

Multiple Regression: Mediation and Conditional Process Analysis

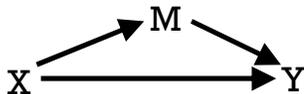
PSY 5102: Advanced Statistics for
Psychological and Behavioral Research 2

Goals

- Introduce the idea of mediation
 - Assumptions
 - Additional variables
- Introduce the idea of conditional process analysis
 - Various forms of this analysis

What is Mediation?

- Mediation is a hypothesized causal chain in which one variable (X) affects a second variable (M) which, in turn, affects a third variable (Y)



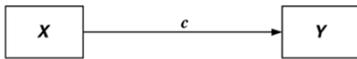
- M “mediates” the relationship between X and Y
- Mediation implies a **causal hypothesis** whereby an independent variable **causes** a mediator which, in turn, **causes** a dependent variable

Interest in Mediation

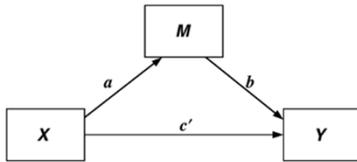
- ◉ Dramatic increase in mentions of “mediation” or “mediator” in psychology abstracts during the past few decades
- ◉ Why such interest in mediation?
 - Desire to understand the mechanisms or processes underlying behavior
 - Theoretical concerns
 - Find more proximal endpoints
 - Attempt to understand why an intervention did not work
 - Missing links
 - Compensatory processes

The Mediation Model

Panel A

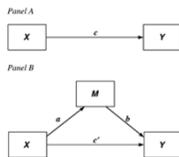


Panel B



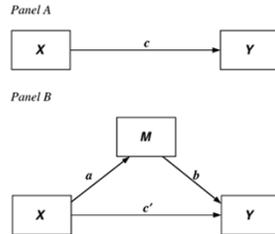
The Four Paths

- ◉ $X \rightarrow Y$: Path c
- ◉ $X \rightarrow M$: Path a
- ◉ $M \rightarrow Y$ (controlling for X): Path b
- ◉ $X \rightarrow Y$ (controlling for M): Path c'



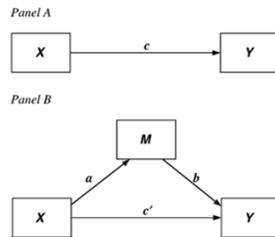
The Four Paths

Path c ($X \rightarrow Y$) is the **total effect** of X on Y



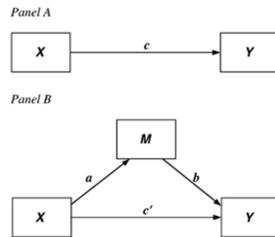
The Four Paths

Path c' ($X \rightarrow Y$) is the **direct effect** of X on Y controlling for M



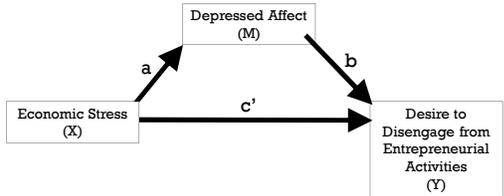
The Four Paths

The product of Path a ($X \rightarrow M$) and Path b ($M \rightarrow Y$) is the **indirect effect** of X on Y through M (i.e., $a*b$)



Example

- Pollack et al. (2012) proposed that economic stress (X) leads to a desire to disengage from entrepreneurial activities (Y) as a result of depressed affect (M)



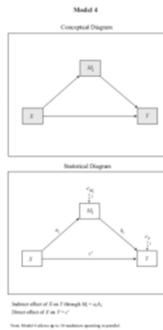
Examining Mediation Using Process

- PROCESS is a computational tool for path analysis-based moderation, mediation, and conditional process analysis (which is a combination of moderation and mediation)
- PROCESS can be downloaded from www.afhayes.com (it is free) and it can be used in conjunction with SPSS

Models from PROCESS

- PROCESS is capable of running a wide variety of analyses (there are nearly 80 models in the current version of PROCESS)

- Model 4: Simple mediation



Models from PROCESS

Model 6
(2 mediators)

Conceptual Diagram

Statistical Diagram

Indirect effect of X on Y through M1 only = a_1b_1
 Indirect effect of X on Y through M2 and M1 in serial = $a_1b_2 + a_2b_1$
 Indirect effect of X on Y through M2 and M1 in parallel = $a_1b_2 + a_2b_1$
 Indirect effect of X on Y through M1 and M2 in serial = $a_1b_1 + a_2b_2$
 Indirect effect of X on Y through M1, M2, and M1 in serial = $a_1b_1 + a_2b_2 + a_3b_1$
 Direct effect of X on Y = c'
 Note: Indirect effects in parentheses opening to zero

Models from PROCESS

Model 6
(3 mediators)

Conceptual Diagram

Statistical Diagram

Indirect effect of X on Y through M1 only = a_1b_1
 Indirect effect of X on Y through M2 and M1 in serial = $a_1b_2 + a_2b_1$
 Indirect effect of X on Y through M3 and M1 in serial = $a_1b_3 + a_3b_1$
 Indirect effect of X on Y through M2 and M1 in parallel = $a_1b_2 + a_2b_1$
 Indirect effect of X on Y through M3 and M1 in parallel = $a_1b_3 + a_3b_1$
 Indirect effect of X on Y through M1, M2, and M3 in serial = $a_1b_1 + a_2b_2 + a_3b_3$
 Indirect effect of X on Y through M1, M2, and M1 in serial = $a_1b_1 + a_2b_2 + a_3b_1$
 Direct effect of X on Y = c'

Models from PROCESS

Model 6
(4 mediators)

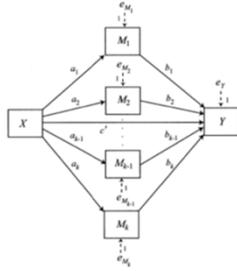
Conceptual Diagram

Statistical Diagram

Indirect effect of X on Y through M1 only = a_1b_1
 Indirect effect of X on Y through M2 and M1 in serial = $a_1b_2 + a_2b_1$
 Indirect effect of X on Y through M3 and M1 in serial = $a_1b_3 + a_3b_1$
 Indirect effect of X on Y through M4 and M1 in serial = $a_1b_4 + a_4b_1$
 Indirect effect of X on Y through M2 and M1 in parallel = $a_1b_2 + a_2b_1$
 Indirect effect of X on Y through M3 and M1 in parallel = $a_1b_3 + a_3b_1$
 Indirect effect of X on Y through M4 and M1 in parallel = $a_1b_4 + a_4b_1$
 Indirect effect of X on Y through M1, M2, and M3 in serial = $a_1b_1 + a_2b_2 + a_3b_3$
 Indirect effect of X on Y through M1, M2, and M1 in serial = $a_1b_1 + a_2b_2 + a_3b_1$
 Indirect effect of X on Y through M1, M2, M3, and M4 in serial = $a_1b_1 + a_2b_2 + a_3b_3 + a_4b_4$
 Indirect effect of X on Y through M1, M2, M3, and M1 in serial = $a_1b_1 + a_2b_2 + a_3b_3 + a_4b_1$
 Direct effect of X on Y = c'

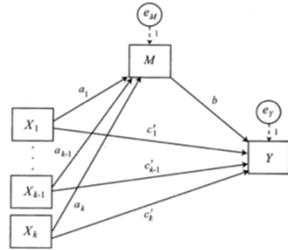
Models from PROCESS

- It is possible to run models involving multiple parallel mediators in PROCESS



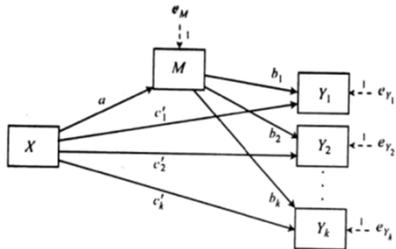
Models from PROCESS

- It is possible to run models involving multiple predictor (X) variables in PROCESS



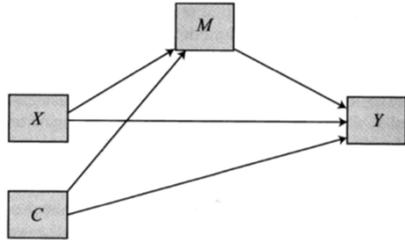
Models from PROCESS

- It is possible to run models involving multiple outcome (Y) variables in PROCESS



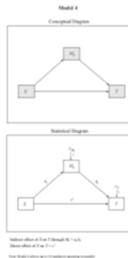
Models from PROCESS

- It is possible to run models that include one or more control (C) variables in PROCESS



Example

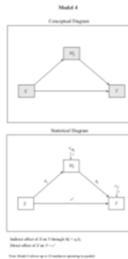
- We will start with a relatively simple example
- Model 4: Simple mediation
- Example: economic stress (X) leads to a desire to disengage from entrepreneurial activities (Y) as a result of depressed affect (M)



process vars=stress affect withdraw/y=withdraw/x=stress/m=affect/total=1/boot=10000/normal=1/model=4

Example

- We will start with a relatively simple example
- Model 4: Simple mediation
- Example: economic stress (X) leads to a desire to disengage from entrepreneurial activities (Y) as a result of depressed affect (M)



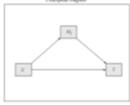
This part of the syntax activates PROCESS

process vars=stress affect withdraw/y=withdraw/x=stress/m=affect/total=1/boot=10000/normal=1/model=4

Example

- We will start with a relatively simple example
- Model 4: Simple mediation
- Example: economic stress (X) leads to a desire to disengage from entrepreneurial activities (Y) as a result of depressed affect (M)

This part of the syntax is the list of the variables that will be included in this analysis

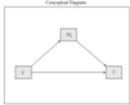


```
process vars=estress affect withdraw/y=withdraw/x=estress/m=affect/total=1/boot=10000/normal=1/model=4
```

Example

- We will start with a relatively simple example
- Model 4: Simple mediation
- Example: economic stress (X) leads to a desire to disengage from entrepreneurial activities (Y) as a result of depressed affect (M)

This part of the syntax identifies the outcome variable (Y)

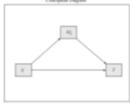


```
process vars=estress affect withdraw/y=withdraw/x=estress/m=affect/total=1/boot=10000/normal=1/model=4
```

Example

- We will start with a relatively simple example
- Model 4: Simple mediation
- Example: economic stress (X) leads to a desire to disengage from entrepreneurial activities (Y) as a result of depressed affect (M)

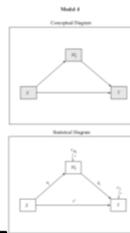
This part of the syntax identifies the predictor variable (X)



```
process vars=estress affect withdraw/y=withdraw/x=estress/m=affect/total=1/boot=10000/normal=1/model=4
```

Example

- We will start with a relatively simple example
- Model 4: Simple mediation
- Example: economic stress (X) leads to a desire to disengage from entrepreneurial activities (Y) as a result of depressed affect (M)

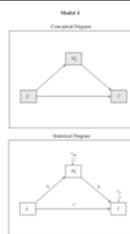


This part of the syntax identifies the mediator variable (M)

```
process vars=estress affect withdraw/y=withdraw/x=estress/m=affect/total=1/boot=10000/normal=1/model=4
```

Example

- We will start with a relatively simple example
- Model 4: Simple mediation
- Example: economic stress (X) leads to a desire to disengage from entrepreneurial activities (Y) as a result of depressed affect (M)

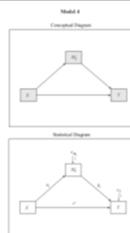


This part of the syntax requests that PROCESS generate the total effect of X on Y

```
process vars=estress affect withdraw/y=withdraw/x=estress/m=affect/total=1/boot=10000/normal=1/model=4
```

Example

- We will start with a relatively simple example
- Model 4: Simple mediation
- Example: economic stress (X) leads to a desire to disengage from entrepreneurial activities (Y) as a result of depressed affect (M)



This part of the syntax requests that PROCESS generate 10,000 bootstrap samples

```
process vars=estress affect withdraw/y=withdraw/x=estress/m=affect/total=1/boot=10000/normal=1/model=4
```

**Example:
Output from PROCESS**

This tells you about Path a (X → M).

Model 1					
Outcome: AFFECT					
	B	SE	beta	CI	p
Constant	0.7424	0.1433	5.1777	0.4558	0.0000
ESTRESS	0.1729	0.0326	5.3308	0.0999	0.0000



**Example:
Output from PROCESS**

R² for AFFECT (M) represents the amount of variance in AFFECT (M) that is explained by ESTRESS (X). To express this value as a percentage, you should multiply this value by 100.

Model 1					
Outcome: AFFECT					
	B	SE	beta	CI	p
Constant	0.7424	0.1433	5.1777	0.4558	0.0000
ESTRESS	0.1729	0.0326	5.3308	0.0999	0.0000



**Example:
Output from PROCESS**

Constant is the Y-intercept for this model.

The row for ESTRESS represents the association between ESTRESS (X) and AFFECT (M). The coefficient is .1729 with a t-value of 5.8308 and a p-value of 0.0000 which means that ESTRESS (X) has a significant positive association with AFFECT (M).

Model 1					
Outcome: AFFECT					
	B	SE	beta	CI	p
Constant	0.7424	0.1433	5.1777	0.4558	0.0000
ESTRESS	0.1729	0.0326	5.3308	0.0999	0.0000



Example: Output from PROCESS

This tells you about Path c' (X → Y when M is included in the model) and Path b (M → Y) which both involve WITHDRAW (Y).

```

Model = 1
1 = WITHDRAW
2 = ESTRESS
3 = AFFECT
Sample size = 200

-----
Outcome: WITHDRAW

Model Summary
R      F(3, 196)    Sig. F
.3401   1.128   .33496   1.000   200.000   0.000

Coefficients
Constant   .7498   0.1433   5.2777   0.0000   0.2670   1.0000
ESTRESS    0.1702   0.0276   6.1000   0.0000   0.1180   0.0000

Outcome: WITHDRAW

Model Summary
R      F(2, 194)    Sig. F
.4247   1.5824   .29494   2.0000   200.000   0.000

Coefficients
Constant   0.2810   0.2000   9.7420   0.0000   0.2000   1.0000
AFFECT     0.2426   0.0331   7.3487   0.0000   0.1480   0.0000
WITHDRAW  -0.2749   0.0324   -8.4887   0.0000   -0.1800   0.0000

Outcome: WITHDRAW

Model Summary
R      F(3, 194)    Sig. F
.5561   3.0541   .02714   1.0000   200.000   0.3615

Coefficients
Constant   0.2810   0.2000   9.7420   0.0000   0.2000   1.0000
ESTRESS    0.2426   0.0331   7.3487   0.0000   0.1480   0.0000
WITHDRAW  -0.2749   0.0324   -8.4887   0.0000   -0.1800   0.1499

-----
Model, Coefficients and Indirectly Affecting

Direct effect of X on Y
Effect      SE      Z      Sig.
WITHDRAW   .0315   1.015   0.315   .7504

Indirect effect of X on Y
Effect      SE      Z      Sig.
ESTRESS    .0324   -1.667   0.1477   .8800
AFFECT     .0324   -1.667   0.1477   .8800

Indirect effect of X on Y
Effect      SE      Z      Sig.
WITHDRAW   .0315   1.015   0.315   .7504

Model Change Test for Indirect Effect
Effect      SE      Z      Sig.
WITHDRAW   .0315   1.015   0.315   .7504

-----
ANALYZED DATA AND RESULTS
-----
Number of bootstrap samples for bias corrected bootstrap confidence intervals: 5000
Level of confidence for all confidence intervals is: 95.0000

```



Example: Output from PROCESS

R² for WITHDRAW (Y) represents the amount of variance in WITHDRAW (Y) that is explained by ESTRESS (X) and AFFECT (M). To express this value as a percentage, you should multiply this value by 100.

```

Model = 1
1 = WITHDRAW
2 = ESTRESS
3 = AFFECT
Sample size = 200

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Outcome: WITHDRAW

Model Summary
R      F(3, 196)    Sig. F
.3401   1.128   .33496   1.000   200.000   0.000

Coefficients
Constant   .7498   0.1433   5.2777   0.0000   0.2670   1.0000
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AFFECT     0.2426   0.0331   7.3487   0.0000   0.1480   0.0000
WITHDRAW  -0.2749   0.0324   -8.4887   0.0000   -0.1800   0.0000

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Model Change Test for Indirect Effect
Effect      SE      Z      Sig.
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ANALYZED DATA AND RESULTS
-----
Number of bootstrap samples for bias corrected bootstrap confidence intervals: 5000
Level of confidence for all confidence intervals is: 95.0000

```



Example: Output from PROCESS

Constant is the Y-intercept for this model.

```

Model = 1
1 = WITHDRAW
2 = ESTRESS
3 = AFFECT
Sample size = 200

-----
Outcome: WITHDRAW

Model Summary
R      F(3, 196)    Sig. F
.3401   1.128   .33496   1.000   200.000   0.000

Coefficients
Constant   .7498   0.1433   5.2777   0.0000   0.2670   1.0000
ESTRESS    0.1702   0.0276   6.1000   0.0000   0.1180   0.0000

Outcome: WITHDRAW

Model Summary
R      F(2, 194)    Sig. F
.4247   1.5824   .29494   2.0000   200.000   0.000

Coefficients
Constant   0.2810   0.2000   9.7420   0.0000   0.2000   1.0000
AFFECT     0.2426   0.0331   7.3487   0.0000   0.1480   0.0000
WITHDRAW  -0.2749   0.0324   -8.4887   0.0000   -0.1800   0.0000

Outcome: WITHDRAW

Model Summary
R      F(3, 194)    Sig. F
.5561   3.0541   .02714   1.0000   200.000   0.3615

Coefficients
Constant   0.2810   0.2000   9.7420   0.0000   0.2000   1.0000
ESTRESS    0.2426   0.0331   7.3487   0.0000   0.1480   0.0000
WITHDRAW  -0.2749   0.0324   -8.4887   0.0000   -0.1800   0.1499

-----
Model, Coefficients and Indirectly Affecting

Direct effect of X on Y
Effect      SE      Z      Sig.
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Indirect effect of X on Y
Effect      SE      Z      Sig.
ESTRESS    .0324   -1.667   0.1477   .8800
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Indirect effect of X on Y
Effect      SE      Z      Sig.
WITHDRAW   .0315   1.015   0.315   .7504

Model Change Test for Indirect Effect
Effect      SE      Z      Sig.
WITHDRAW   .0315   1.015   0.315   .7504

-----
ANALYZED DATA AND RESULTS
-----
Number of bootstrap samples for bias corrected bootstrap confidence intervals: 5000
Level of confidence for all confidence intervals is: 95.0000

```



**Example:
Output from PROCESS**

The row for AFFECT represents the association between AFFECT (M) and WITHDRAW (Y). The coefficient is .7691 with a t-value of 7.4627 and a p-value of 0.0000 which means that AFFECT (M) has a significant positive association with WITHDRAW (Y).

```

Model 1
  Y = WITHDRAW
  X = AFFECT
  M = AFFECT
  Sample size = 200

Outcome: AFFECT

Model Summary
  R      F(1, 198)    SS      MS      P
0.3601  0.1129  33.8988  33.8988  0.0000

Coefficients
  B          SE      Beta      t      P      LLCI      ULCI
AFFECT      0.7691  0.1031  7.4627  0.0000  0.5170  0.9814
WITHDRAW    0.1702  0.0276  0.6166  6.1699  0.0000  0.1160  0.2243

Outcome: WITHDRAW

Model Summary
  R      F(2, 196)    SS      MS      P
0.4247  0.1824  28.4246  14.2123  0.0000

Coefficients
  B          SE      Beta      t      P      LLCI      ULCI
AFFECT      0.7691  0.1031  7.4627  0.0000  0.5170  0.9814
WITHDRAW    0.1702  0.0276  0.6166  6.1699  0.0000  0.1160  0.2243

Outcome: WITHDRAW

Model Summary
  R      F(2, 197)    SS      MS      P
0.4243  0.2041  1.0714  0.0054  0.3615

Coefficients
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
AFFECT      0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020

Total, Direct and Indirect Effects
Direct effect of X on Y
  B          SE      Beta      t      P      LLCI      ULCI
AFFECT      0.7691  0.1031  7.4627  0.0000  0.5170  0.9814
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
Indirect effect of X on Y
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
Total effect of X on Y
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
Model Change Test for Indirect Effect
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020

Number of bootstrap samples for bias corrected bootstrap confidence intervals = 5000
Level of confidence for all confidence intervals is output = 95.0000
  
```



**Example:
Output from PROCESS**

The row for ESTRESS represents the association between ESTRESS (X) and WITHDRAW (Y). The coefficient is -0.0768 with a t-value of -1.4667 and a p-value of 0.1437 which means that ESTRESS (X) does not have a significant association with WITHDRAW (Y) when AFFECT (M) is included in the model.

```

Model 1
  Y = WITHDRAW
  X = ESTRESS
  M = AFFECT
  Sample size = 200

Outcome: AFFECT

Model Summary
  R      F(1, 198)    SS      MS      P
0.3601  0.1129  33.8988  33.8988  0.0000

Coefficients
  B          SE      Beta      t      P      LLCI      ULCI
ESTRESS     -0.0768  0.0523  -1.4667  0.1437  -0.1850  0.0314
WITHDRAW    0.1702  0.0276  0.6166  6.1699  0.0000  0.1160  0.2243

Outcome: WITHDRAW

Model Summary
  R      F(2, 196)    SS      MS      P
0.4247  0.1824  28.4246  14.2123  0.0000

Coefficients
  B          SE      Beta      t      P      LLCI      ULCI
ESTRESS     -0.0768  0.0523  -1.4667  0.1437  -0.1850  0.0314
WITHDRAW    0.1702  0.0276  0.6166  6.1699  0.0000  0.1160  0.2243

Outcome: WITHDRAW

Model Summary
  R      F(2, 197)    SS      MS      P
0.4243  0.2041  1.0714  0.0054  0.3615

Coefficients
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
ESTRESS     -0.0010  0.0007  -0.8605  -1.2400  0.2160  -0.0020  -0.0010

Total, Direct and Indirect Effects
Direct effect of X on Y
  B          SE      Beta      t      P      LLCI      ULCI
ESTRESS     -0.0768  0.0523  -1.4667  0.1437  -0.1850  0.0314
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
Indirect effect of X on Y
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
Total effect of X on Y
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
Model Change Test for Indirect Effect
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020

Number of bootstrap samples for bias corrected bootstrap confidence intervals = 5000
Level of confidence for all confidence intervals is output = 95.0000
  
```



**Example:
Output from PROCESS**

This tells you about Path c (X → Y when M is not included in the model).

```

Model 1
  Y = WITHDRAW
  X = ESTRESS
  M = AFFECT
  Sample size = 200

Outcome: AFFECT

Model Summary
  R      F(1, 198)    SS      MS      P
0.3601  0.1129  33.8988  33.8988  0.0000

Coefficients
  B          SE      Beta      t      P      LLCI      ULCI
ESTRESS     -0.0768  0.0523  -1.4667  0.1437  -0.1850  0.0314
WITHDRAW    0.1702  0.0276  0.6166  6.1699  0.0000  0.1160  0.2243

Outcome: WITHDRAW

Model Summary
  R      F(2, 196)    SS      MS      P
0.4247  0.1824  28.4246  14.2123  0.0000

Coefficients
  B          SE      Beta      t      P      LLCI      ULCI
ESTRESS     -0.0768  0.0523  -1.4667  0.1437  -0.1850  0.0314
WITHDRAW    0.1702  0.0276  0.6166  6.1699  0.0000  0.1160  0.2243

Outcome: WITHDRAW

Model Summary
  R      F(2, 197)    SS      MS      P
0.4243  0.2041  1.0714  0.0054  0.3615

Coefficients
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
ESTRESS     -0.0010  0.0007  -0.8605  -1.2400  0.2160  -0.0020  -0.0010

Total, Direct and Indirect Effects
Direct effect of X on Y
  B          SE      Beta      t      P      LLCI      ULCI
ESTRESS     -0.0768  0.0523  -1.4667  0.1437  -0.1850  0.0314
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
Indirect effect of X on Y
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
Total effect of X on Y
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
Model Change Test for Indirect Effect
  B          SE      Beta      t      P      LLCI      ULCI
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020
WITHDRAW    0.0010  0.0007  0.8605  1.2400  0.2160  0.0000  0.0020

Number of bootstrap samples for bias corrected bootstrap confidence intervals = 5000
Level of confidence for all confidence intervals is output = 95.0000
  
```



Example: Output from PROCESS

R² for the TOTAL EFFECT MODEL represents the amount of variance in WITHDRAW (Y) that is explained by ESTRESS (X) when AFFECT (M) is not included in the model. To express this value as a percentage, you should multiply this value by 100.

```

Model 1
1 = WITHDRAW
X = ESTRESS
M = AFFECT
Sample size = 200

Outcome: AFFECT
Model Summary
R      R Square    Adjusted R Square    F      Sig.
1     0.176     0.118     0.098     2.000     0.000

Coefficients:
Constant    0.749    0.143    0.277    0.000    0.370    0.000
ESTRESS     0.172    0.070    0.030    0.000    0.149    0.000

Outcome: WITHDRAW
Model Summary
R      R Square    Adjusted R Square    F      Sig.
1     0.427    0.289    0.246     2.000     0.000

Coefficients:
Constant    0.461    0.000    0.000    0.000    0.940    0.000
AFFECT      0.240    0.111    0.067    0.000    0.340    0.000
ESTRESS     -0.170    0.014    -0.007    0.147    0.180    0.000

***** TOTAL EFFECT MODEL *****
Outcome: WITHDRAW
Model Summary
R      R Square    Adjusted R Square    F      Sig.
1     0.061    0.004    0.014     1.000     0.300

Coefficients:
Constant    0.461    0.000    0.000    0.000    0.940    0.000
ESTRESS     0.061    0.004    0.014     1.035    0.301    0.000

Total effect of X on Y
AFFECT     0.240    0.111    0.067    0.000    0.340    0.000
ESTRESS    -0.170    0.014    -0.007    0.147    0.180    0.000

Indirect effect of X on Y
AFFECT     0.130    0.008    0.011    0.004

Model change test for indirect effect
WILCOX     0.000    0.999    0.000

***** ANALYZED NOTES AND WARNINGS *****
Number of bootstrap samples for bias corrected bootstrap confidence intervals = 5000
Level of confidence for all confidence intervals is output = 95.0000

```



Example: Output from PROCESS

Constant is the Y-intercept for this model.

```

Model 1
1 = WITHDRAW
X = ESTRESS
M = AFFECT
Sample size = 200

Outcome: AFFECT
Model Summary
R      R Square    Adjusted R Square    F      Sig.
1     0.176     0.118     0.098     2.000     0.000

Coefficients:
Constant    0.749    0.143    0.277    0.000    0.370    0.000
ESTRESS     0.172    0.070    0.030    0.000    0.149    0.000

Outcome: WITHDRAW
Model Summary
R      R Square    Adjusted R Square    F      Sig.
1     0.427    0.289    0.246     2.000     0.000

Coefficients:
Constant    0.461    0.000    0.000    0.000    0.940    0.000
AFFECT      0.240    0.111    0.067    0.000    0.340    0.000
ESTRESS     -0.170    0.014    -0.007    0.147    0.180    0.000

***** TOTAL EFFECT MODEL *****
Outcome: WITHDRAW
Model Summary
R      R Square    Adjusted R Square    F      Sig.
1     0.061    0.004    0.014     1.000     0.300

Coefficients:
Constant    0.461    0.000    0.000    0.000    0.940    0.000
ESTRESS     0.061    0.004    0.014     1.035    0.301    0.000

Total effect of X on Y
AFFECT     0.240    0.111    0.067    0.000    0.340    0.000
ESTRESS    -0.170    0.014    -0.007    0.147    0.180    0.000

Indirect effect of X on Y
AFFECT     0.130    0.008    0.011    0.004

Model change test for indirect effect
WILCOX     0.000    0.999    0.000

***** ANALYZED NOTES AND WARNINGS *****
Number of bootstrap samples for bias corrected bootstrap confidence intervals = 5000
Level of confidence for all confidence intervals is output = 95.0000

```



Example: Output from PROCESS

The row for ESTRESS represents the association between ESTRESS (X) and WITHDRAW (Y). The coefficient is 0.0561 with a t-value of 1.0353 and a p-value of 0.3015 which means that ESTRESS (X) does not have a significant association with WITHDRAW (Y) even when AFFECT (M) is NOT included in the model.

```

Model 1
1 = WITHDRAW
X = ESTRESS
M = AFFECT
Sample size = 200

Outcome: AFFECT
Model Summary
R      R Square    Adjusted R Square    F      Sig.
1     0.176     0.118     0.098     2.000     0.000

Coefficients:
Constant    0.749    0.143    0.277    0.000    0.370    0.000
ESTRESS     0.172    0.070    0.030    0.000    0.149    0.000

Outcome: WITHDRAW
Model Summary
R      R Square    Adjusted R Square    F      Sig.
1     0.427    0.289    0.246     2.000     0.000

Coefficients:
Constant    0.461    0.000    0.000    0.000    0.940    0.000
AFFECT      0.240    0.111    0.067    0.000    0.340    0.000
ESTRESS     -0.170    0.014    -0.007    0.147    0.180    0.000

***** TOTAL EFFECT MODEL *****
Outcome: WITHDRAW
Model Summary
R      R Square    Adjusted R Square    F      Sig.
1     0.061    0.004    0.014     1.000     0.300

Coefficients:
Constant    0.461    0.000    0.000    0.000    0.940    0.000
ESTRESS     0.056    0.002    0.001     1.035    0.301    0.000

Total effect of X on Y
AFFECT     0.240    0.111    0.067    0.000    0.340    0.000
ESTRESS    -0.170    0.014    -0.007    0.147    0.180    0.000

Indirect effect of X on Y
AFFECT     0.130    0.008    0.011    0.004

Model change test for indirect effect
WILCOX     0.000    0.999    0.000

***** ANALYZED NOTES AND WARNINGS *****
Number of bootstrap samples for bias corrected bootstrap confidence intervals = 5000
Level of confidence for all confidence intervals is output = 95.0000

```



Bootstrap Confidence Interval

- ◎ PROCESS uses a bootstrapping approach to estimate the confidence interval for the indirect effect
- ◎ Steps for constructing the bootstrap confidence interval
 1. Take a random sample of n cases from the original sample (sampled with replacement) where n is the size of the original sample. This is called a bootstrap sample.
 2. Estimate the indirect effect ($a*b$) in this bootstrap sample.
 3. Repeat Steps 1 and 2 a total of k times (k is usually a large number such as 10,000) saving the value of $a*b$ for each bootstrap sample.
 4. Sort the k indirect effects ($a*b$) from each bootstrap sample from low to high.
 5. Find the lower bound and upper bound of the 95% confidence interval.
 6. If the 95% confidence interval does not contain 0, then the indirect effect is significant (i.e., mediation is supported).

Previous Approaches to Mediation

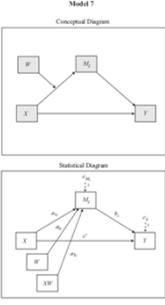
- ◎ The most popular approach to mediation in the past was **the causal steps approach** which is also referred to as **the Baron and Kenny approach**
- ◎ Problems with the Baron and Kenny approach...
 1. It does not formally quantify the indirect effect nor does it require an inferential test about the indirect effect.
 2. The ability to claim that M is a mediator depends of rejecting three null hypotheses (Path c , Path a , and Path b) which makes it a relatively low power approach for detecting indirect effects.
 3. The failure to find a significant Path c ($X \rightarrow Y$) is a stopping point (i.e., this approach argues that it is impossible to mediate an association that is not significant) but this logic is flawed. There are many situations in which mediation may occur even when the total effect ($X \rightarrow Y$) appears to be 0. For example, if there are two mediators where the association through one mediator is positive and the association through the other mediator is negative, then it may lead to a situation where the total effect is 0.
 4. This approach does not quantify the indirect effect so it encourages researchers to think about indirect effects in qualitative terms (e.g., no mediation, partial mediation, full mediation).

Conditional Process Analysis

- ◎ Conditional process analysis is used when the analytical goal is to describe and understand the conditional nature of the mechanism (or mechanisms) by which a variable transmits its effect on another
 - This is a blend of **moderation** ("conditional nature") and **mediation** ("the mechanism [or mechanisms] by which a variable transmits its effect on another")
 - This has been referred to by labels such as **moderated mediation** and **mediated moderation**
- ◎ The mechanism linking X to Y can be said to be conditional if the indirect effect of X on Y through M is contingent on a moderator

Models from PROCESS

- PROCESS is capable of running a wide variety of conditional process analyses
- Model 7: Moderator of $X \rightarrow M$



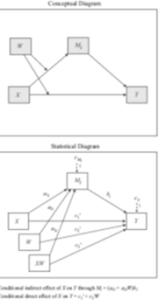
Model 7 Conceptual Diagram: A path diagram showing a moderator W influencing the relationship between X and M. X also influences M, and M influences Y.

Model 7 Statistical Diagram: A path diagram showing the statistical model for Model 7. It includes paths for W to X (a1), W to M (a2), X to M (a3), M to Y (b), and error terms for X, M, and Y.

Conditional indirect effect of X on Y through M = $(a_3 + a_2a_1) \times b$
Direct effect of X on Y = c'
Note: Model 7 allows up to 10 moderation settings to be tested.

Models from PROCESS

- Model 8: Moderator of $X \rightarrow M$ and $X \rightarrow Y$



Model 8 Conceptual Diagram: A path diagram showing a moderator W influencing both the relationship between X and M, and the relationship between X and Y. X also influences M, and M influences Y.

Model 8 Statistical Diagram: A path diagram showing the statistical model for Model 8. It includes paths for W to X (a1), W to M (a2), W to Y (a3), X to M (a4), M to Y (b), and error terms for X, M, and Y.

Conditional indirect effect of X on Y through M = $(a_4 + a_2a_1) \times b$
Conditional direct effect of X on Y = $c' + a_3$
Note: Model 8 allows up to 10 moderation settings to be tested.

Models from PROCESS

- Model 9: Two moderators of $X \rightarrow M$



Model 9 Conceptual Diagram: A path diagram showing two moderators, W1 and W2, influencing the relationship between X and M. X also influences M, and M influences Y.

Model 9 Statistical Diagram: A path diagram showing the statistical model for Model 9. It includes paths for W1 to X (a1), W1 to M (a2), W2 to X (a3), W2 to M (a4), X to M (a5), M to Y (b), and error terms for X, M, and Y.

Conditional indirect effect of X on Y through M = $(a_5 + a_2a_1 + a_4a_3) \times b$
Direct effect of X on Y = c'
Note: Model 9 allows up to 10 moderation settings to be tested.

Models from PROCESS

Model 10

Conceptual Diagram

Statistical Diagram

Conditional indirect effect of X on Y through M: $\gamma_1 = a_1 a_2 + a_{11} a_2 + a_{12} a_2 + a_{13} a_2 + a_{14} a_2$
 Conditional direct effect of X on Y: $\gamma_2 = a_2 + a_{11} a_2 + a_{12} a_2 + a_{13} a_2 + a_{14} a_2$
*Model 10 allows for threshold centering to occur.

Models from PROCESS

Model 11

Conceptual Diagram

Statistical Diagram

Conditional indirect effect of X on Y through M: $\gamma_1 = a_1 a_2 + a_{11} a_2 + a_{12} a_2 + a_{13} a_2 + a_{14} a_2$
 Direct effect of X on Y: $\gamma_2 = a_2$
*Model 11 allows for threshold centering to occur.

Models from PROCESS

Model 12

Conceptual Diagram

Statistical Diagram

Conditional indirect effect of X on Y through M: $\gamma_1 = a_1 a_2 + a_{11} a_2 + a_{12} a_2 + a_{13} a_2 + a_{14} a_2$
 Conditional direct effect of X on Y: $\gamma_2 = a_2 + a_{21} a_2 + a_{22} a_2 + a_{23} a_2 + a_{24} a_2$
*Model 12 allows for threshold centering to occur.

Models from PROCESS

Model 14: Moderators of $M \rightarrow Y$

Conceptual Diagram

Statistical Diagram

Conditional indirect effect of X on Y through M : $a_1b_1 = a_1b_1$
 Direct effect of X on Y : a_2

*Model 14 allows up to 10 random opening in parallel

Models from PROCESS

Model 17: Two moderators of $M \rightarrow Y$ and $X \rightarrow Y$

Conceptual Diagram

Statistical Diagram

Conditional indirect effect of X on Y through M : $a_1b_1 = a_1b_1$
 Conditional direct effect of X on Y : $a_2 + a_2W + a_2Z$

*Model 17 allows up to 10 random opening in parallel

Models from PROCESS

Model 24: Two moderators of $X \rightarrow M$ and $X \rightarrow Y$ and a third moderator of $M \rightarrow Y$

Conceptual Diagram

Statistical Diagram

Conditional indirect effect of X on Y through M : $a_1b_1 = a_1b_1$
 Conditional direct effect of X on Y : $a_2 + a_2W + a_2Z$

*Model 24 allows up to 10 random opening in parallel

Models from PROCESS

- Model 45: Two moderators of $X \rightarrow M$ and two moderators of $M \rightarrow Y$

Model 45
Conceptual Diagram

Model 45
Statistical Diagram

Conditional indirect effect of X on Y through M: $\gamma_1 + \gamma_2 + \gamma_3 W + \gamma_4 Z$
 Conditional direct effect of X on Y: $\beta_1 + \beta_2 + \beta_3 V + \beta_4 Q$
 Model fit statistics: $\chi^2(1) = 0.00, p = 0.96, CFI = 0.99, RMSEA = 0.00$

Models from PROCESS

- Model 57: Two moderators of $X \rightarrow M$ and $X \rightarrow Y$ that include the three-way interactions ($X*W*Z$) and two moderators of $M \rightarrow Y$ and $X \rightarrow Y$ that include the three-way interactions ($X*V*Q$)

Model 57
Conceptual Diagram

Model 57
Statistical Diagram

Conditional indirect effect of X on Y through M: $\gamma_1 + \gamma_2 + \gamma_3 W + \gamma_4 Z + \gamma_5 WZ$
 Conditional direct effect of X on Y: $\delta_1 + \delta_2 + \delta_3 V + \delta_4 Q + \delta_5 VQ$
 Model fit statistics: $\chi^2(1) = 0.00, p = 0.96, CFI = 0.99, RMSEA = 0.00$

Models from PROCESS

- Model 59: A moderator of $X \rightarrow M$, $M \rightarrow Y$, and $X \rightarrow Y$

Model 59
Conceptual Diagram

Model 59
Statistical Diagram

Conditional indirect effect of X on Y through M: $\gamma_1 + \beta_1 W$
 Conditional direct effect of X on Y: $\delta_1 + \delta_2 + \delta_3 W$
 Model fit statistics: $\chi^2(1) = 0.00, p = 0.96, CFI = 0.99, RMSEA = 0.00$
