

Moderation and Mediation Application to Data Synthesis

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Mediator and Moderator Definitions

Data Synthesis for Mediation

Data Synthesis for Moderation

Website: www.rjpl.faculty.asu.edu.

Book: MacKinnon, D. P. (2008) Introduction to Statistical Mediation Analysis, Mahwah, NJ: Erlbaum.

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Mediation Statements

- If children are **successful at school** they will be less anti-social.
- If unemployed persons can maintain their **self-esteem** they will be more likely to be reemployed.
- If **norms** become more tolerant of sexual orientation, then prejudice will decrease.
- If positive **parental communication** is increased then there will be reduced family problems related to adolescent sexual orientation.

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Mediator

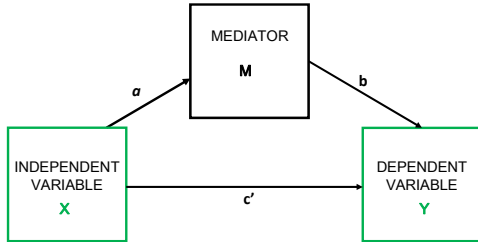
A variable that is intermediate in the causal process relating an independent to a dependent variable.

- Condom promotion program (X) changes attitudes about sexual enjoyment from condoms (M) which changes condom use (Y) (Choi et al., 2008).
- Stress of Sexual minority status (X) affects social norms (M), social support (M) which affects alcohol use (Y), suicidality (Y), Depression (Y) (Hatzenbuehler, 2009, *Psychological Bulletin*)
- Affective regulation (X) affects stimulant use (M) and nonadherence to medications (M) which affects viral load (Y) (Carrico et al., 2007).

■ Your Examples.....

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Single Mediator Model



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Mediator Definitions

- A mediator is a variable in a chain whereby an independent variable causes the mediator which in turn causes the outcome variable (Sobel, 1990)
- The generative mechanism through which the focal independent variable is able to influence the dependent variable (Baron & Kenny, 1986)
- A variable that occurs in a causal pathway from an independent variable to a dependent variable. It causes variation in the dependent variable and itself is caused to vary by the independent variable (Last, 1988)

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Mediation is important because...

- Central questions in many fields are about mediating processes.
- Important for basic research on mechanisms of effects.
- Critical for applied research, especially prevention and treatment to identify critical ingredients leading to more efficient interventions.
- Many interesting statistical and mathematical issues.

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S→O→R Theory I

- Stimulus→ Organism → Response (SOR) theory whereby the effect of a Stimulus on a Response depends on mechanisms in the organism (Woodworth, 1928). These mediating mechanisms translate the Stimulus to the Response. SOR theory is ubiquitous in psychology.
- Stimulus: Multiply 24 and 16
- Organism: You
- Response: Your Answer
- Organism as a Black Box

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S→O→R Theory II

- Note that the mediation process is usually unobservable.
- Process may operate at different levels: individuals, neurons, cells, atoms, families, therapy groups, clinics, states etc.
- Mediating processes may happen simultaneously.
- Mediating process may be part of a longer chain. The researcher needs to decide what part of a long mediation chain to study, the micromediatonal chain.
- Mediation as Measurement.

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Two, Three, and Four Variable Effects

- Two variables: $X \rightarrow Y$, $Y \rightarrow X$, $X \leftrightarrow Y$ are reciprocally related. Measures of effect include the correlation, covariance, regression coefficient, odds ratio, mean difference.
- Three variables: $X \rightarrow M \rightarrow Y$, $X \rightarrow Y \rightarrow M$, $Y \rightarrow X \rightarrow M$, and all combinations of reciprocal relations. Special names for third-variable effects, confounder, mediator, moderator/interaction.
- Four variables: many possible relations among variables, e.g., $X \rightarrow Z \rightarrow M \rightarrow Y$
- Five variables..., Six variables...

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Third-Variable for Explanation

- Observe relation and then try to explain it.
- Elaboration method described by Lazarsfeld and colleagues (1955; Hyman, 1955) where third variables are included in an analysis to see if/how the observed relation changes.
- Intervening (Mediator)
- Specification (Moderator)
- Replication (Covariate)
- Explanation (Confounder)

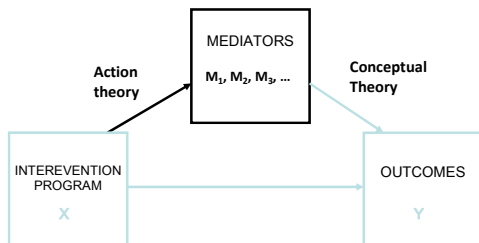
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Mediation by Design

- Select mediating variables that are causally related to an outcome variable.
- Intervention is designed to change these mediators.
- If mediators are causally related to the outcome, then an intervention that changes the mediator will change the outcome.
- Common in applied research like prevention and treatment.

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Intervention Mediation Model



If the mediators selected are causally related to Y, then changing the mediators will change Y. Test of each theory is important when total effect is nonsignificant.

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Mediation Regression Equations

- Tests of mediation for a single mediator use information from some or all of three equations.
- The coefficients in the equations may be obtained using methods such as ordinary least squares regression, covariance structure analysis, or logistic regression.
- The product of coefficients test is the method of choice. It extends to more complicated models such as the multiple mediator model.

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Single Mediator Regression Equations

$$Y = i_1 + \hat{c} X + e_1$$

$$M = i_2 + \hat{a} X + e_2$$

$$Y = i_3 + \hat{c}' X + \hat{b} M + e_3$$

$\hat{a}\hat{b} = \hat{c} - \hat{c}' = \text{estimator of the mediated effect for ordinary least squares analysis but not other methods.}$

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Moderation Statements

- Treatment effects differ for **males and females**.
- Program effects on condom use are greater for people who are more likely to be **risk takers**.
- Program effects differ as a function of the **baseline measure of the outcome variable**.
- Example moderators: (1) Stable: gender, age, race, (2) Individual Differences: SES, risk taking, impulsivity
- Your examples

SPECIAL ISSUE OF PREVENTION SCIENCE ON ANALYSIS OF SUBGROUPS!

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Moderator Definitions

- A moderator is a variable that modifies the form or strength of the relation between an independent variable and a dependent variable.
- The effect of one factor depends on the level of another factor.
- Theory may predict which persons will have an effect and which persons will not.
- Differs from a mediator in that there is not a causal sequence such that the variable transmits the effect of an independent variable to a dependent variable as for a mediator.

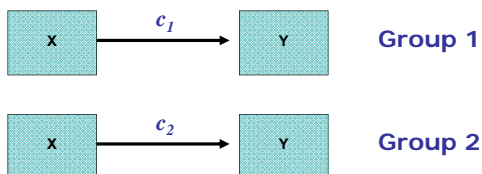
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Moderation is important because ...

- Acknowledges individual differences-idiographic approach; Lumpers and splitters.
- Some groups may have larger effects than other groups. Some groups may even have opposite effects.
- Could tailor programs to aspects of individuals and contexts. May be substantial challenges to delivering programs to different groups however, e.g., classic case of delivering to groups of high-risk persons.

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Path Diagram of the Moderation Model for Individual Groups



Different regression coefficients predict Y from X in each group, indicating that the X-Y relation differs across values of the moderator

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Testing Moderator Effects for Individual Groups (1)

- Individual regression equations for the groups are estimated:

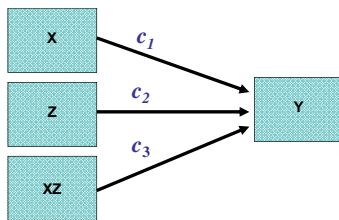
$$\text{Group Z=1: } Y_1 = i_1 + \hat{c}_1 X + e_1$$

$$\text{Group Z=2: } Y_2 = i_2 + \hat{c}_2 X + e_2$$

$$\text{Moderator Effect} = \hat{c}_2 - \hat{c}_1$$

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Path Diagram of the Moderation Model for Combined Groups



$$Y = i_2 + \hat{c}_1 X + \hat{c}_2 Z + \hat{c}_3 XZ + e$$

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Moderation Applications

- Moderation for Explanation: Are there groups for whom effects differ? Are there groups with a program effect?
- Moderation by Design: Effects are hypothesized to differ between groups. Best example is when the moderator is part of design, e.g., an effect is expected for girls but not boys.

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Synthesis for Mediating and Moderating Variables

- Required sample sizes for mediation and moderation can be larger than the observed total sample which reduces power to detect mediator and moderator effects in a single study.
- Combining data from multiple studies can increase power to detect effects. This is especially true when looking at moderation by low frequency moderators such as individuals with different sexual orientations.
- Way to replicate research results.

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Data Sharing Across Studies

1. Shared summary information: means, variances, etc.
 2. Shared data sets: all data
 3. Shared analytic method: same analysis on all data sets but not sharing of all data.
- (Brown et al., 2013, *Prevention Science*),

- It is ideal if the actual data can be obtained from each study because much more can be done.
- See Brown et al. (2013) for critical issues in data sharing like detailed knowledge of study history.

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Mediation for Integrated Data Analysis and Meta-Analysis 1

- Estimates: X to M, a , and M to Y, b , relations. Also X to Y, c and c' , and mediated effect, ab .
- Relation of M to Y is more problematic because M is not randomized so relation between M and Y is correlational.
- Mediator constructs may differ across studies. Even if it is the same construct, measurement may differ. Is this a weakness or a strength? Strengths: use as estimates of different aspects of a random process, measurement facets, Weaknesses: comparing variables that are not really comparable, differ by time, respondents, age, etc.

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Mediation for Integrated Data Analysis and Meta-Analysis 2

- Different studies may be best modeled as random effects-as a random sample of all studies.
- R Program to combine estimates from different studies (Huang, Brown, & MacKinnon, 2013).
- Note some studies may only have X to M or only M to Y and ideally these different study results can be combined to provide a more accurate assessment of mediation because it includes results from many studies.

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Moderation for Integrated Data Analysis and Meta-Analysis 1

- Need measures of X, Y, and Z.
- Need at least means of Y at levels of X and Z. If Z is continuous it is more problematic as you would have values for Y for every value of X and Z.
- Different possibilities for integrated data analysis versus meta-analysis. With all of the data there are many more possibilities.
- Note that studies may be more likely to have the same measures of X, Y, and Z than for the mediation case; but this problem remains for moderators, e.g., interventions, X, can differ across studies.

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Moderation for Integrated Data Analysis and Meta-Analysis 2

- How programs benefit or harm across subgroups of persons within a defined population.
- How do effects differ across contexts, schools, families, locations, states, etc..
- Effects may also differ by baseline risk.
- What are the important moderators for LGBT studies? Race/Ethnicity, sexual orientation, age, identification, state and local laws, policies, ... (see Hatzenbuehler, 2009)

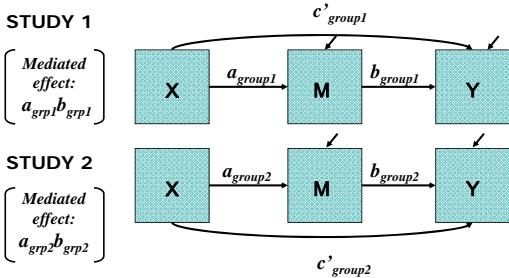
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Mediation and Moderation Simultaneously

- Combining mediation and moderation into a single analysis allows examination of several effects not possible with either model alone
- Complex research hypotheses can be considered.
- Analyses are more complex, however
- IDA is an example of a moderation of a mediation process.

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Path Model for the Mediated Effect in Individual Studies



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Summary

- Mediation and moderation represent ways to extract more information from a research study.
- Integrated data analysis and meta analysis provide important ways to investigate mediation and moderation effects especially given the often large sample size requirements to detect moderation and mediation effects in single studies.
- Theory is crucial for the identification and testing of moderators and mediators.
- Plan studies to include measures of moderators and mediators.

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