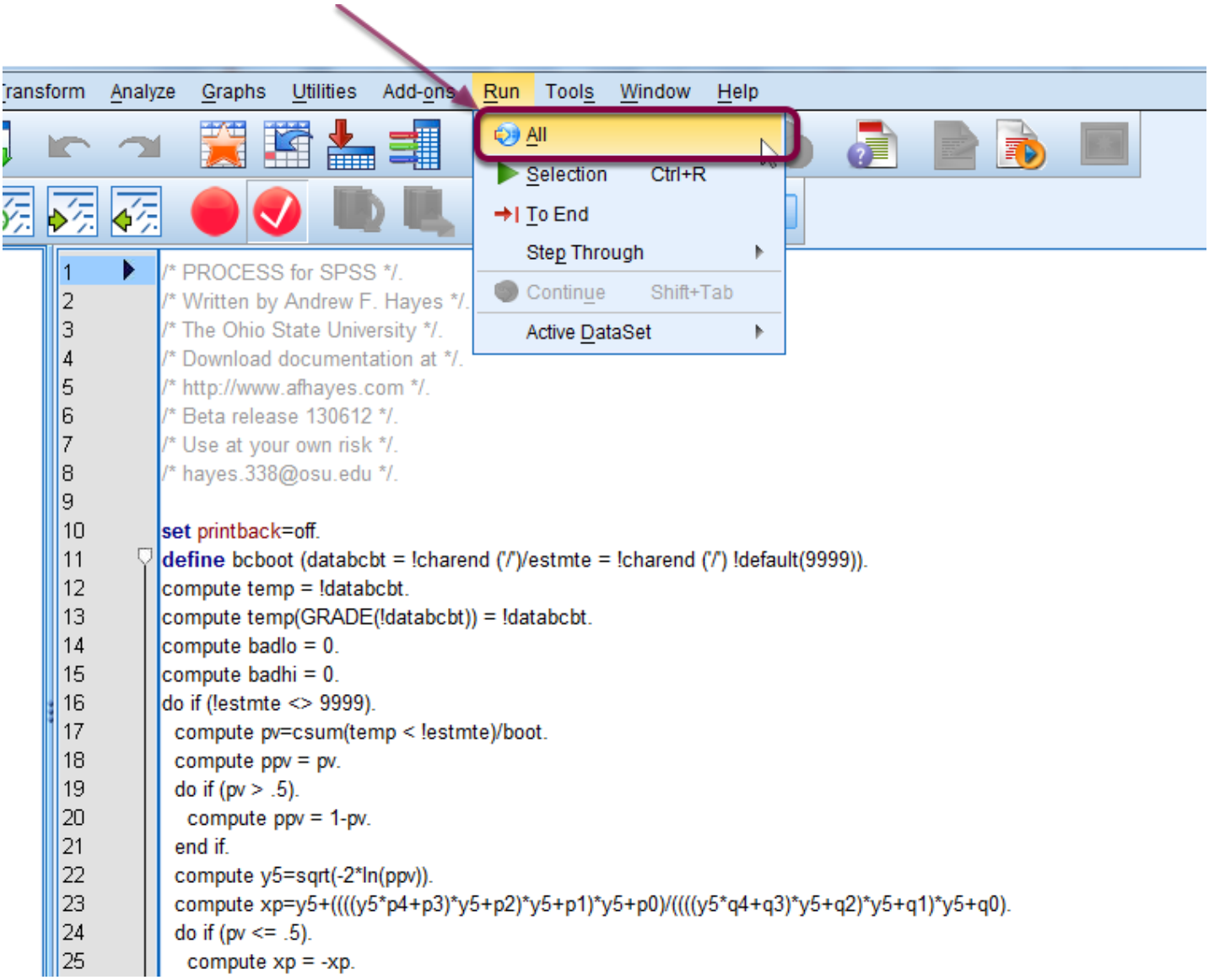
This is the file you downloaded from the Hayes website



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

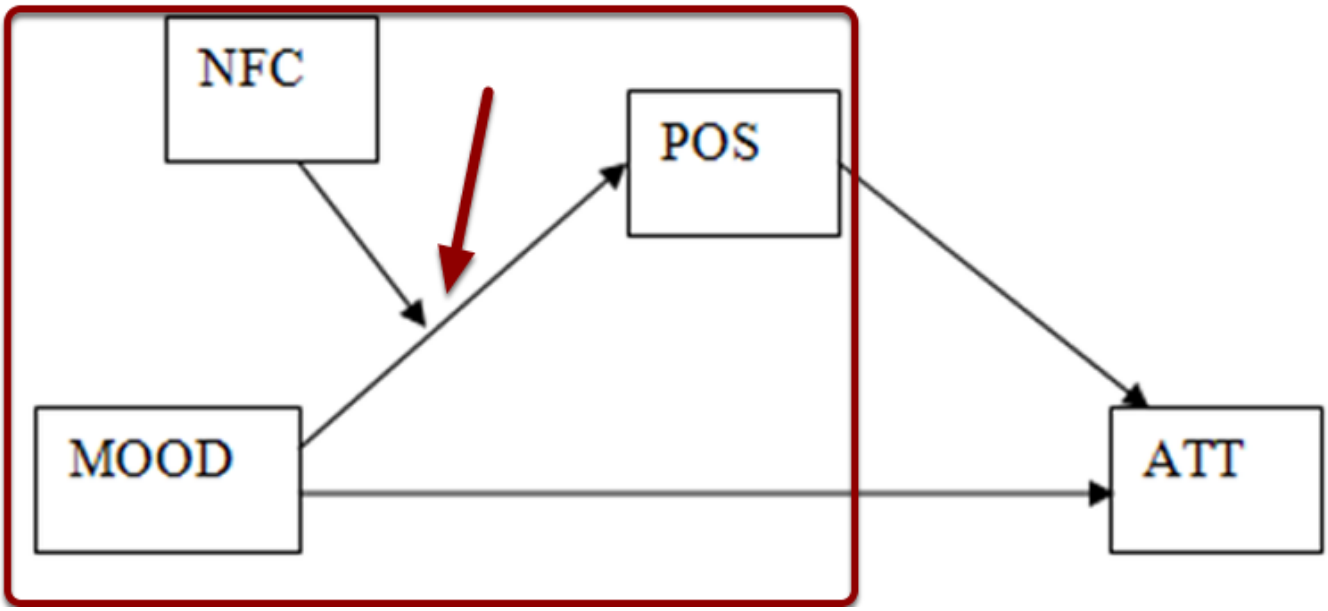


2) Decide which model to test

You will need to consult the PDF that comes with the Zip file "templates.pdf".

Note: There are 76 models that can be tested by this macro !

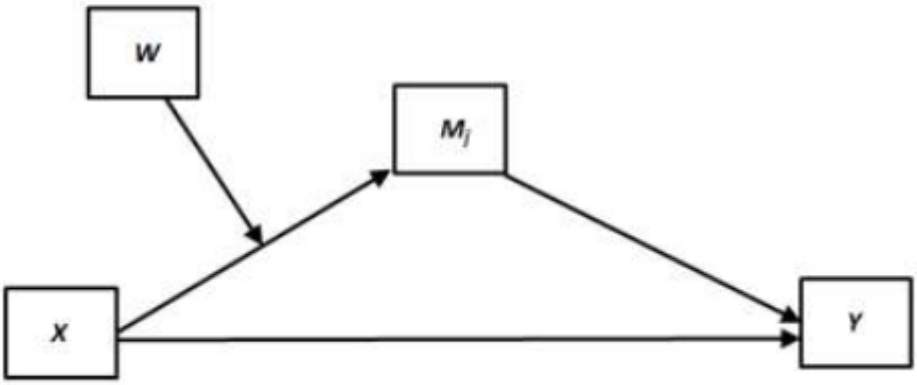
Fortunately, the most common ones are listed in detail at the beginning of the documents. We need to choose the moderated mediation model in which the "a" path is moderated



Model 7 looks like it will do the job quite nicely

Model 7

Conceptual Model



Now we can set up the syntax to test this model

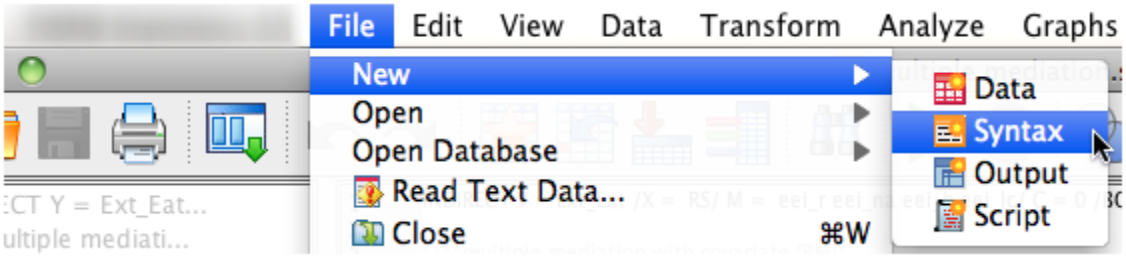
In this step you need to tell the macro which of your variables are the IV, DV, Mediator and Moderator.

To do this you need to create a new syntax file and set up your model using this template:

PROCESS vars = xvar mvlist yvar wvar/y=yvar/x=xvar/m=mvlist/w=wvar/model=7/boot = 5000.

This is the syntax for the example model:

PROCESS vars = MOOD POS ATT NFC/y=ATT/x=MOOD/m=POS/w=NFC/model=7/boot = 5000.



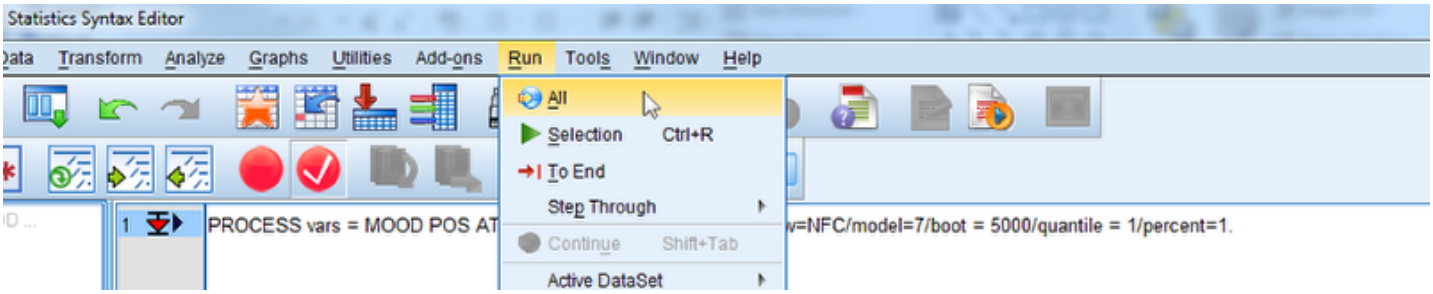
Run this syntax

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

2017 update: while previously we choose 5000 samples, it is better these days to ask for 10000

(yes, I could have updated the syntax and image but I'm a lazy bugger)



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

```
BREAK.
i if.
 DO THE RESAMPLING OF THE DATA */.
 if (#j > 1).
 compute v = trunc(uniform(n,1)*n)+1.
 compute dat(:,1:3)=dd(v,1:3).
nd if.
 SET UP THE DATA COLUMNS FOR PROCESSING */.
mpute y = dat(:,1).
mpute x = dat(:,2).
mpute z = dat(:,3).
mpute xz = dat(:,2:3).

 CALCULATE REGRESSION STATISTICS NEEDED TO COMPUTE c-c'  */
```

Running MATRIX...

Ok, let's re-run this using the Dropdown windows

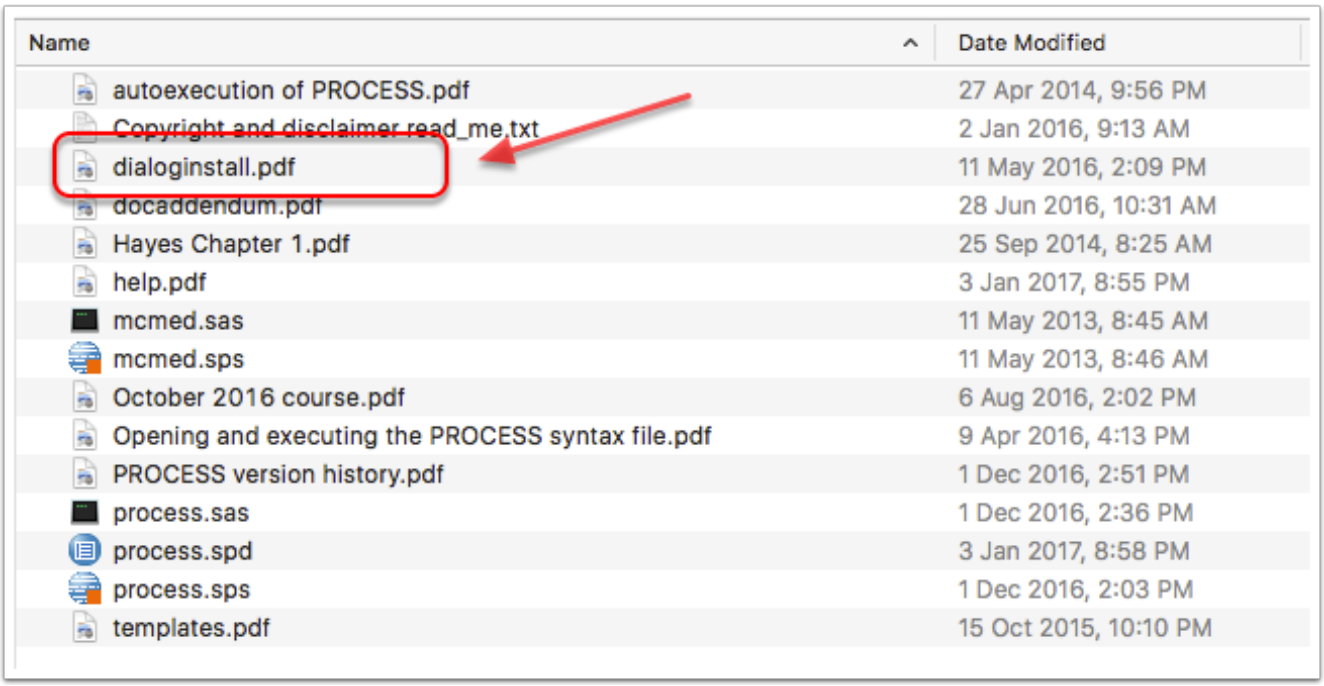
The alternative approach to writing syntax for this specific macro is to use the very user-friendly custom dialog script provided when you download the PROCESS zip file.

Name	Date Modified
autoexecution of PROCESS.pdf	27 Apr 2014, 9:56 PM
Copyright and disclaimer read_me.txt	2 Jan 2016, 9:13 AM
dialoginstall.pdf	11 May 2016, 2:09 PM
docaddendum.pdf	28 Jun 2016, 10:31 AM
Hayes Chapter 1.pdf	25 Sep 2014, 8:25 AM
help.pdf	3 Jan 2017, 8:55 PM
mcmed.sas	11 May 2013, 8:45 AM
mcmed.sps	11 May 2013, 8:46 AM
October 2016 course.pdf	6 Aug 2016, 2:02 PM
Opening and executing the PROCESS syntax file.pdf	9 Apr 2016, 4:13 PM
PROCESS version history.pdf	1 Dec 2016, 2:51 PM
process.sas	1 Dec 2016, 2:36 PM
process.spd	3 Jan 2017, 8:58 PM
process.sps	1 Dec 2016, 2:03 PM
templates.pdf	15 Oct 2015, 10:10 PM

Install the script

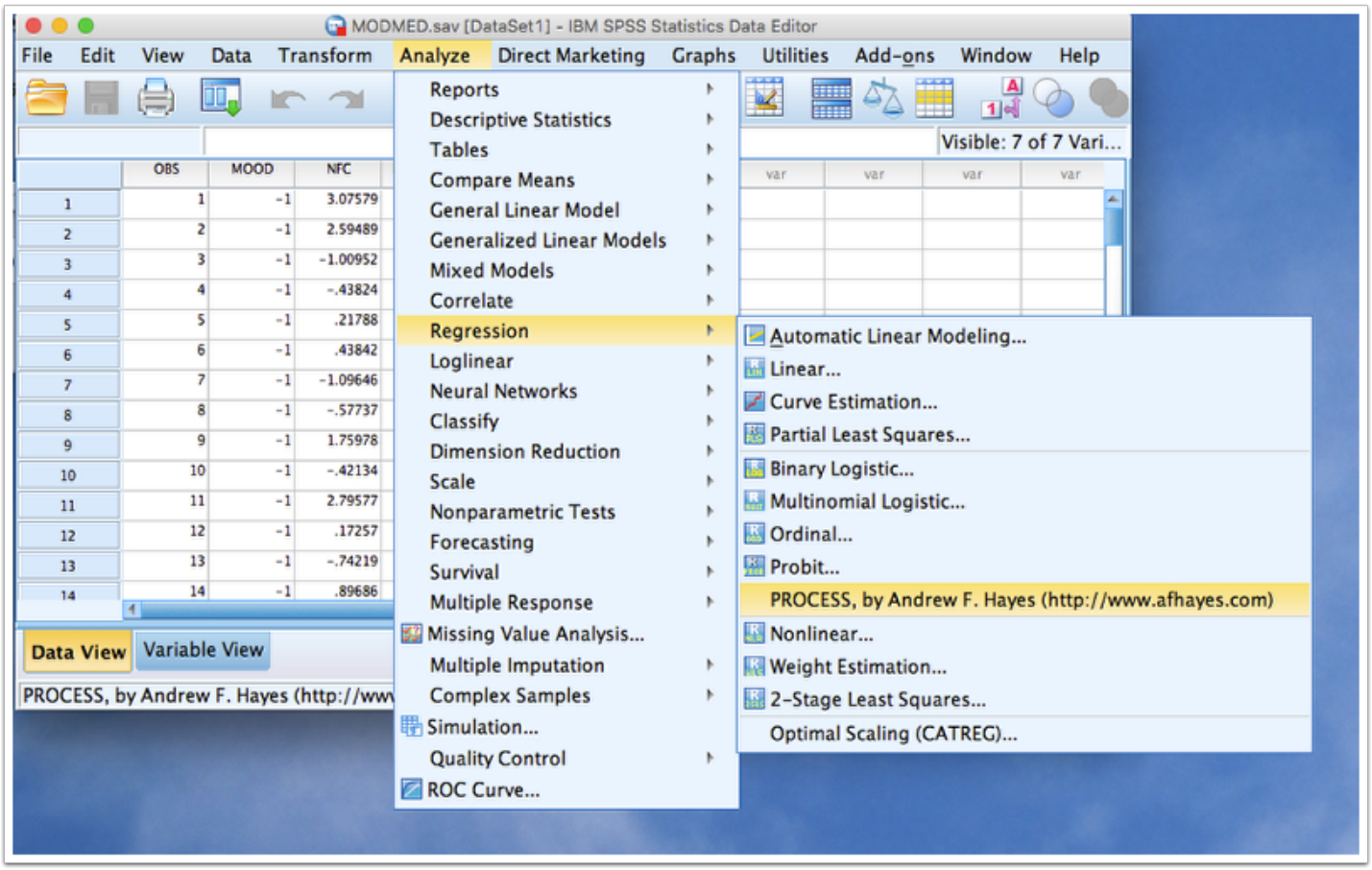
See the dialoginstall.pdf for installation instructions (also part of the Zip file).

Apparently you do not need to do this part in SPSS ver 24 (see Hayes webite)



Name	Date Modified
autoexecution of PROCESS.pdf	27 Apr 2014, 9:56 PM
Copyright and disclaimer read_me.txt	2 Jan 2016, 9:13 AM
dialoginstall.pdf	11 May 2016, 2:09 PM
docaddendum.pdf	28 Jun 2016, 10:31 AM
Hayes Chapter 1.pdf	25 Sep 2014, 8:25 AM
help.pdf	3 Jan 2017, 8:55 PM
mcmed.sas	11 May 2013, 8:45 AM
mcmed.sps	11 May 2013, 8:46 AM
October 2016 course.pdf	6 Aug 2016, 2:02 PM
Opening and executing the PROCESS syntax file.pdf	9 Apr 2016, 4:13 PM
PROCESS version history.pdf	1 Dec 2016, 2:51 PM
process.sas	1 Dec 2016, 2:36 PM
process.spd	3 Jan 2017, 8:58 PM
process.sps	1 Dec 2016, 2:03 PM
templates.pdf	15 Oct 2015, 10:10 PM

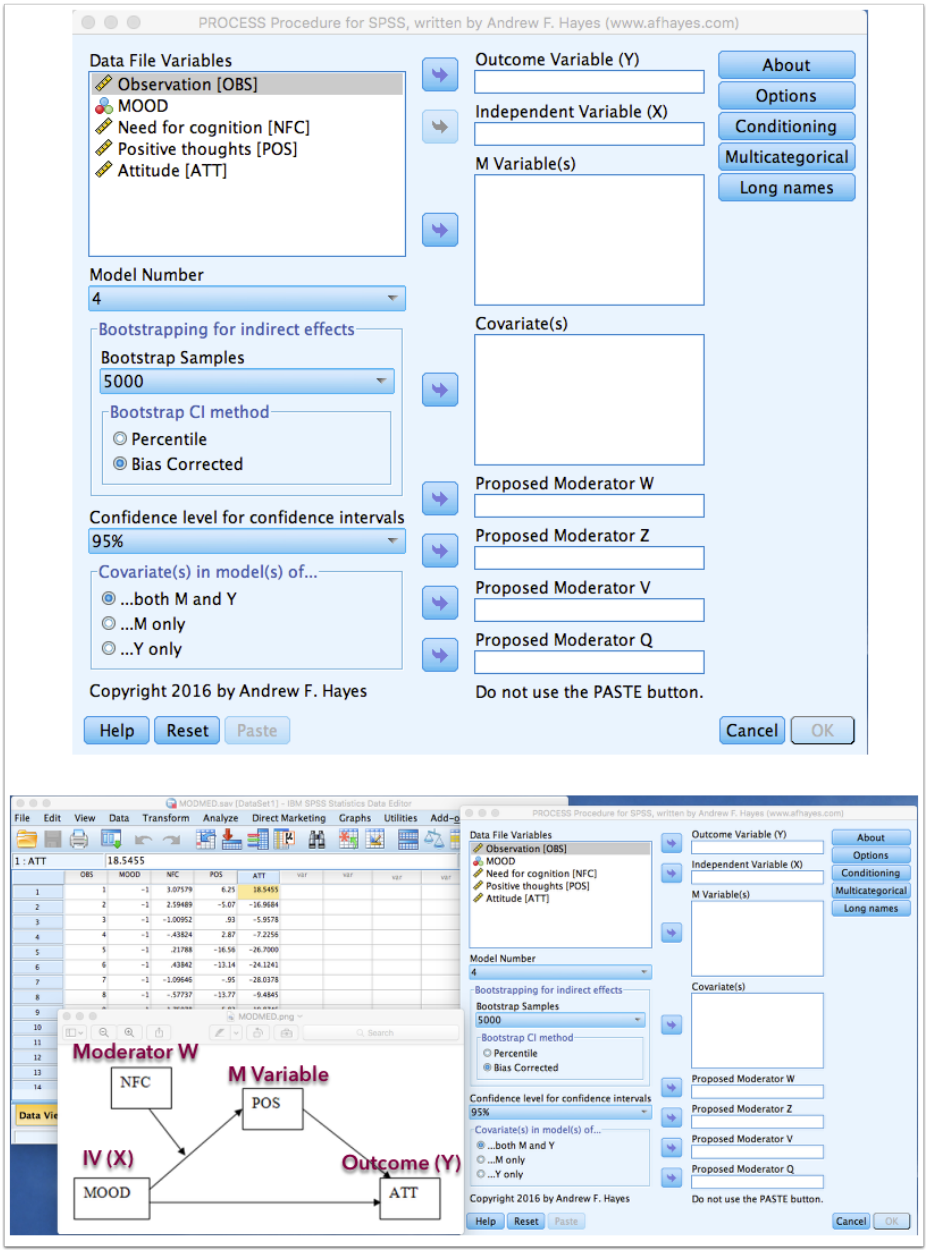
The dropdown menu will appear under Regression under Analyze



Now you can set up the model

You will still need to know which number model you are testing. Recall that we obtained this from the Templates.pdf that came with the zip file.

To help remember which variable goes where I find it helpful to have the specified model near me.



Then choose the relevant options

Now, all the variables have been entered and I have asked for:

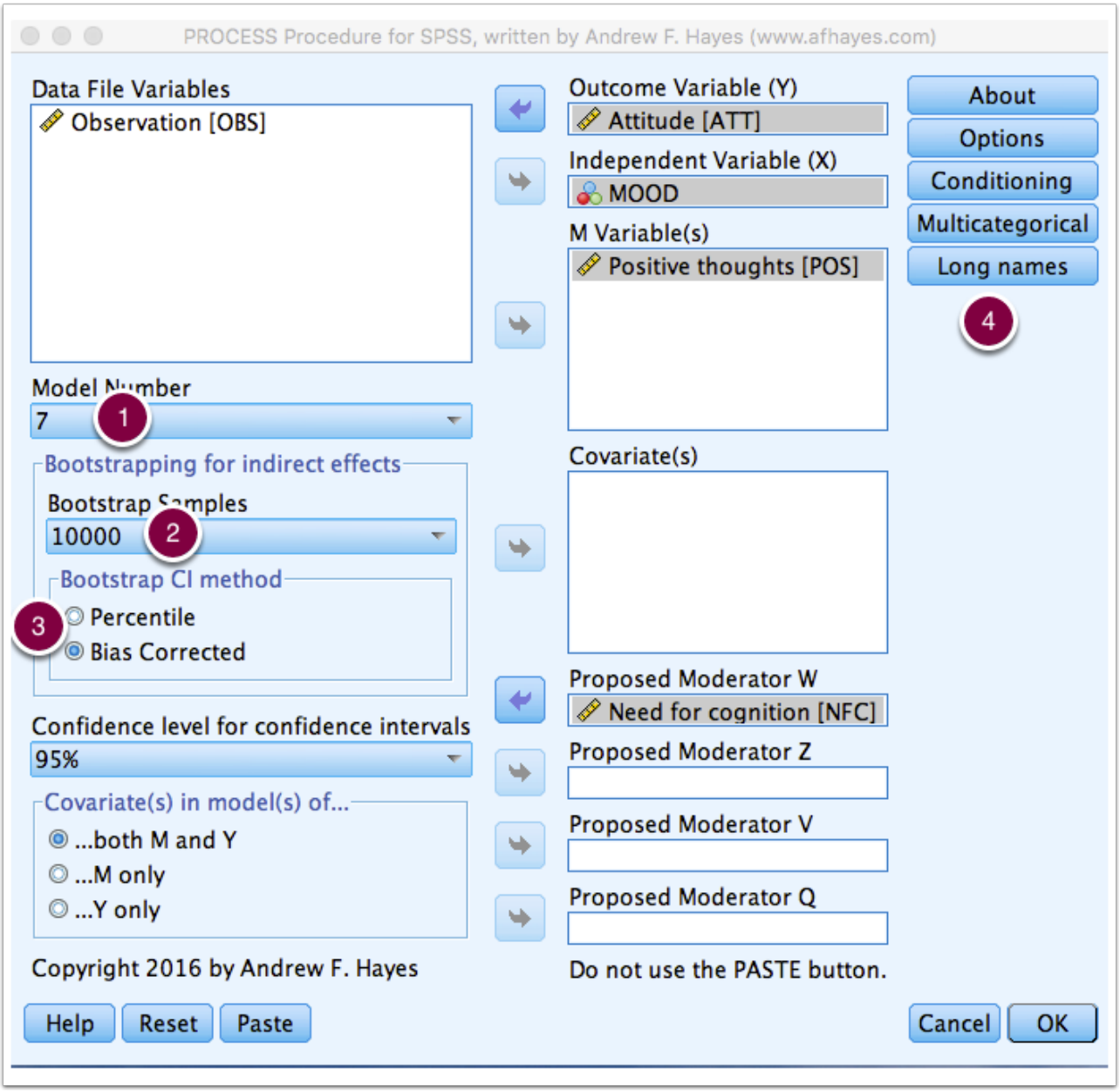
(1) Model number 7 (see above - this comes from the Template.pdf in the downloaded ZIP file)

(2) 10000 bootstraps

(3) The Bias Corrected estimates (although you could have asked for Percentile - there's a good paper on the conditions under which one is preferred over the other - Hayes & Scharkow (2013))

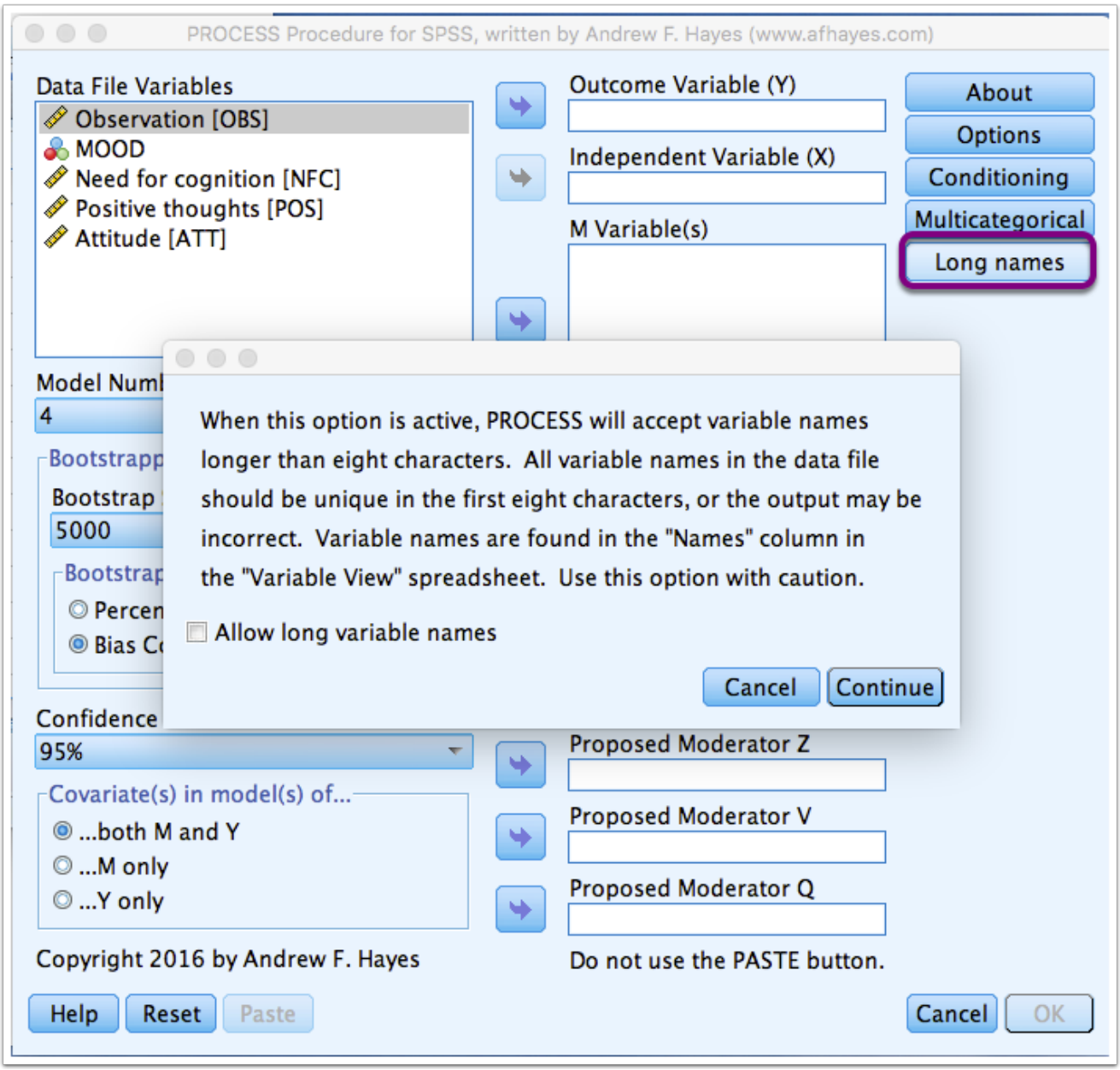
(4) You'll see that there are a few extra options to choose from. Some are quite useful. Let's have a look....

Also notice that you can have multiple mediators (just add them to the "M Variable(s)" box.


PROCESS Procedure for SPSS, written by Andrew F. Hayes (www.afhayes.com)
Data File Variables
Observation [OBS]
Outcome Variable (Y)
Attitude [ATT]
Independent Variable (X)
MOOD
M Variable(s)
Positive thoughts [POS]
Covariate(s)
Proposed Moderator W
Need for cognition [NFC]
Proposed Moderator Z
Proposed Moderator V
Proposed Moderator Q
About
Options
Conditioning
Multicategorical
Long names
4
Model Number
7
1
Bootstrapping for indirect effects
Bootstrap Samples
10000
2
Bootstrap CI method
3
Percentile
Bias Corrected
Confidence level for confidence intervals
95%
Covariate(s) in model(s) of...
...both M and Y
...M only
...Y only
Copyright 2016 by Andrew F. Hayes
Do not use the PASTE button.
Help
Reset
Paste
Cancel
OK

Allow Long Names

One of the frustrating aspects of the macro earlier on was then restriction on the number of letters in your variable names. Now you can simple click on "Long names" and "allow long variable names". Bam ! Problem solved.

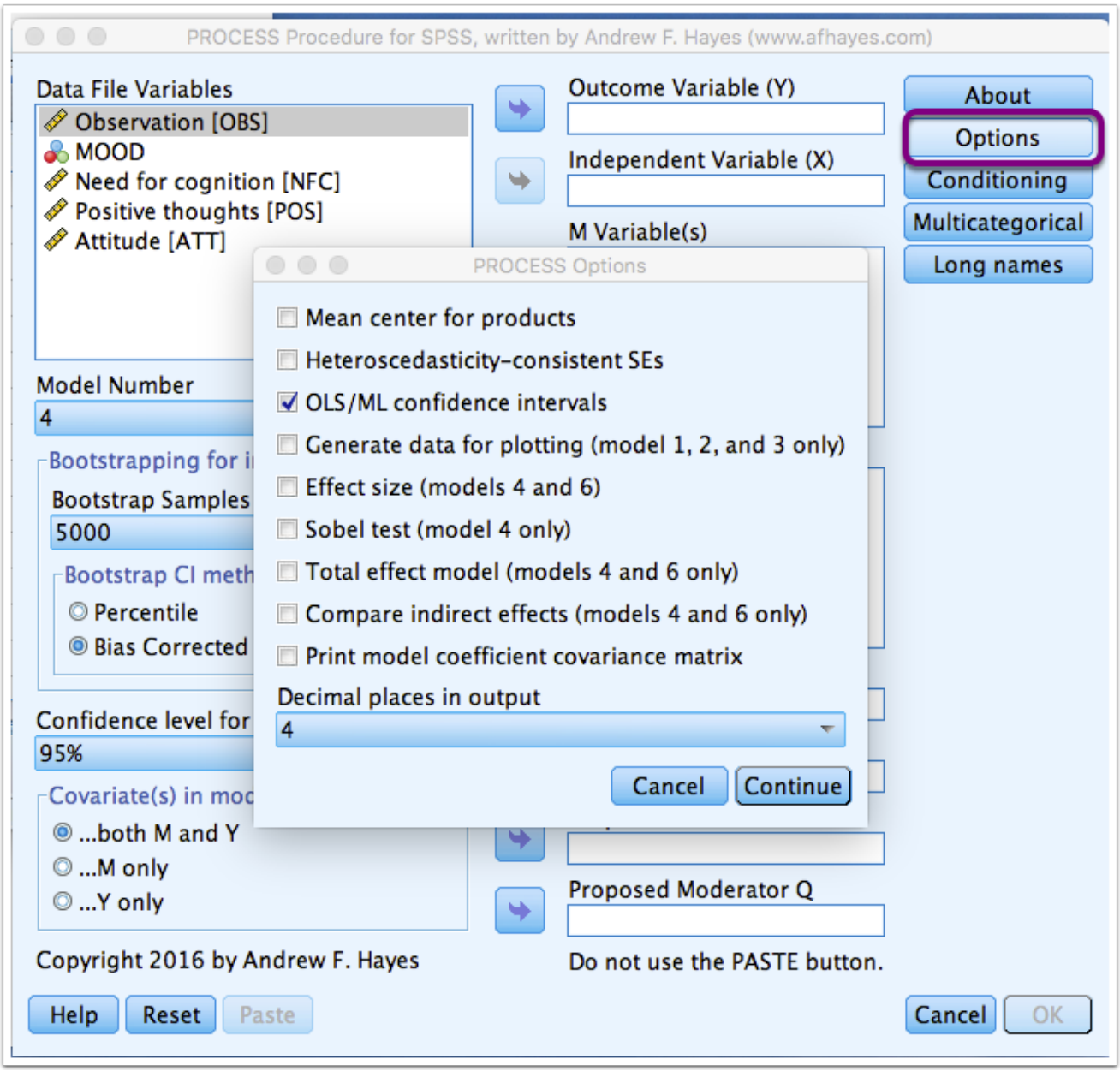


Options

Clicking on "Options" gives a host of, well, options.

There is really nothing here that we need to change.

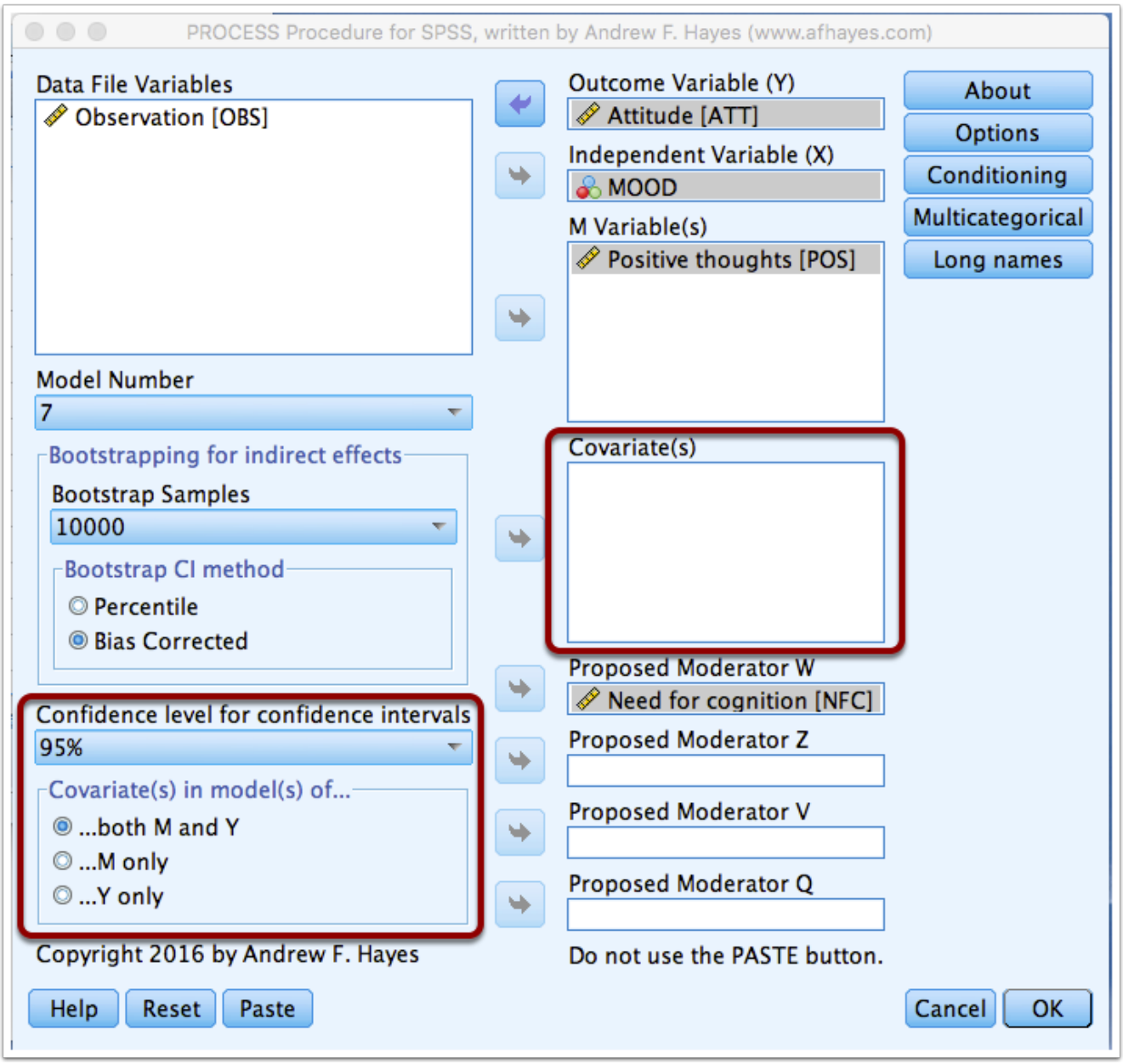
Note: Mean centering. Mean centering of variable when testing interactions has been a topic of interest and debate for sometime. Current recommendation is to NOT mean centre. So leave unclicked.



With Covariates

If you have any covariates, you can enter them here. We do not have any in this example.

Notice that you can specify the variable to which the covariate is applied.



Ok - now press "OK"

The output will be the same whether you use the dropdown boxes or syntax. The only reason some coefficients changes is because the bootstrapped estimates draw random sample.

3) Interpret the output - predictors of the MEDIATING variable (i.e, path a)

First - Check the variables were correctly specifed (1)

The second part of the output provides the regular tests of significance of:

- Main effects of MOOD and NFC on the mediating variable (POS) (2)
- The interaction between MOOD and NFC on POS (3)
- (Note the interaction terms are listed below to remind you) -see the pink highlighted section

As can be seen, there is a significant main effect of MOOD and a significant interaction (we'll come back to this)...

```
Run MATRIX procedure:

************* PROCESS Procedure for SPSS Release 2.16.1 ******************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 7
    Y = ATT
    X = MOOD
    M = POS
    W = NFC

Sample size
        100

**************************************************************************
Outcome: POS

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .5656      .3200    48.5739    15.0557     3.0000    96.0000      .0000

Model
              coeff         se          t          p       LLCI       ULCI
constant      .0404      .6971      .0579      .9540    -1.3435     1.4242
MOOD         4.3357      .6971     6.2193      .0000     2.9519     5.7196
NFC           .7672      .5130     1.4956      .1380     -.2510     1.7854
int_1        1.2565      .5130     2.4496      .0161      .2383     2.2747

Product terms key:

 int_1    MOOD        X     NFC
```

4) Interpret the output - predictors of the DEPENDENT variable (i.e, path b)

The third part of the output provides the regular tests of significance of:

- Main effects of MOOD and POS on the DV (ATT)

- Note that there is no interaction term here as we are effectively testing path b and path c'

As can be seen, there is a significant main effect of POS (path b) and a non-significant direct effect of MOOD (in Baron and Kenny terms - this suggest a mediated effect). However, we need to both a) test the significance of the indirect effect and b) at which levels of the moderator does occur....

```
**************************************************************************
Outcome: ATT

Model Summary
          R       R-sq          F        df1        df2          p
      .6356      .4039    32.8662     2.0000    97.0000      .0000

Model
              coeff         se          t          p
constant     1.9807     1.3099     1.5121      .1338
POS          1.1571      .1853     6.2450      .0000
MOOD         1.7844     1.5343     1.1631      .2477
```

5) Tests of Direct and Indirect Effects

Finally, we have tests of the indirect effect at -1SD, the mean and +1SD of the moderating variable (NFC)

The output provides the 95% Bias corrected bootstrapped confidence interval (at each of these levels of the moderating variable)

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).

So we check for whether ZERO lies between the lower CI (BootLLCI) and the upper CI (BootULCI). Those that DO NOT include zero are considered siginifcant.

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

```
******************** DIRECT AND INDIRECT EFFECTS *************************

Direct effect of X on Y
     Effect         SE          t          p
     1.7844     1.5343     1.1631      .2477

Conditional indirect effect(s) of X on Y at values of the moderator(s)

Mediator
           NFC     Effect    Boot SE   BootLLCI   BootULCI
POS    -1.4046     2.9747     1.3048      .8629     6.0901
POS      .0000     5.0168     1.1930     3.0490     7.8043
POS     1.4046     7.0590     1.6517     4.3221    10.9696

Values for quantitative moderators are the mean and plus/minus one SD from mean
```

Interpretation

The indirect effect is stronger at higher levels of POS (although all indirect effects are significantly different from zero)

Additional Issues: Index of Moderated Mediation

The Index of moderated mediation tests the significance of the moderated mediation, i.e., the difference of the indirect effects across the moderator (see Hayes, 2015). In this case, the confidence interval does not contain zero - therefore the overall moderated mediation model was supported.

```
******************** INDEX OF MODERATED MEDIATION ************************

Mediator
          Index    SE(Boot)    BootLLCI    BootULCI
POS      1.4539       .6301       .3919      2.8993
```

Summary

This tipsheet has run through using the Hayes (2013) PROCESS macro for testing a moderated mediation models with manifest variables. Covariates can also be used with this macro, as can dichotomous DVs (not addressed in this tipsheet).

For those wishing to include multiple 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.

For those wishing to test mediation models with categorical predictors you can use Hayes' excellent MEDIATE macro or as of Ver 2.16, PROCESS allows categorical IVs.

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.

Hayes, A. F., & Scharkow, M. (2013). The relative trustworthiness of inferential tests of the indirect effect in statistical mediation analysis: Does method really matter? *Psychological Science, 24,* 1918-1927

Published papers using PROCESS

Tobin, S. J., Loxton, N. J., & Neighbors, C. (2014). Coping with Causal Uncertainty through Alcohol Use. *Addictive Behaviors, 39*, 580-585. doi: 10.1016/j.addbeh.2013.11.009

- **Used Model 8** - moderated multiple mediation with continuous DV and continuous moderator

Loxton, N. J., Mitchell, R., Dingle, G. A., & Sharman, L. S. (2016). How to tame your BAS: Reward sensitivity and music involvement. *Personality and Individual Differences, 97*, 35-39.

- Used Model 4 - multiple mediation with continuous DV

Maxwell, A.M., Loxton, N.J., & Hennegan, J.M. (2017). Exposure to food cues moderates the indirect effect reward sensitivity and external eating via implicit eating expectancies. *Appetite, 111,* 135-141

- **Used Model 7 -** moderated mediation with dichotomous moderator and continuous mediator

Loxton, N.J. & Tipman, R.J. (2017). Reward sensitivity and food addiction in women. *Appetite, 115,* 28-35.

- Used Model 4 - multiple mediation with continuous DV

Several models that I would now test using PROCESS, were tested using the earlier INDIRECT macro and I have included those references in that tipsheet.

Tipsheet updated 27 July 2017