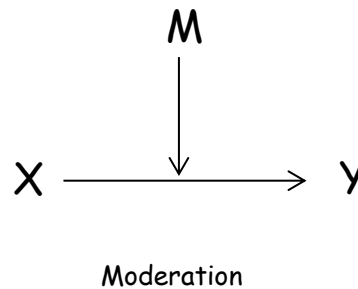


# Moderation

A moderator is a variable that specifies conditions under which a given predictor is related to an outcome. The moderator explains 'when' a DV and IV are related. *Moderation* implied an interaction effect, where introducing a moderating variable changes the direction or magnitude of the relationship between two variables. A moderation effect could be (a) Enhancing, where increasing the moderator would increase the effect of the predictor (IV) on the outcome (DV); (b) Buffering, where increasing the moderator would decrease the effect of the predictor on the outcome; or (c) Antagonistic, where increasing the moderator would reverse the effect of the predictor on the outcome.



Hierarchical multiple regression is used to assess the effects of a moderating variable. To test moderation, we will in particular be looking at the *interaction* effect between X and M and whether or not such an effect is significant in predicting Y.

## Steps in Testing Moderation

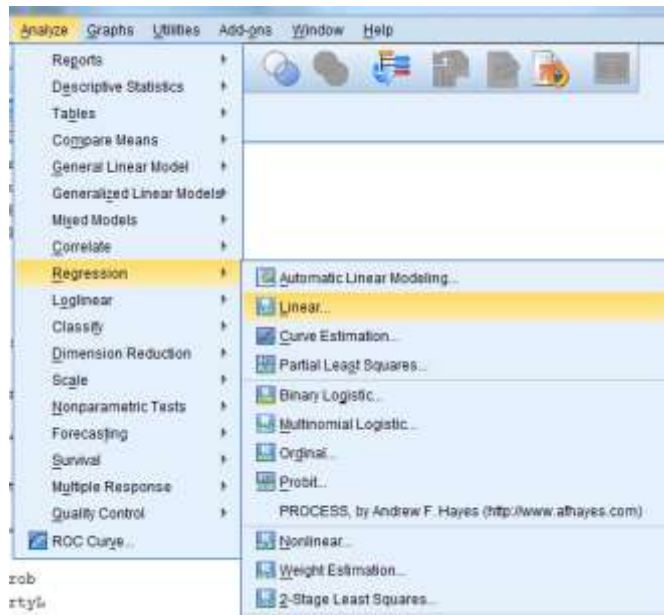
In order to confirm a third variable making a moderation effect on the relationship between the two variables X and Y, we must show that the nature of this relationship changes as the values of the moderating variable M change. This is in turn done by including an interaction effect in the model and checking to see if indeed such an interaction is significant and helps explain the variation in the response variable better than before. In more explicit terms the following steps should be followed:

1. First, you need to standardize all variables to make interpretations easier afterwards and to avoid multicollinearity (the SPSS process described below does this for you automatically).
2. If you are using regular regression menu items in SPSS or similar software, you would also need to dummy code categorical variables and manually create product terms for the predictor and moderator variables (dummy coding is still necessary with the discussed process, however product terms are created automatically).
3. Fit a regression model (block 1) predicting the outcome variable Y from both the predictor variable X and the moderator variable M. Both effects as well as the model in general ( $R^2$ ) should be significant.
4. Add the interaction effect to the previous model (block 2) and check for a significant  $R^2$  change as well as a significant effect by the new interaction term. If both are significant, then moderation is occurring.
  - If the predictor and moderator are not significant with the interaction term added, then complete moderation has occurred.
  - If the predictor and moderator are significant with the interaction term added, then moderation has occurred, however the main effects are also significant.

## Conducting the Analysis in SPSS

Similar to mediation, moderation can also be checked and tested using the regular linear regression menu item in SPSS. For this purpose you would need to dummy code categorical variables, center the variables as well as create the interaction effect(s) manually. We on the other hand will use the PROCESS developed by Andrew F. Hayes which does the centering and interaction terms automatically. You do however still need to dummy code categorical variables with more than 2 categories before including them in the model.

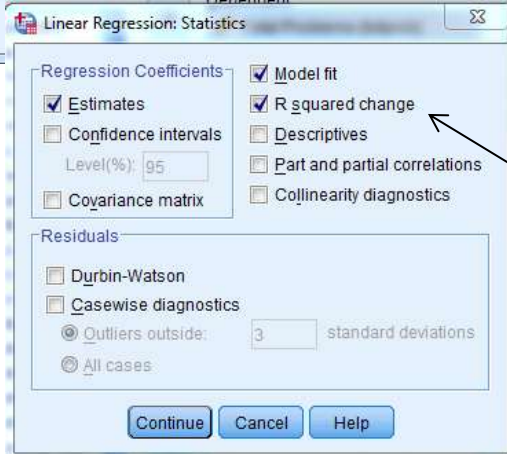
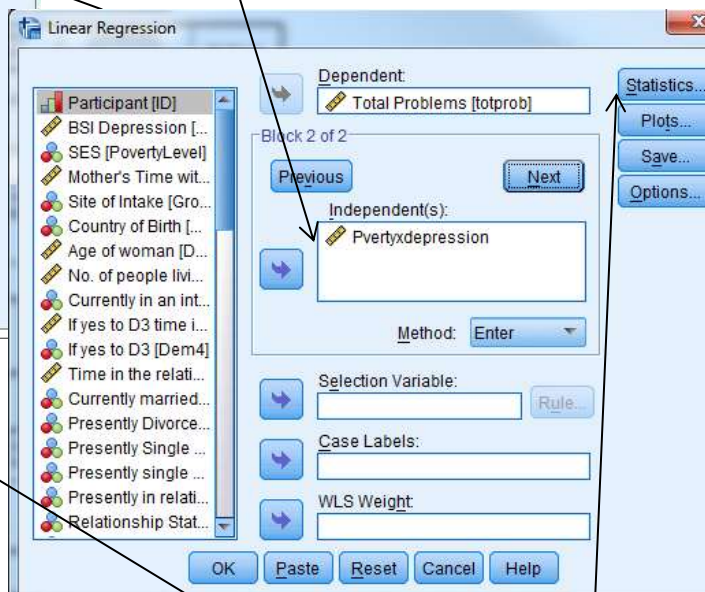
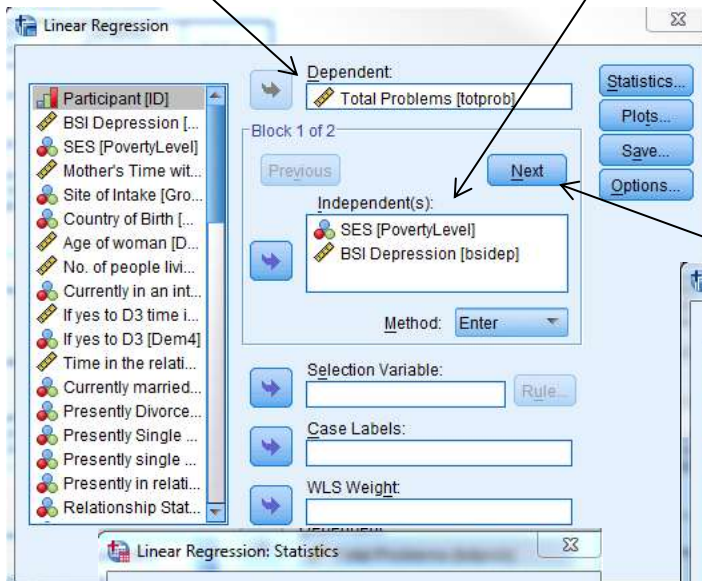
1. Create the uncentered interaction term. Transform → Compute → Var1\*Var2
2. Start by running the model with the uncentered interaction to get the amount of variance accounted for by the predictors with and without the interaction.



2. Place DV (outcome) in Dependent Box

2. Place IV s(predictors) in Independent Box

2. Click "Next" and place the interaction term in the empty "Independents box."



2. Click "Statistics" and select Estimates, Model fit, and R square change

**Step 1** - At this step, you are only interested in if the models are significant and if the amount of variance accounted for in Model 2 (with the interaction) is significantly more than Model 1 (without the interaction).

**Is model 1 (without the interaction term) significant?**

→ Yes,  $F(2, 297) = 76.57, p < .001$

**ANOVA<sup>c</sup>**

| Model |            | Sum of Squares | df  | Mean Square | F      | Sig.              |
|-------|------------|----------------|-----|-------------|--------|-------------------|
| 1     | Regression | 77437.125      | 2   | 38718.563   | 76.573 | .000 <sup>a</sup> |
|       | Residual   | 150175.871     | 297 | 505.643     |        |                   |
|       | Total      | 227612.997     | 299 |             |        |                   |
| 2     | Regression | 81995.064      | 3   | 27331.688   | 55.558 | .000 <sup>b</sup> |
|       | Residual   | 145617.933     | 296 | 491.952     |        |                   |
|       | Total      | 227612.997     | 299 |             |        |                   |

a. Predictors: (Constant), BSI Depression, SES  
 b. Predictors: (Constant), BSI Depression, SES, Pvertyxdepression  
 c. Dependent Variable: Total Problems

**Is model 2 (with the interaction term) significant?** → Yes,  $F(3, 296) = 55.56, p < .001$

**Model Summary<sup>c</sup>**

| Model | R                 | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics |          |     |     |               |
|-------|-------------------|----------|-------------------|----------------------------|-------------------|----------|-----|-----|---------------|
|       |                   |          |                   |                            | R Square Change   | F Change | df1 | df2 | Sig. F Change |
| 1     | .583 <sup>a</sup> | .340     | .336              | 22.48650                   | .340              | 76.573   | 2   | 297 | .000          |
| 2     | .600 <sup>b</sup> | .360     | .354              | 22.18000                   | .020              | 9.265    | 1   | 296 | .003          |

a. Predictors: (Constant), BSI Depression, SES  
 b. Predictors: (Constant), BSI Depression, SES, Pvertyxdepression  
 c. Dependent Variable: Total Problems

**Does model 2 account for significantly more variance than model 1?**

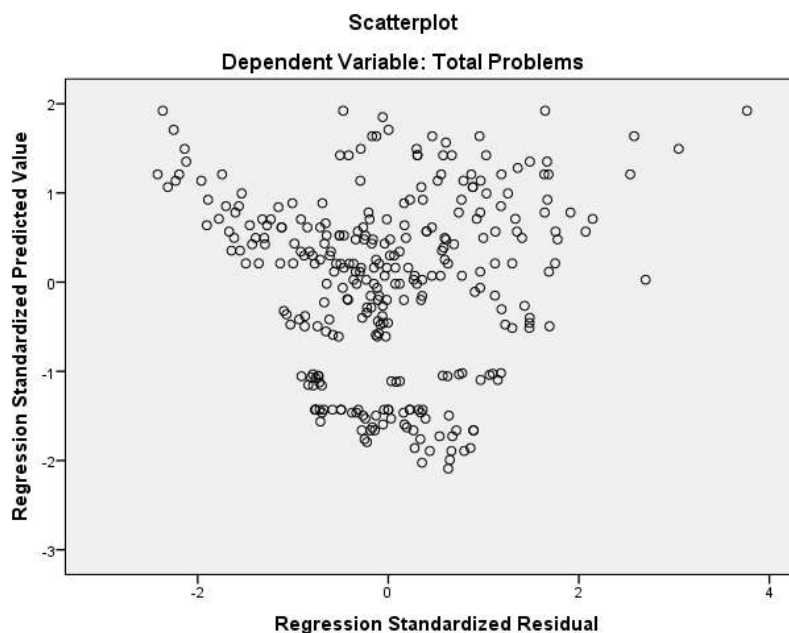
In this example, Model 2 with the interaction between depression and poverty level accounted for significantly more variance than just depression and poverty level by themselves,  $R^2$  change = .020,  $p = .003$ , indicating that there is potentially significant moderation between depression and poverty level on child's behavior problems.

**Syntax for Step 1**

```
REGRESSION
/MISSING LISTWISE
/STATISTICS COEFF OUTS R ANOVA COLLIN TOL CHANGE
/CRITERIA=PIN(.05) POUT(.10)
/NOORIGIN
/DEPENDENT totprob
/METHOD=ENTER PovertyLevel bsidep
/METHOD=ENTER Pvertyxdepression
/SCATTERPLOT=(*ZPRED,*ZRESID).
```

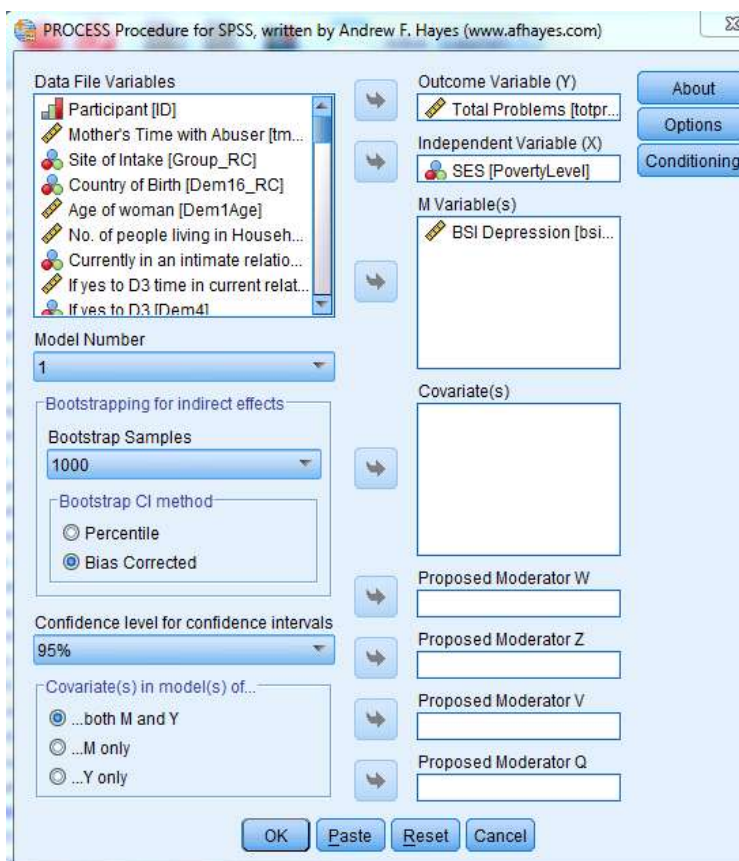
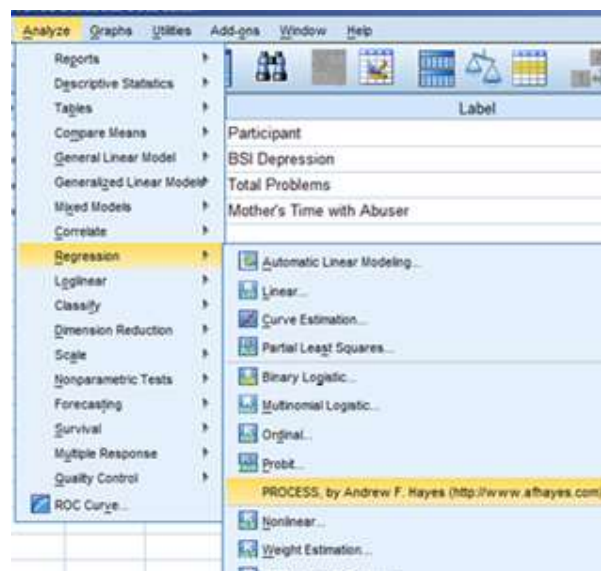
This scatterplot syntax will give you a graph of the residuals so you can examine heteroskedasticity.

You want the scatter plot to be well distributed.



**Step 2** - Since there is a potentially significant moderation effect, we can run the regression on the centered terms to examine the effect. While you can do this by centering the terms yourself and building the regression, this is best done using an add-on process.

3. Your dataset must be open. To run the analysis, click on analyze, then regression, then PROCESS, by Andrew F. Hayes (http://www.afhayes.com). If you don't see this menu item, it means that this process first needs to be installed on your computer.



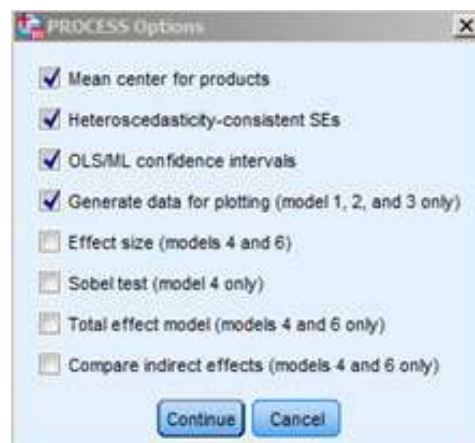
4. The PROCESS Dialog will open. Select and move the initial IV (X), the DV (Y) and the moderator variable (M) into their appropriate boxes as shown in the picture.

5. You can also include any covariates in the appropriate box.

6. In order to test a *moderation* effect, make sure that the Model Number is set to 1.

7. Click on the Options button and select appropriate options. To better examine the effect of a moderating variable, the first four options (Mean center for products, Heteroscedasticity-consistent SEs, OLS/ML confidence intervals, and Generate data for plotting) can be selected.

8. The syntax for this process is very long. You can create a syntax file by clicking on Paste.





**Output** - After running this process, the output you will see will look similar to what is shown below. Since bootstrapping is used to calculate standard errors and confidence intervals, this might take a little while.

Run MATRIX procedure:

\*\*\*\*\* PROCESS Procedure for SPSS Beta Release 140712 \*\*\*\*\*

Written by Andrew F. Hayes, Ph.D. <http://www.afhayes.com>

\*\*\*\*\*

Model = 1

Y = totprob  
X = PovertyL  
M = bsidep

Sample size

300

\*\*\*\*\*

Outcome: totprob

Model Summary

| R     | R-sq  | F       | df1    | df2      | p     |
|-------|-------|---------|--------|----------|-------|
| .6002 | .3602 | 56.6464 | 3.0000 | 296.0000 | .0000 |

Model

|          | coeff   | se     | t       | p     | LLCI    | ULCI    |
|----------|---------|--------|---------|-------|---------|---------|
| constant | 42.4127 | 1.2801 | 33.1317 | .0000 | 39.8934 | 44.9320 |
| bsidep   | .5487   | .2126  | 2.5802  | .0104 | .1302   | .9672   |
| PovertyL | 10.8893 | .9639  | 11.2975 | .0000 | 8.9924  | 12.7863 |
| int_1    | .4319   | .1525  | 2.8323  | .0049 | .1318   | .7320   |

Interactions:

int\_1 PovertyL X bsidep

\*\*\*\*\*

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

| bsidep  | Effect  | se     | t       | p     | LLCI    | ULCI    |
|---------|---------|--------|---------|-------|---------|---------|
| -6.6380 | 8.0223  | 1.0958 | 7.3207  | .0000 | 5.8657  | 10.1789 |
| .0000   | 10.8893 | .9639  | 11.2975 | .0000 | 8.9924  | 12.7863 |
| 6.6380  | 13.7564 | 1.6452 | 8.3617  | .0000 | 10.5187 | 16.9941 |

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

\*\*\*\*\*

Data for visualizing conditional effect of X of Y

| PovertyL | bsidep  | yhat    |
|----------|---------|---------|
| -1.4453  | -6.6380 | 27.1759 |
| .0000    | -6.6380 | 38.7707 |
| 1.4453   | -6.6380 | 50.3654 |
| -1.4453  | .0000   | 26.6742 |
| .0000    | .0000   | 42.4127 |
| 1.4453   | .0000   | 58.1513 |
| -1.4453  | 6.6380  | 26.1724 |
| .0000    | 6.6380  | 46.0548 |
| 1.4453   | 6.6380  | 65.9372 |

Use these values to  
plot the interaction  
using the Excel file  
"Interaction Plot"

\*\*\*\*\* ANALYSIS NOTES AND WARNINGS \*\*\*\*\*

Level of confidence for all confidence intervals in output:

95.00

NOTE: The following variables were mean centered prior to analysis:

PovertyL bsidep

NOTE: All standard errors for continuous outcome models are based on the HC3 estimator

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

The first part of the output lists the variables in the analysis, indicating which is considered as a dependent variable (Y), which an independent variable (X) and which a moderator (M). The total sample size is also displayed. Then the results from a regression model are displayed which includes the interaction effect between the independent variable and the moderator.

### Step 3 - Plot the interaction points to interpret the interaction.

Open the Excel file "Interaction Plot" and enter the values from the output in the green cells (B4:D6). Also change the labels in A3 and C2 to reflect your variable names.

|    | A               | B                 | C                  | D               |
|----|-----------------|-------------------|--------------------|-----------------|
| 1  |                 |                   |                    |                 |
| 2  |                 | <u>Depression</u> |                    |                 |
| 3  | <u>Poverty</u>  | (1 SD Below)      | (Mean)             | (1 SD Above)    |
| 4  | (1 SD Below)    | 27.176            | 26.6742            | 26.1724         |
| 5  | (Mean)          | 38.771            | 42.4127            | 46.0541         |
| 6  | (1 SD Above)    | 50.365            | 42.4127            | 65.9371         |
| 7  |                 |                   |                    |                 |
| 8  |                 | Low Depression    | Average Depression | High Depression |
| 9  | Low Poverty     | 27.176            | 26.674             | 26.172          |
| 10 | Average Poverty | 38.771            | 42.413             | 46.055          |
| 11 | High Poverty    | 50.365            | 42.413             | 65.937          |
| 12 |                 |                   |                    |                 |

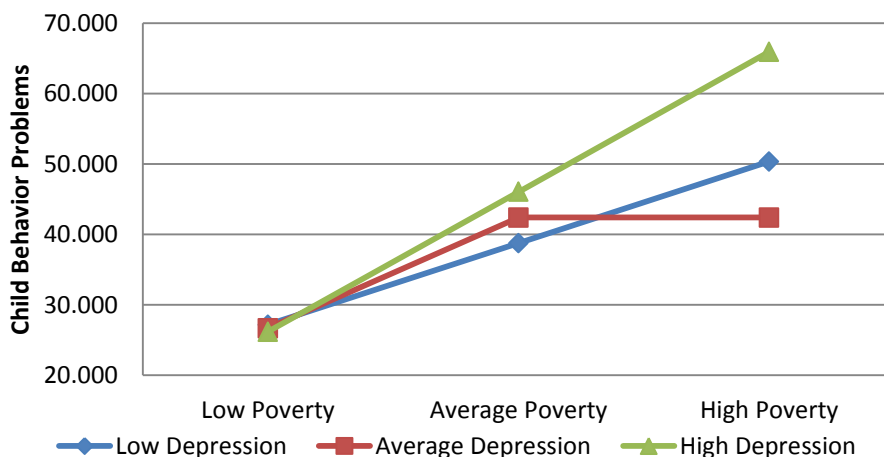
Change the variables names in the blue cells only to accurately describe your chart. Keep the "Low Average High".

### Sample Write up

To test the hypothesis that the child behavior problems are a function of multiple risk factors, and more specifically whether mother's depression moderates the relationship between poverty level and child behavior problems, a hierarchical multiple regression analysis was conducted. In the first

step, two variables were included: poverty level and mother's depression. These variables accounted for a significant amount of variance in child's behavior problems,  $R^2 = .340$ ,  $F(2, 297) = 76.57$ ,  $p < .001$ . To avoid potentially problematic high multicollinearity with the interaction term, the variables were centered and an interaction term between poverty level and mother's depression was created (Aiken & West, 1991).

Next, the interaction term between poverty level and mother's depression was added to the regression model, which accounted for a significant proportion of the variance in child behavior problems,  $\Delta R^2 = .02$ ,  $\Delta F(1, 296) = 9.27$ ,  $p = .001$ ,  $b = .432$ ,  $t(296) = 2.83$ ,  $p < .01$ . Examination of the interaction plot showed an enhancing effect that as poverty and mother's depression increased, child behavior problems increased. At low poverty, child behavior problems were similar for mother's with low, average, or high depression. Children from high poverty homes with mother's who had high depression had the worst behavior problems.

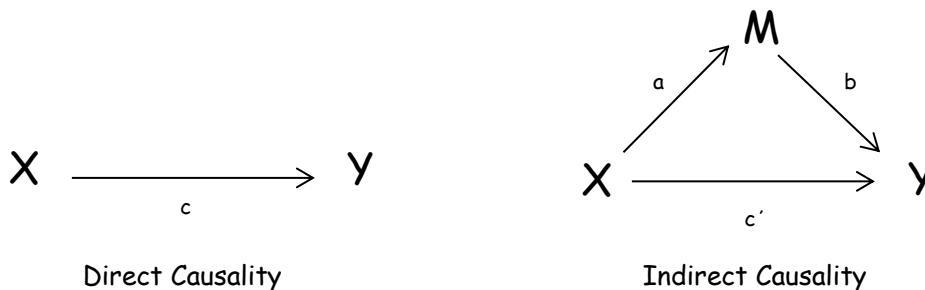


### References

Aiken, L. S., & West, S. G. (1991). Multiple regression: Testing and interpreting interactions. Thousand Oaks, CA: Sage.

# Mediation

Mediation implies a situation where the effect of the independent variable on the dependent variable can best be explained using a third *mediator* variable which is caused by the independent variable and is itself a cause for the dependent variable. That is to say instead of X causing Y directly, X is causing the mediator M, and M is in turn causing Y. The causal relationship between X and Y in this case is said to be *indirect*. The relationships between the independent, the mediator and the dependent variables can be depicted in form of a path diagram/model.



Each arrow in a path diagram represents a causal relationship between two variables to which a coefficient or weight is assigned. These coefficients are nothing but the standardized regression coefficients (betas) showing the direction and magnitude of the effect of one variable on the other.

## Variables

Instead of using the terms independent and dependent variables, it would make more sense in the context of path models to speak of exogenous and endogenous variables.

*Exogenous Variables* - Variables which in the context of the model have no explicit causes. That is to say they have no arrows going to them.

*Endogenous Variables* - Variables which in the context of the model are causally affected by other variables. That is to say they have arrows going to them.

From a regression standpoint, for every endogenous variable in the model a regression model should be fitted.

## Assumptions

1. *Continuous Measurements*. All variables are assumed to be measured on a continuous scale.
2. *Normality*. All variables are assumed to follow a Normal distribution.
3. *Independence*. The errors associated with one observation are not correlated with the errors of any other observation.
4. *Linearity*: relationships among the variables are assumed to be linear.

## Steps in Testing Mediation

In order to confirm a mediating variable and its significance in the model, we must show that while the mediator is caused by the initial IV and is a cause of the DV, the initial IV loses its significance when the mediator is included in the model. In more explicit terms, we should follow the following four steps:

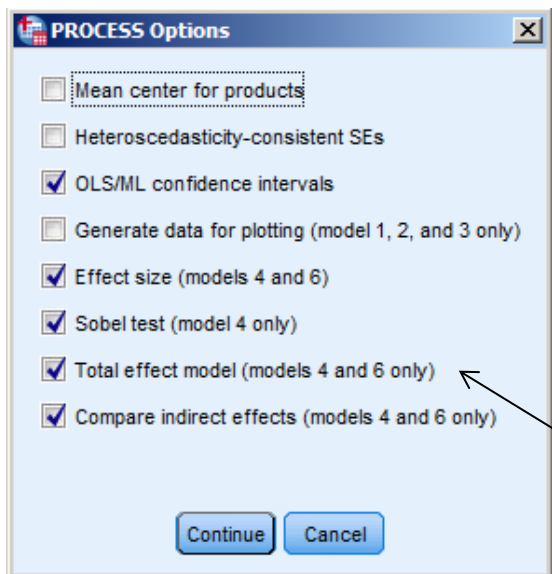
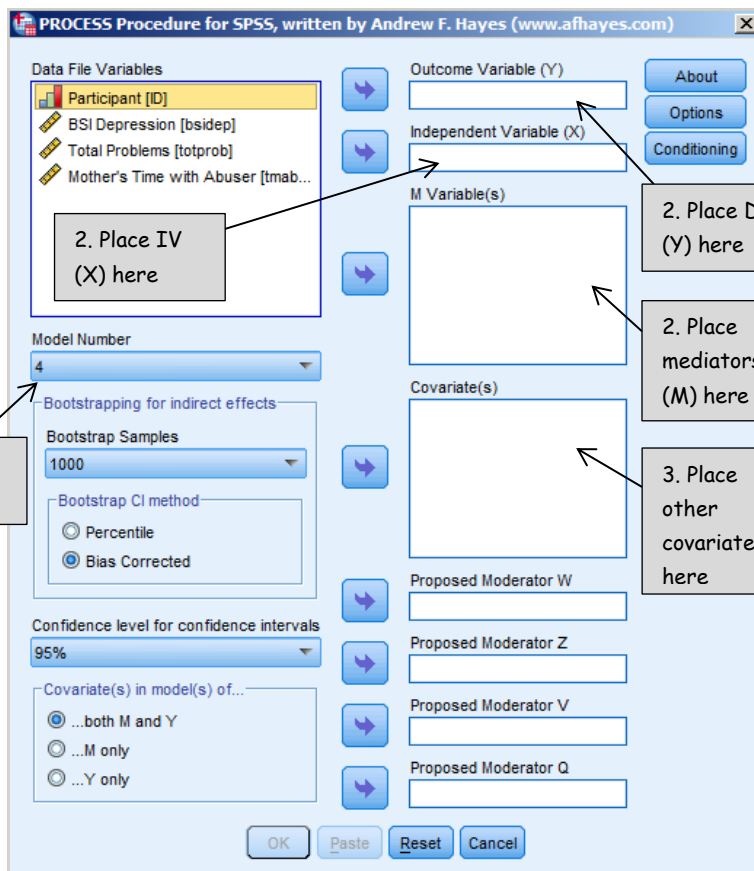
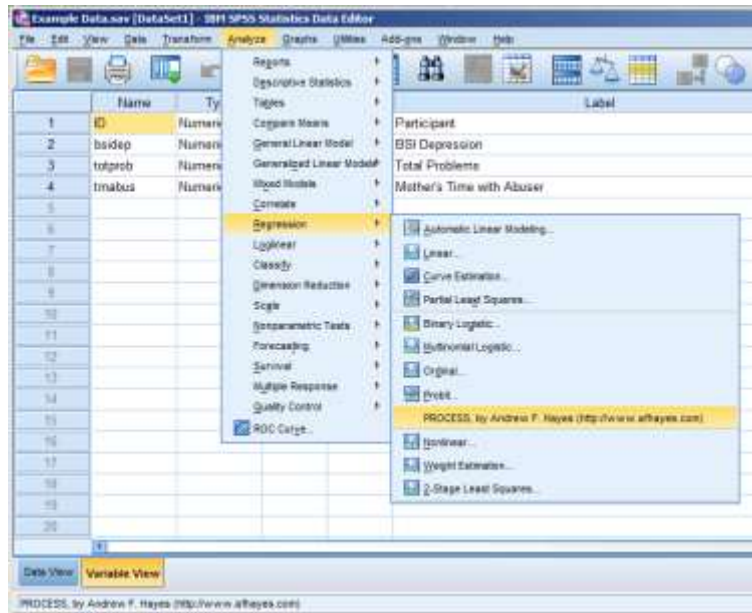
1. Confirm the significance of the relationship between the initial IV and DV ( $X \rightarrow Y$ )
2. Confirm the significance of the relationship between the initial IV and the mediator ( $X \rightarrow M$ )
3. Confirm the significance of relationship between the mediator and the DV in the presence of the IV ( $M|X \rightarrow Y$ )
4. Confirm the insignificance (or the meaningful reduction in effect) of the relationship between the initial IV and the DV in the presence of the mediator ( $X|M \rightarrow Y$ )

Steps 3 and 4 will involve the same regression model.

### Conducting the Analysis in SPSS

Mediation can be tested by following the above steps using the regular linear regression menu item in SPSS, or more conveniently using a special PROCESS developed by Andrew F. Hayes which is described below.

1. Your dataset must be open. To run the analysis, click analyze, then regression, then PROCESS, by Andrew F. Hayes (<http://www.afhayes.com>)  
If you don't see this menu item, it means that this process first needs to be installed on your computer.
2. The PROCESS Dialog will open. Select and move the initial IV (X), the DV (Y) and the mediator variable (M) into their appropriate boxes as shown in the picture.
3. You can also include any covariates in the appropriate box.
4. In order to test a *mediation* effect, make sure that the Model Number is set to 4.
5. Click on the Options button and select appropriate options. To better examine the effect of a mediating variable, the last four options (Effect size, Sobel test, Total effect model, and Compare indirect effects) can be selected.
6. The syntax for this process is very long. You can create a syntax file by clicking on Paste.



5. Select appropriate options



**Output** After running this process, the output will look similar to what is shown below. Since bootstrapping is used to calculate standard errors and confidence intervals, this might take a little while.

Run MATRIX procedure:

\*\*\*\*\* PROCESS Procedure for SPSS Beta Release 140712 \*\*\*\*\*

Written by Andrew F. Hayes, Ph.D. <http://www.afhayes.com>

\*\*\*\*\*

Model = 4

Y = totprob  
X = tmabus  
M = bsidep

Variables in the analysis

Sample size  
300

\*\*\*\*\*

Outcome: bsidep

Model Summary

| R     | R-sq  | F        | df1    | df2      | p     |
|-------|-------|----------|--------|----------|-------|
| .7079 | .5011 | 299.3041 | 1.0000 | 298.0000 | .0000 |

Model

|          | coeff  | se    | t       | p     | LLCI   | ULCI    |
|----------|--------|-------|---------|-------|--------|---------|
| constant | 5.0764 | .3748 | 13.5439 | .0000 | 4.3388 | 5.8140  |
| tmabus   | 9.3921 | .5429 | 17.3004 | .0000 | 8.3237 | 10.4605 |

\*\*\*\*\*

Outcome: totprob

Model Summary

| R     | R-sq  | F       | df1    | df2      | p     |
|-------|-------|---------|--------|----------|-------|
| .2974 | .0884 | 14.4054 | 2.0000 | 297.0000 | .0000 |

Model

|          | coeff   | se     | t       | p     | LLCI    | ULCI    |
|----------|---------|--------|---------|-------|---------|---------|
| constant | 32.3713 | 2.6812 | 12.0735 | .0000 | 27.0948 | 37.6479 |
| bsidep   | .9080   | .3260  | 2.7852  | .0057 | .2664   | 1.5496  |
| tmabus   | 5.4908  | 4.3256 | 1.2694  | .2053 | -3.0220 | 14.0035 |

\*\*\*\*\* TOTAL EFFECT MODEL \*\*\*\*\*

Outcome: totprob

Model Summary

| R     | R-sq  | F       | df1    | df2      | p     |
|-------|-------|---------|--------|----------|-------|
| .2542 | .0646 | 20.5867 | 1.0000 | 298.0000 | .0000 |

Model

|          | coeff   | se     | t       | p     | LLCI    | ULCI    |
|----------|---------|--------|---------|-------|---------|---------|
| constant | 36.9809 | 2.1332 | 17.3357 | .0000 | 32.7828 | 41.1790 |
| tmabus   | 14.0191 | 3.0898 | 4.5373  | .0000 | 7.9386  | 20.0997 |

\*\*\*\*\* TOTAL, DIRECT, AND INDIRECT EFFECTS \*\*\*\*\*

Total effect of X on Y

| Effect  | SE     | t      | p     | LLCI   | ULCI    |
|---------|--------|--------|-------|--------|---------|
| 14.0191 | 3.0898 | 4.5373 | .0000 | 7.9386 | 20.0997 |

| Direct effect of X on Y |        |        |        |       |         |         |
|-------------------------|--------|--------|--------|-------|---------|---------|
|                         | Effect | SE     | t      | p     | LLCI    | ULCI    |
|                         | 5.4908 | 4.3256 | 1.2694 | .2053 | -3.0220 | 14.0035 |

| Indirect effect of X on Y |        |         |          |          |
|---------------------------|--------|---------|----------|----------|
|                           | Effect | Boot SE | BootLLCI | BootULCI |
| bsidep                    | 8.5283 | 3.1283  | 2.7878   | 14.9841  |

Indirect effect of X on Y significantly greater than zero

| Partially standardized indirect effect of X on Y |        |         |          |          |
|--|--------|---------|----------|----------|
|  | Effect | Boot SE | BootLLCI | BootULCI |
| bsidep   | .3091  | .1078   | .1041    | .5142    |

| Completely standardized indirect effect of X on Y |        |         |          |          |
|---|--------|---------|----------|----------|
|   | Effect | Boot SE | BootLLCI | BootULCI |
| bsidep  | .1546  | .0539   | .0520    | .2573    |

| Ratio of indirect to total effect of X on Y |        |         |          |          |
|---|--------|---------|----------|----------|
|   | Effect | Boot SE | BootLLCI | BootULCI |
| bsidep                                      | .6083  | .2777   | .1872    | 1.2285   |

| Ratio of indirect to direct effect of X on Y |        |          |          |          |
|--|--------|----------|----------|----------|
|  | Effect | Boot SE  | BootLLCI | BootULCI |
| bsidep                                       | 1.5532 | 250.7987 | -4.9630  | 109.7770 |

| R-squared mediation effect size (R-sq_med) |        |         |          |          |
|--|--------|---------|----------|----------|
|  | Effect | Boot SE | BootLLCI | BootULCI |
| bsidep                                     | .0597  | .0228   | .0232    | .1196    |

| Preacher and Kelley (2011) Kappa-squared |        |         |          |          |
|--|--------|---------|----------|----------|
|  | Effect | Boot SE | BootLLCI | BootULCI |
| bsidep                                   | .1130  | .0386   | .0399    | .1910    |

| Normal theory tests for indirect effect |        |        |        |       |
|---|--------|--------|--------|-------|
|   | Effect | se     | Z      | p     |
|   | 8.5283 | 3.1065 | 2.7453 | .0060 |

\*\*\*\*\* ANALYSIS NOTES AND WARNINGS \*\*\*\*\*

Number of bootstrap samples for bias corrected bootstrap confidence intervals:  
1000

Level of confidence for all confidence intervals in output:  
95.00

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

The first part of the output lists all variables in the analysis, indicating which is considered as a dependent variable (Y), which an independent variable (X) and which a mediator (M). The total sample size is also displayed.

Then a series of regression models are fitted, first predicting the mediator variable using the independent variable (step 2); then the dependent variable using both the independent variable and the mediator (steps 3 and 4); and finally the dependent variable using the independent variable (step 1). In this case, while the independent variable was a significant predictor for both the dependent and the mediator variables, it is no longer significant in the presence of the mediator variable; confirming the mediation effect. A measure for the indirect effect of X on Y is also presented after the regression models. In this case the effect size was 8.5283, with a 95% confidence interval which did not include zero; that is to say the effect was significantly greater than zero at a = .05.

**Sample Write up**

In Step 1 of the mediation model, the regression of mother's time spent with the abuser on child behavior problems, ignoring the mediator, was significant,  $b = 14.02$ ,  $t(298) = 14.02$ ,  $p = <.001$ . Step 2 showed that the regression of the mother's time spent with the abuser on the mediator, depression, was also significant,  $b = 9.39$ ,  $t(298) = 17.30$ ,  $p = <.001$ . Step 3 of the mediation process showed that the mediator (depression), controlling for mother's time with the abuser, was significant,  $b = .908$ ,  $t(297) = 2.79$ ,  $p = .0057$ . Step 4 of the analyses revealed that, controlling for the mediator (depression), mother's time with the abuser scores was not a significant predictor of child behavior problems,  $b = 5.49$ ,  $t(297) = 1.23$ ,  $p = .2053$ . A Sobel test was conducted and found full mediation in the model ( $z = 2.74$ ,  $p = .006$ ). It was found that depression fully mediated the relationship between mother's time spent with the abuser and child behavior problems.