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Module Title: Introduction to Statistics

Session Title: Testing Indirect Effects

Topic title: Mediation

After working through this session you should be able to:

- To understand how to test the indirect effect to establish mediation
- To use parametric and non-parametric tests for testing the indirect effects

Baron and Kenny Steps

Before, we focused on understanding the four steps from Baron and Kenny to establish mediation.

Are all four steps essential?

- Step 1 establishes that there is an effect (path c) that may be mediated, but is **not essential** for establishing mediation. (see **http://davidakenny.net/cm/mediate.htm**)
- Steps 2 and 3 are **essential** for establishing mediation
    - These steps (2 & 3) establish paths a and b (and also c′) which lead to an estimate of the indirect effect (ab). Existence of an indirect effect is **sufficient** to justify mediation
- Newer methods (e.g. Sobel test) recommend testing **only the indirect effect** (paths a and b) to establish mediation

Testing the Indirect Effect “ab”

- There are several methods for testing the indirect effect:

$$\begin{cases} H_0: ab = 0 \\ H_1: ab \neq 0 \end{cases}$$

- Two of the commonly used tests are:

- Sobel test (Normal Theory Approach)
- Nonparametric Sobel test (bootstrapping)

Sobel Test of Indirect Effect

$$\begin{cases} H_0: ab = 0 \\ H_1: ab \neq 0 \end{cases}$$

- Sobel statistic test is based on an approximate z-statistic, given by: $Z = \frac{ab}{SE(ab)}$
- SE(ab) denotes the standard error of the estimated indirect effect, given by:

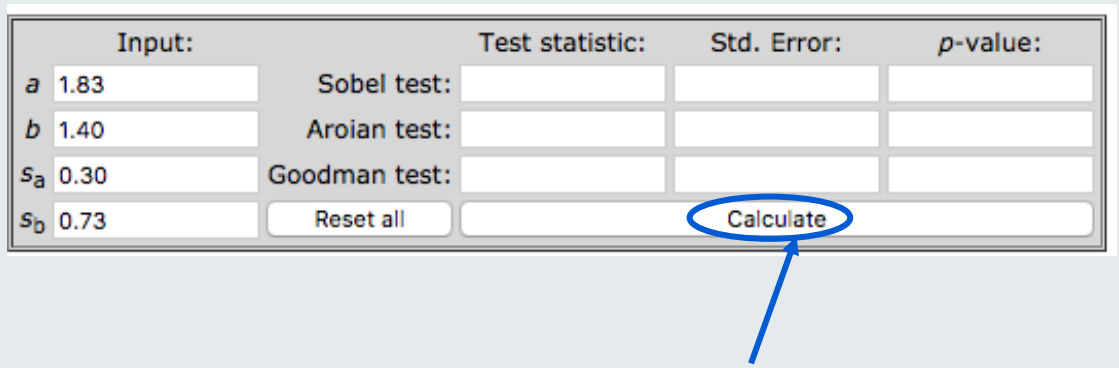
$$\mathbf{SE(ab)} = \sqrt{\mathbf{a^2 S_b^2 + b^2 S_a^2}}$$

Where $\mathbf{S_a}$ and $\mathbf{S_b}$ are **SE of the coefficients for a and b** (Taken from the multiple linear regression model)

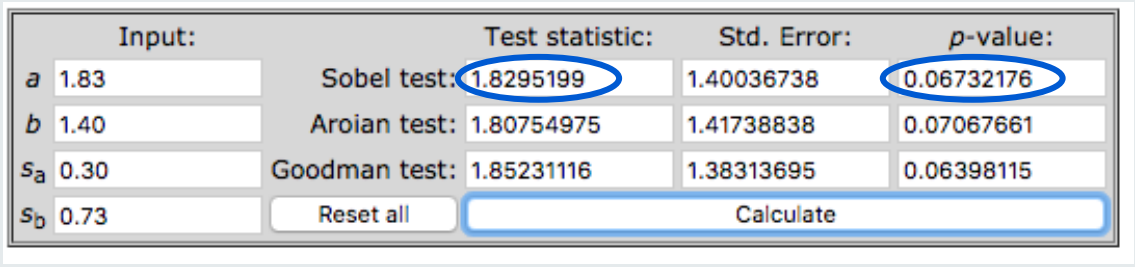
- Decision rule: if Z in absolute value is greater than 1.96, reject the hypothesis that the indirect effect is zero.

Software, Output and Interpretation Slide

- The test can be done using online calculator
- **http://quantpsy.org/sobel/sobel.htm**



Input:			Test statistic:	Std. Error:	*p*-value:
a	1.83	Sobel test:			
b	1.40	Aroian test:			
s_a	0.30	Goodman test:			
s_b	0.73	Reset all	Calculate		

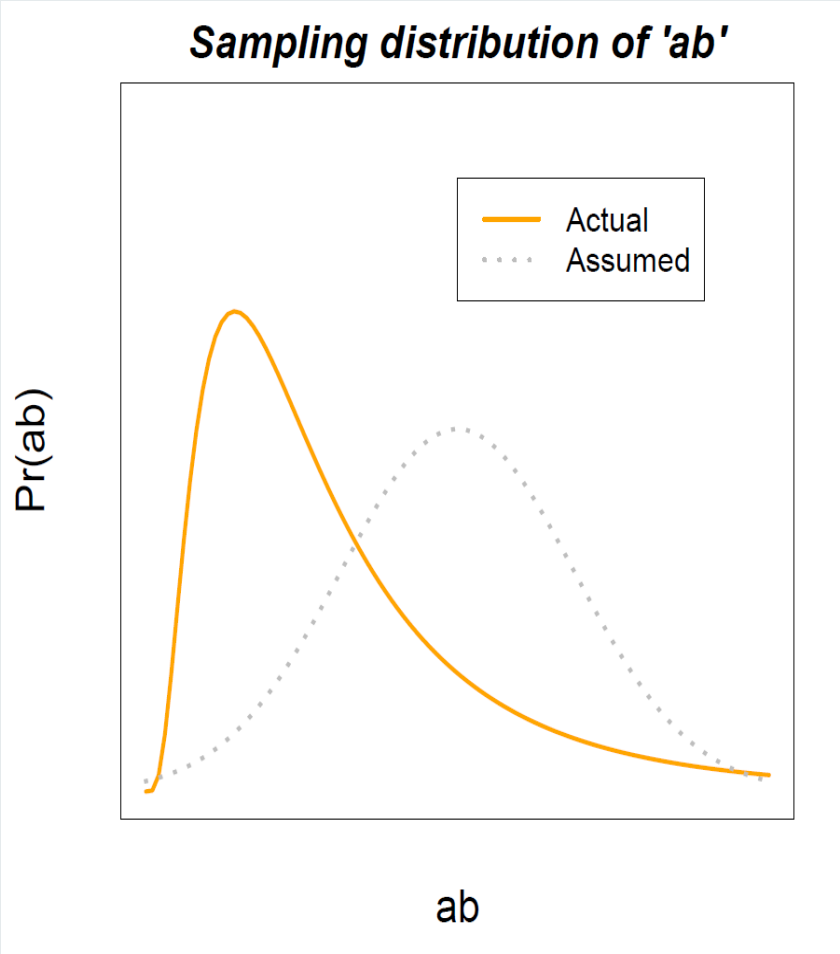


Input:			Test statistic:	Std. Error:	*p*-value:
a	1.83	Sobel test:	1.8295199	1.40036738	0.06732176
b	1.40	Aroian test:	1.80754975	1.41738838	0.07067661
s_a	0.30	Goodman test:	1.85231116	1.38313695	0.06398115
s_b	0.73	Reset all	Calculate		

As Z (Sobel Test Statistic) in absolute value is less than 1.96, fail to reject the null hypothesis that the indirect effect is zero (p=0.067)

Limitation of Sobel Test

- Sobel test is based on **normal** approximation (z-test)
- Sampling distribution of ‘ab’ is actually highly skewed
- Large values of ‘ab’ are more variable than the smaller values
- This may lower the statistical power of the Sobel test
- Sobel test works well only in **large samples**, because the skewness is reduced.



Non-parametric Sobel Test

- Nonparametric version of Sobel test via bootstrapping offers a **better alternative** that **imposes no distributional assumptions.**
- **Bootstrapping** requires taking a **large number of samples** (with replacement) from the original dataset
- **Indirect effect (ab)** is **estimated for each** of the bootstrap samples
- These bootstrap estimates are used to **form a non-parametric sampling distribution** of the indirect effect
- From the sampling distribution a **confidence interval for ab** is estimated.
- Indirect effect is said to be significant if the **confidence interval does not contain zero.**

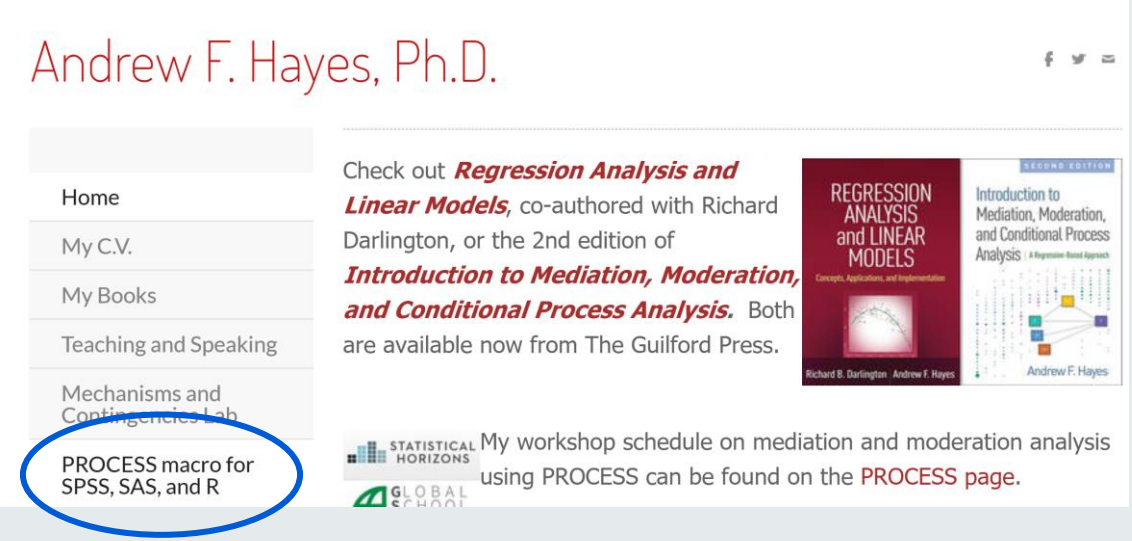
Bias-corrected Bootstrap

It is possible that the mean of the bootstrap estimates differs slightly from the original estimate of indirect effect (ab).

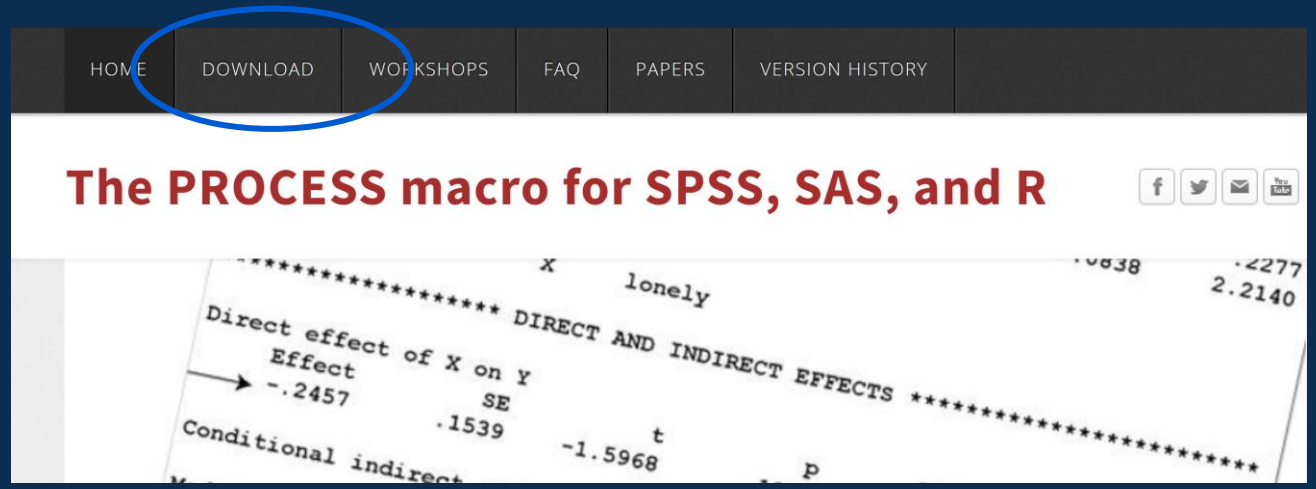
Bias-corrected bootstrap is the recommended method for testing indirect effect

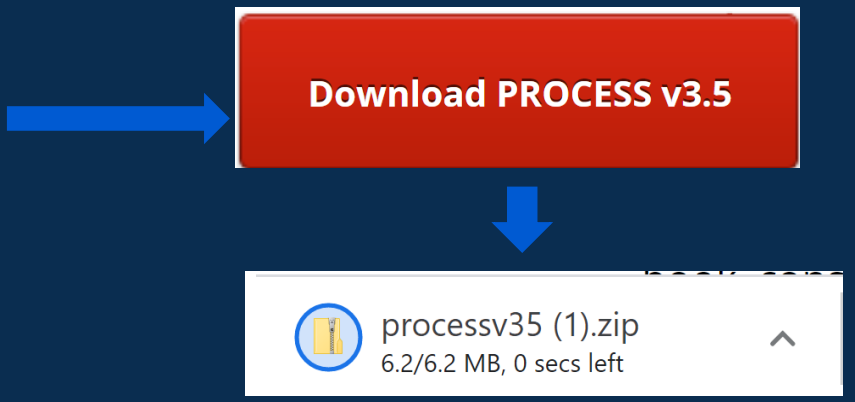
This can be done using the PROCESS macro (see Hayes & Rockwood, 2017), if installed in your SPSS

Can be downloaded free from Andrew Hayes' website http://www.afhayes.com

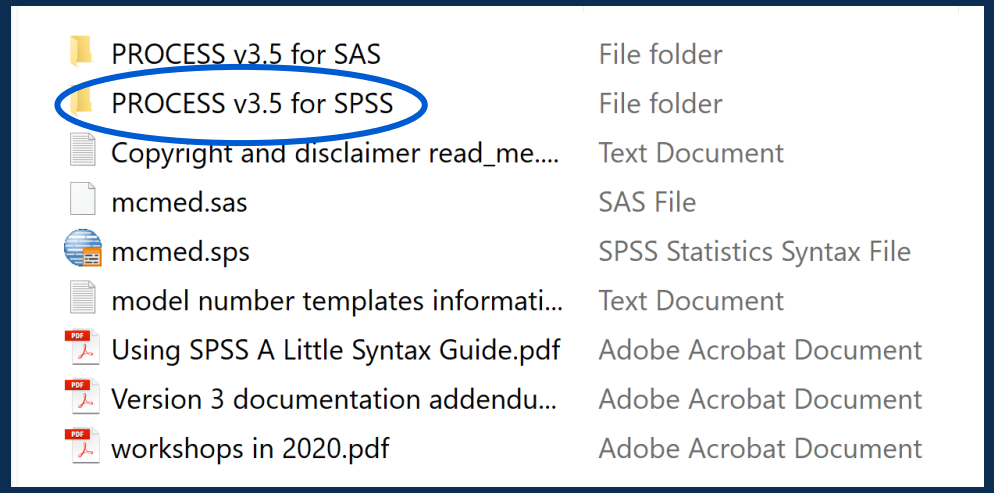


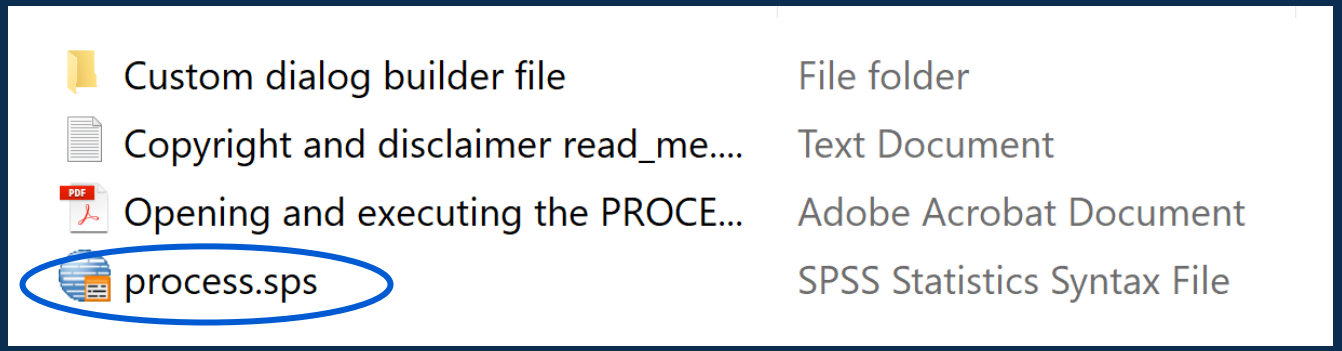
Process Macro ‘how to’ Option 1





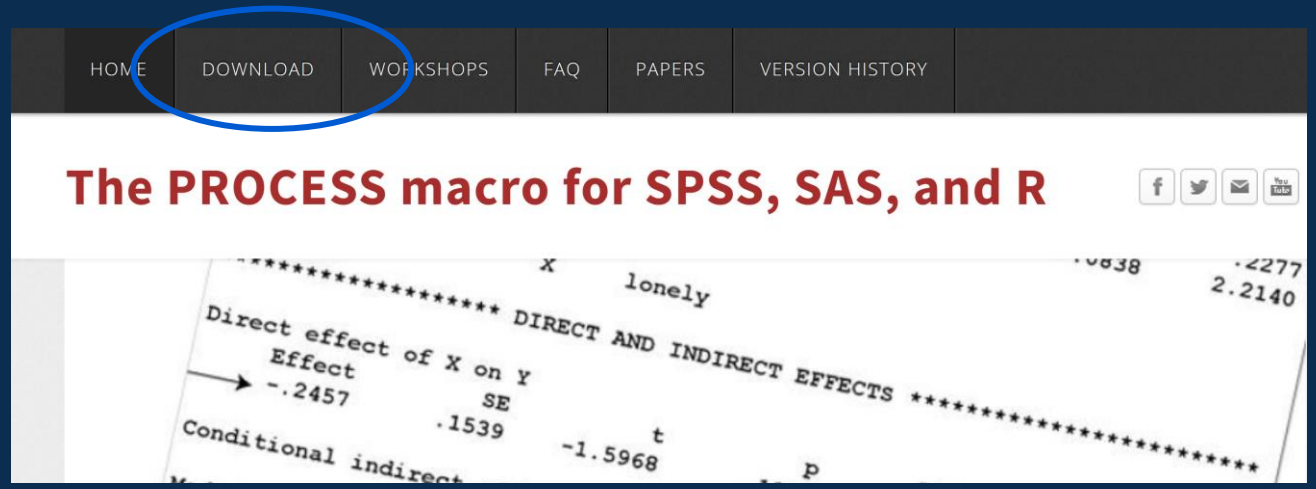
Click ‘Download; Scroll down the page and Click ‘Download PROCESS v3.5). Open the zip file
Open the PROCESS v3,5 for SPSS folder.

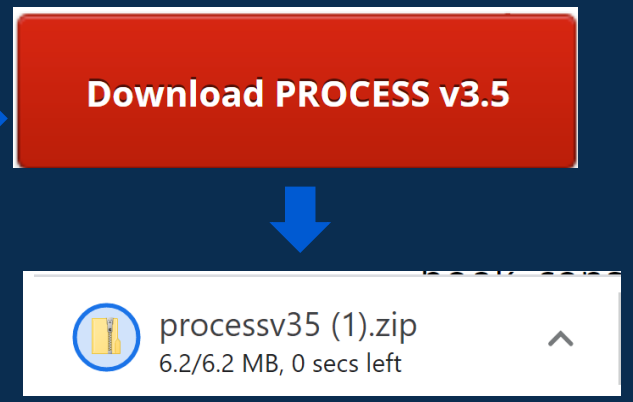




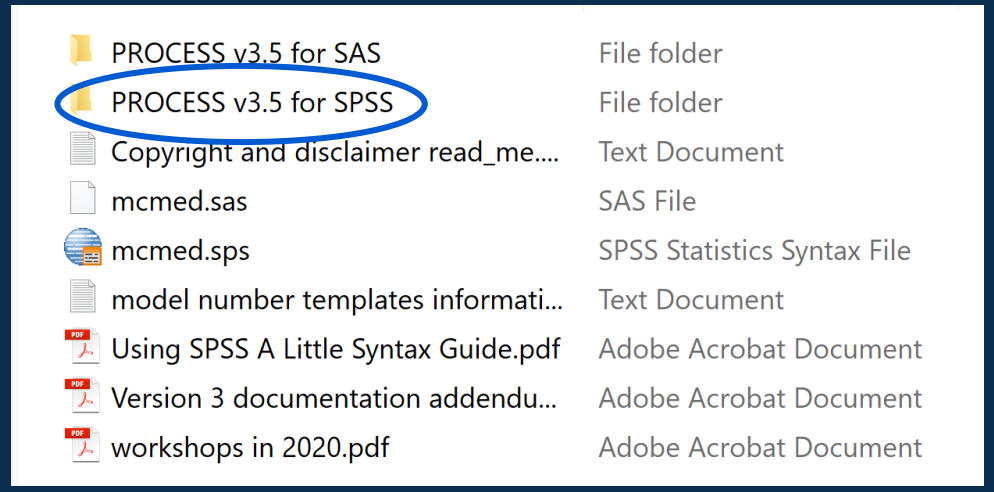
Extract and Open the process.sps file in a new syntax window in SPSS
Run all by , selecting all syntax clicking on the big green triangle

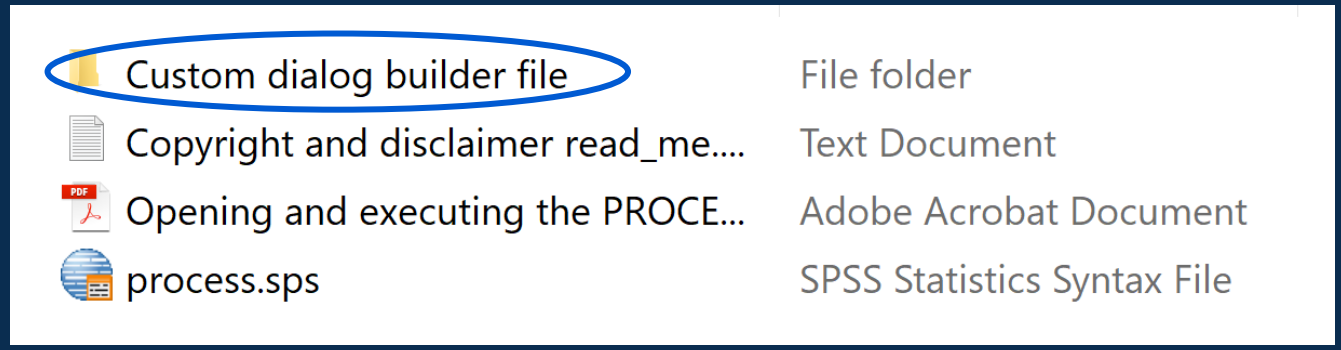
Process Macro ‘how to’ Option 2



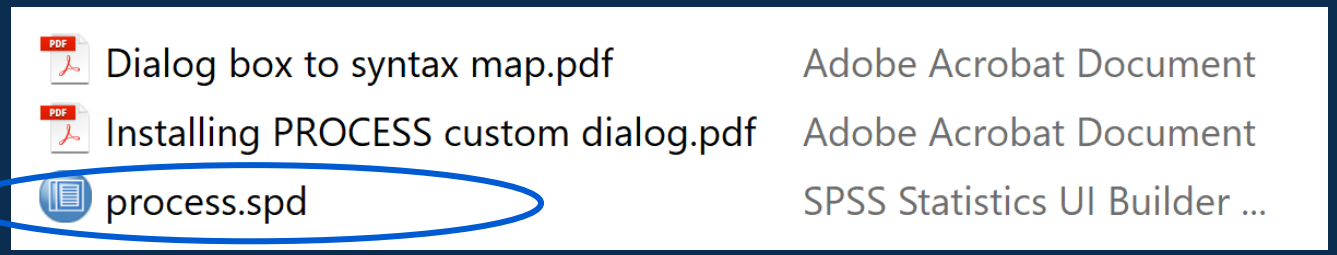


Click ‘Download; Scroll down the page and Click ‘Download PROCESS v3.5). Open the zip file Open the PROCESS v3,5 for SPSS folder.



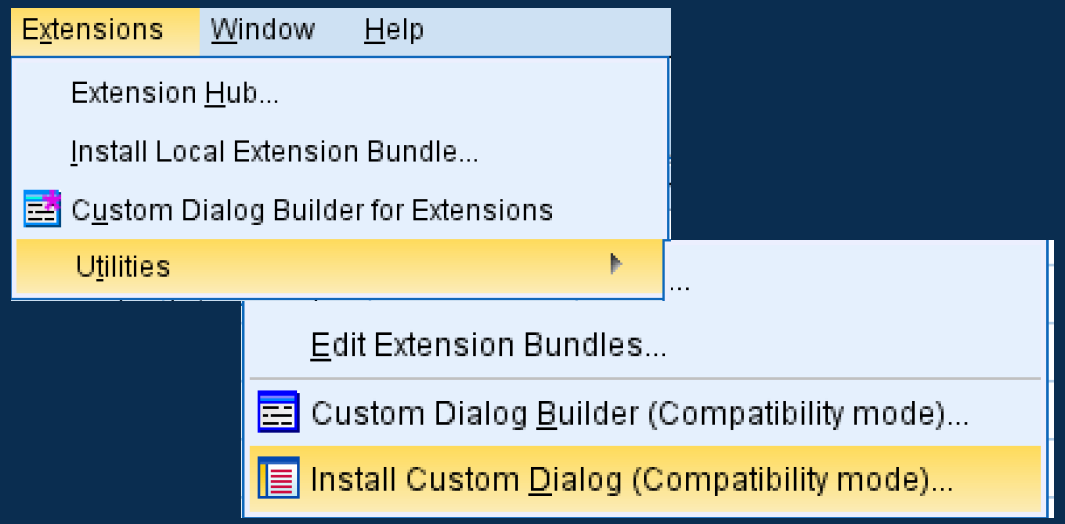


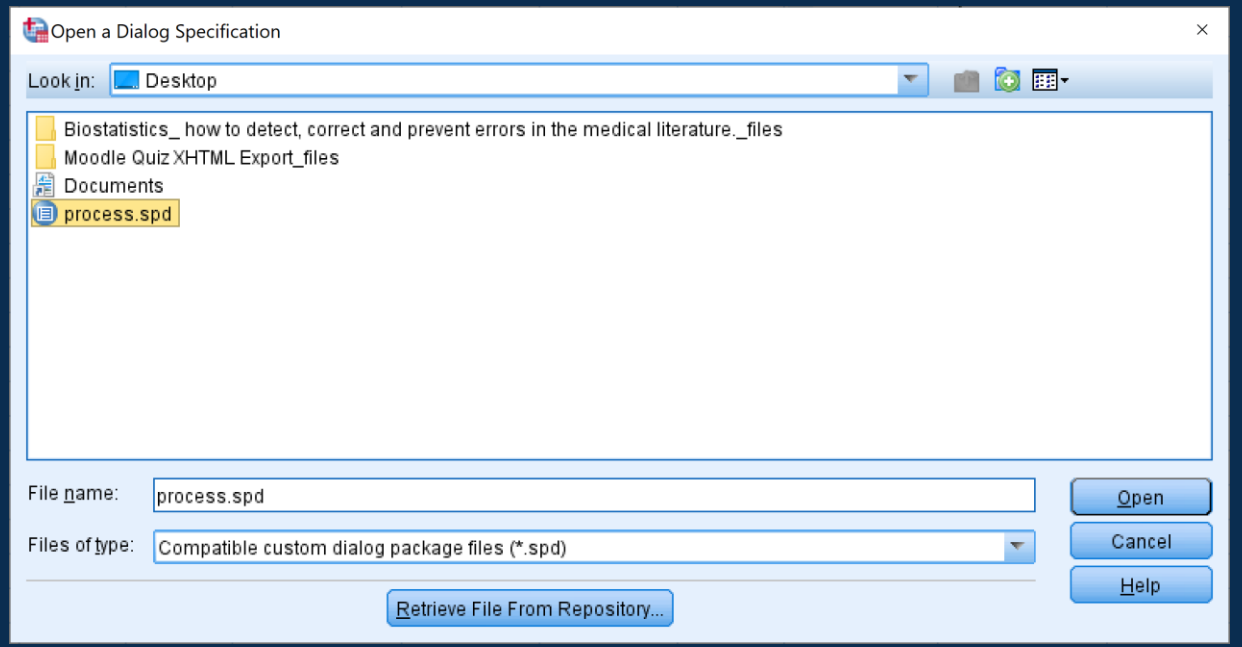
Process Macro ‘how to’ Option 2



Extract the process.spd file

Extensions → Utilities → Install Custom Dialog





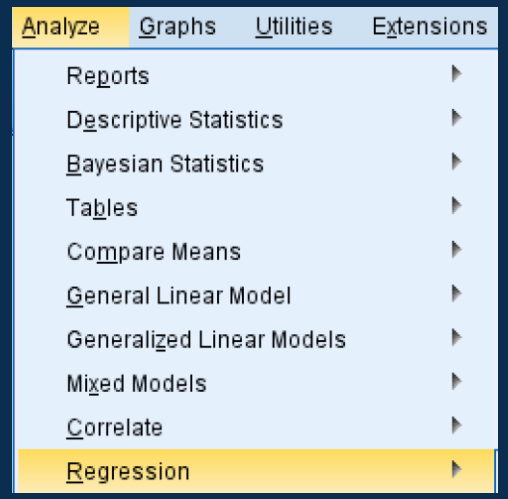
SPSS Slide: 'How to'

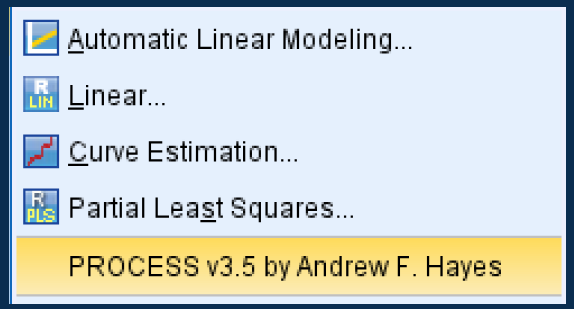
Use Lecture_8_data to test an indirect effect. In the regression menu you will see a new option PROCESS

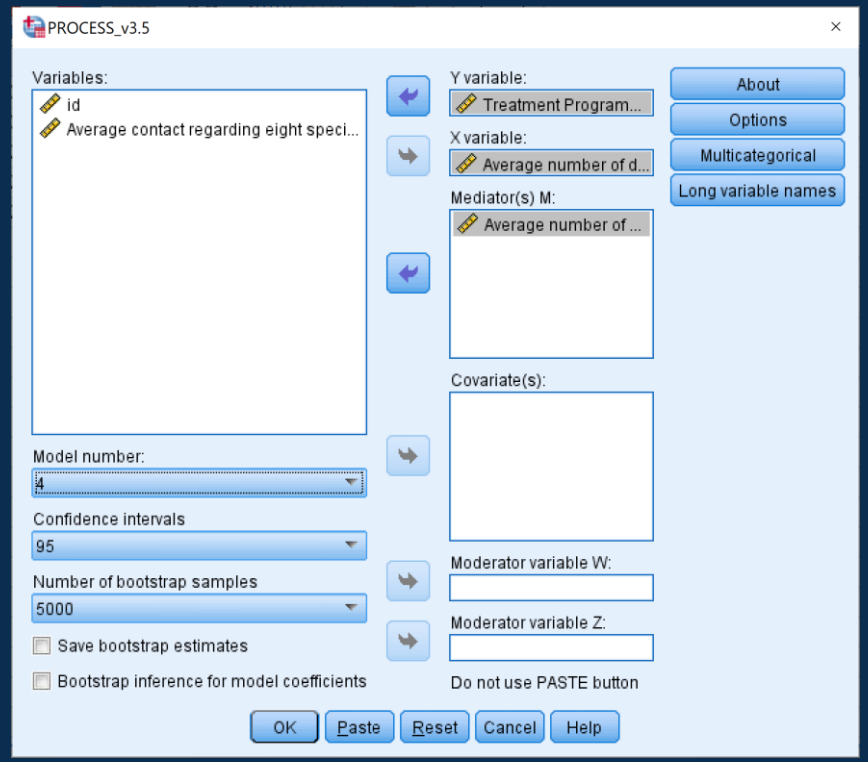
Computing probit regression models

1) Use **Analyse -> Regression -> PROCESS**

2) Add' days_hous' in '**Outcome**' box, 'treat' in the '**independent variables**' box and the contacts in the '**M Variables**'. Box, choose **'Model 4'**







Note:
PROCESS does not allow variable names to be more than eight characters

Make the names shorter in the 'variable view' of the dataset.

Output and Interpretation Slide

```
Model   : 4
    Y   : days_hou
    X   : treat
    M   : contacts

Sample
Size:   109
```

OUTCOME VARIABLE:
contacts

Model Summary

R	R-sq	MSE	F	df1	df2	p
.2364	.0559	14.0765	6.3329	1.0000	107.0000	.0133

Model

	coeff	se	t	p	LLCI	ULCI
constant	2.6889	.4727	5.6885	.0000	1.7518	3.6259
treat	1.8311	.7276	2.5165	.0133	.3887	3.2736

OUTCOME VARIABLE:
days_hou

Model Summary

R	R-sq	MSE	F	df1	df2	p
.4694	.2203	136.4668	14.9774	2.0000	106.0000	.0000

Model

	coeff	se	t	p	LLCI	ULCI
constant	9.0246	1.6796	5.3729	.0000	5.6946	12.3547
treat	3.9979	2.3317	1.7146	.0893	-.6249	8.6206
contacts	1.3982	.3010	4.6450	.0000	.8014	1.9949

Printed: Baron and Kenny Step 2 and Step 3

Output and Interpretation

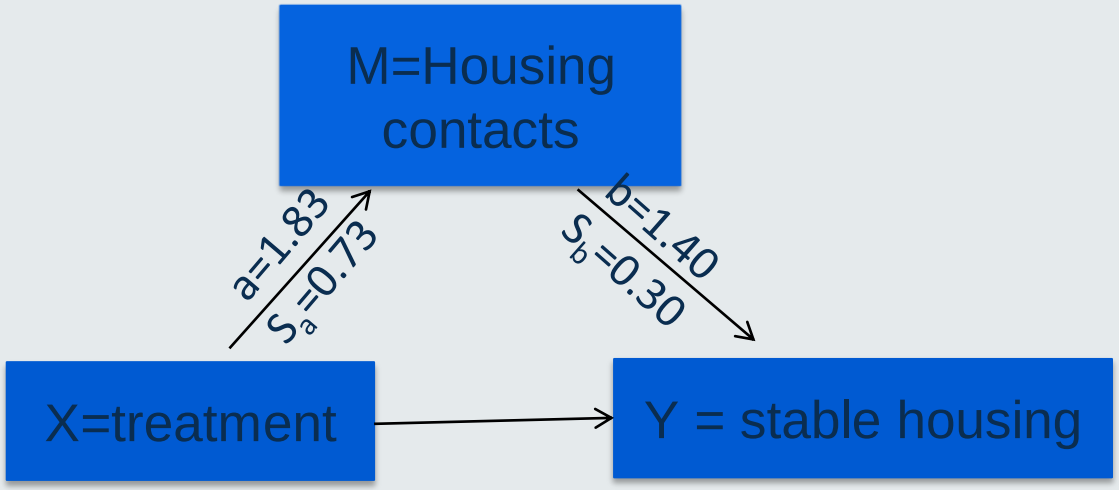
```
****************** DIRECT AND INDIRECT EFFECTS OF X ON Y ******************

Direct effect of X on Y
     Effect         se          t          p       LLCI       ULCI
     3.9979     2.3317     1.7146      .0893     -.6249     8.6206

Indirect effect(s) of X on Y:
             Effect     BootSE   BootLLCI   BootULCI
contacts     2.5602     1.1526     .4928     5.0439
```

Check the 95% Bias-corrected bootstrap confidence interval. As the interval does not contain zero **we can reject the null hypothesis that the indirect effect is zero and say that the indirect effect is significant. Thus, there is significant mediation.**

Knowledge Check

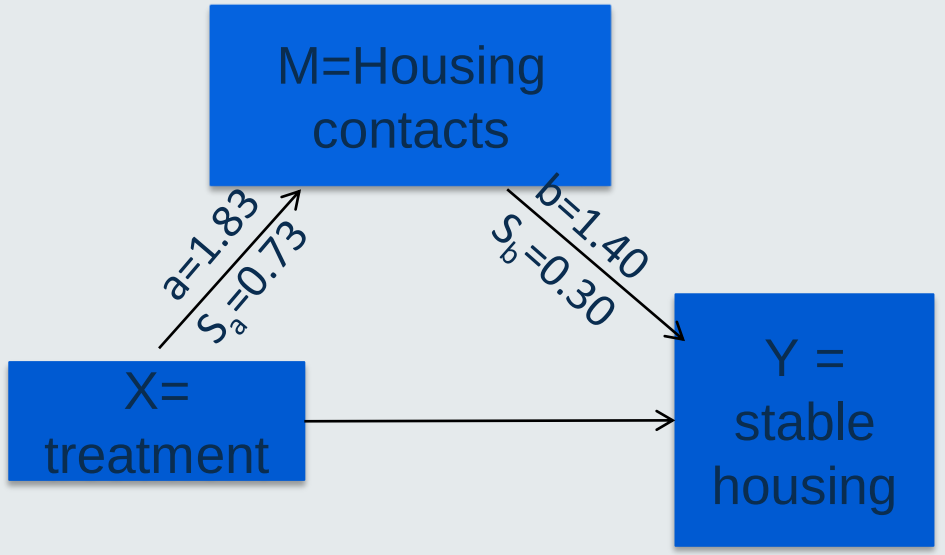
Using the stable housing data and the given path diagram, answer:

Q1. Compute the indirect effect ‘ab’.
Q2. Compute the standard error of the indirect effect ‘se(ab)’
Q3. Is the indirect effect significantly different from zero?



Knowledge Check Solutions

Using the stable housing data and the given path diagram, answer:



Q1. Compute the indirect effect 'ab'.

Indirect effect: ab = 1.83×1.40 =2.56

Q2. Compute the standard error of the indirect effect 'SE(ab)'

$$\mathbf{SE(ab)} = \sqrt{\mathbf{a^2S_b^2 + b^2S_a^2}} = \sqrt{\mathbf{(1.83)^2(0.30)^2 + (1.4)^2(0.73)^2}} = \mathbf{1.16}$$

Q3. Is the indirect effect significantly different from zero?

Z-statistic = ab/SE(ab)= 2.56/1.16= 2.21; Z-statistic > 1.96, we reject the hypothesis that ab=0 (at 5% significance level) p-value =0.027 (<0.05; significant)

We conclude that the indirect effect is **statistically different from zero**.

References

MacKinnon, D. P., Fairchild, A. J. and Fritz, M.S (2007). Mediation analysis, Annual Review of Psychology, 58, 593–614

David Kenny's Website on mediation: http://davidakenny.net/cm/mediate.htm

Hayes, A .F. (2013). Introduction to Mediation, Moderation, and Conditional Process Analysis, Guildford Press.

Andrew Hayes' website (www.afhayes.com) offering free downloads of SPSS macros plus data files for the book's examples.

Preacher, Kristopher J.; Hayes, Andrew F (2008). "Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models". Behavior Research Methods. 40 (3): 879–891. doi:10.3758/BRM.40.3.879

Frazer, Baron and Tix (2004) Testing Moderator and Mediator Effects in Counselling Psychology
Journal of Counselling Psychology Copyright 2004 by the American Psychological Association, Inc.
2004, Vol. 51, No. 1, 115–134 0022-0167/04/$12.00 DOI: 10.1037/0022-0167.51.1.115

More advanced book:
MacKinnon, D. P (2007). Introduction to Statistical Mediation Analysis, Lawrence Erlbaum Associates, New York

Thank you

Please contact your module leader or the course lecturer of your programme, or visit the module's forum for any questions you may have.

If you have comments on the materials (spotted typos or missing points) please contact Dr Iniesta:

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