Mediators and Moderators

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Outline

• Differences between mediators and moderators
• Designing and testing mediation
  o Designing mediation studies
  o Testing mediation
    ▪ Regression
    ▪ SEM
    ▪ MLM
• Designing and testing moderation
  o Designing moderation studies
  o Testing moderation
    ▪ Regression
    ▪ SEM
    ▪ MLM
Some “vocabulary”

- Mediation
  - Boxes are variables
  - Paths are regression weights

Diagram:
- Boxes represent variables: X, M, Y
- Arrows represent paths: a, b, c, c'
- Boxes X and Y are connected by c and c'
- Box M is connected to X and Y by a and b
Some “vocabulary”

- Moderation
  - Note: The actual moderation model fit to our data does not exactly match this diagram (involves another X*Z interaction construct)
Mediator vs. Moderator

- **Mediator: middle-person**
  - Mediation occurs when \( X \rightarrow M \rightarrow Y \)
  - Mediation is a *causal* process
  - Key word: because

- **Moderator: “changer”**
  - Variable that alters the strength of another relationship *(A.K.A. an interaction!)*
  - Moderation occurs when the effect of X on Y depends on Z
  - Key word: depends
Mediator vs. Moderator

- **Mediator is the letter carrier, or delivery agent**
  - X causes change in M
  - M causes change in Y
  - X predicts change in Y via M (ab is sig.).
- **Moderator is an interaction!**
  - Depending on Z, X to Y changes in strength
Mediation:

- The transmission of a causal effect by way of another variable (i.e. mediator)
- E.g., "why, by what means, or through what process does motivation exert its effect on grades?"

Three conditions exist:

- X, M, & Y must be separated in time
- X is significantly related to change in M
- M is significantly related to change in Y
• Most mediation studies use cross-sectional data.

• Causal conclusions require temporal separation.

• Cole and Maxwell highlight this problem and suggest study designs that help to mitigate it.
The Problem with Cross Sectional Designs

- Equivalent models in a cross sectional design:
Longitudinal Mediation Design
Longitudinal Mediation Design

- When testing mediation three or more timepoints are ideal.
  - Think about the spacing of timepoints!

- What is only two timepoints of data are available?
  - The “half longitudinal” design
The “Half Longitudinal” Design

• Requires the assumption of stationarity
  • The effects of $X \rightarrow M$ and $X \rightarrow M$ are unchanging over time
• $X$ can be measured or experimental manipulated
Mediation Example

- Research Question: Is the relationship between caretaker health and protective factors against child abuse mediated by stress and/or depression?
Mediation Example

Note: Only significant paths are shown

Bootstrapped 95% CI LL=-.01, UL=-.50
How do you know if you have mediation?

- Testing for significance of mediation:
  \[ c - c' \neq 0 \]
  \[ a \ast b \neq 0 \]
Five Approaches to Testing Mediation

- Baron & Kenny’s Causal Steps approach [REALLY BAD]
  - Do a series of regressions and determine if $C'$ is $< C$.
  - Not a test of mediation (ab pathway)

- Product of Coefficients approach (Sobel test) [NOT SO BAD]
  - Determine if ab is significant using a Wald test
  - Significance test of ab is problematic. Assumes normal distribution of SEs.

- SEM estimation of indirect effect [NOT GREAT]
  - Determine if ab is significant
    - ab is a parameter in the model
  - Uses ML estimation to determine significance of indirect effect
Five Approaches to Testing Mediation

- **Monte Carlo approach [BETTER]**
  - Determine if $ab$ is significant
  - Assumes $a$ and $b$ are normally distributed but not $ab$
    - Simulates values of $ab$ based on estimate and SE of $a$ and $b$
  - See quantpsy.org for a web-based calculator

- **Bootstrap approach [BEST]**
  - Determine if $ab$ is significant
  - Relies on resampling to determine the appropriate standard error to test for significance
    - Draw 1000s of samples from data with replacement
    - Run model on each bootstrapped sample
    - Get distribution of estimates from samples
  - Automated in Mplus, see Kuant guides for bootstrapping in LISREL
  - See quantpsy.org for SPSS and SAS macros to for regression
Hypothesis Testing with Confidence Intervals

- $H_0: a^*b = 0$
  - If $a^*b$ is significant we say there is a less than 5% chance that $a^*b = 0$ in the population

- A 95% CI provides the same information
  - If 0 is not within the 95% CI: there is at least a 95% chance than $a^*b \neq 0$. **Significant mediation effect.**
  - If 0 is within the 95% CI: there is less than a 95% chance that $a^*b \neq 0$. **Non-significant mediation effect.**
Testing Mediation in Regression

1. Regress Y on X (c)
2. Regress Y on M (a)
3. Regress Y on X and M (c’ and b)
4. Use bootstrapping or the Monte Carlo technique to test mediation
5. Interpret
   - X causes changes in M, M causes changes in Y
Testing Mediation in SEM

1. Set up SEM model with a, b, and c’ paths in one model.
2. Use bootstrapping or the Monte Carlo technique to test mediation
3. Interpret
   - X causes changes in M, M causes changes in Y
Advantages to Testing Mediation in SEM

- Latent variables
- Simultaneous estimation of all pathways
- Ability to analyze longitudinal mediation
Testing Mediation in MLM

1. Regress Y on X (c)
2. Regress Y on M (a)
3. Regress Y on X and M (c’ and b)
4. The Monte Carlo technique to test mediation
5. Interpret
   o X causes changes in M, M causes changes in Y

• NOTE: If a model has random slopes, things get tricky! Be careful!
Designing Moderation Studies

- Identify the focal predictor (X) and the moderator (Z)
- Identify the scale of the moderator
  - Discrete? Continuous?
Moderation Models

- Conceptual model

- Analysis model
Steps to Testing Moderation

1. Test for main effect of X and Z on Y
2. Test for interaction of X and Z on Y
3. Plot and probe significant interactions
   - Plotting an interaction is graphically displaying interaction
   - Probing an interaction is determining at what values of Z is the effect of X on Y significant
Moderation in Regression

- Regress Y on main effects
  - \( Y = B_0 + B_1X + B_2Z \)

- Regress Y on main effects and interactions
  - \( Y = B_0 + B_1X + B_2Z + B_3X*Z \)
  - If \( B_3 \) is significant there is a significant interaction
  - DO NOT INTERPRET \( B_1 \) or \( B_2 \) when an interaction term is present
  - \( X*Z \) must be computed manually in SPSS, SAS and R will do so automatically
Moderation in Regression: Centering

- **Centering**
  - Regression texts often recommend centering X and Z before computing interaction terms
  - CENTERING DOES NOT AFFECT THE SIGNIFICANCE OF AN INTERACTION!
  - Centering makes the intercept interpretable
  - Centering does not make $B_1$ or $B_2$ interpretable
Moderation in Regression: Categorical Moderators

- Categorical predictors in regression are represented with dummy variables
  - e.g., the variable class (freshman, sophomore, junior, senior) would be represented by 3 dummy codes.

- An interaction with a categorical predictors requires as many product terms as dummy variables.
  - e.g., X*D1, X*D2, X*D3
Two techniques:

- Simple slopes analysis
  - Find the effect of X on Y at specified values of Z
- Johnson-Neyman Technique
  - Find the values of Z for which the effect of X on Y is significant

Both can be easily implemented with the calculators at quantpsy.org
Simple slopes analysis

- Find the simple intercept and slope for a significant interaction
  - $Y = B_0 + B_1X + B_2Z + B_3X*Z$
  - $Y = B_0 + B_2Z + B_1X + B_3X*Z$
  - $Y = (B_0 + B_2Z) + (B_1 + B_3Z)X$

Simple Intercept
Simple Slope
Moderation in MLM

- Process of testing moderation MLM is identical to that of regression
  - Even with random slopes!
Moderation in SEM

- Categorical moderators
  - Use multiple group SEM
- Continuous moderators
  - How do you multiply latent variables?
  - Several techniques for moderation in SEM
    - Orthogonalizing
    - Mean Centering
    - LMS
    - See KUant Guide for details
Currently methods for plotting and probing interactions in SEM are limited

- Can calculate simple intercepts and slopes in LISREL and Mplus
• Moderated mediation

\[ Z \rightarrow X \rightarrow M \rightarrow b \rightarrow Y \]

\[ Z \rightarrow M \]

\[ X \rightarrow Y \]

\[ c' \]
Many different types of moderated mediation
- Z moderates a pathway, or b pathway or both
- Different moderations of the a and b pathway

Test mediation at different values of the moderator
• Thank you!
Additional Reading on Mediation

  - Convincing argument for testing mediation over time rather than concurrently.
  - The first half of this chapter describes testing mediation in SEM.
  - If the first paper wasn’t convincing, then this one surely should get the point across.
Additional Reading on Mediation

  - Provides LISREL and Mplus syntax for longitudinal mediation designs.
  - A book all about mediation!
  - Overview of bootstrapping for testing mediation
  - Two papers addressing issues in mediation with MLM


Additional Reading on Moderation

- Moderation in SEM:

- Moderated Mediation: