Modern Mediation Analysis

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September 30, 2016

Introductions
Workshop Goals
Definitions
Examples of Mediating Variables
History

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Introductions

- Undergraduate Social Psychology Class from Charles Judd around 1978 at Harvard University
- Graduate School at the University of California, Los Angeles Quantitative Psychology
- Drug Prevention Research at University of Southern California
- Support from the National Institute on Drug Abuse

http://www.public.asu.edu/~davidpm/

- Prevention Science Methodology Group
- MacKinnon, D. P. (2008) Introduction to Statistical Mediation Analysis, Mahwah, NJ: Erlbaum.
- Introductions in small groups

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Introduction Questions

What is your name?

Where are you from?

Why are you taking this workshop?

What is your area of interest?

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Workshop Activities

- Agenda
- Lecture
- Handouts
- Small Group Activities
- Computer Examples
- Questions and Feedback
- Book

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Workshop Goals

- Understand conceptual motivation for mediating variables.
- Understand the importance of mediation in many research areas.
- Statistical analysis of the single and multiple mediator models.
- General Statistical background for mediation analysis
- Exposure to Models with Moderators and Mediators
- Exposure to Path analysis mediation model
- Exposure to Longitudinal mediation models.
- Exposure to alternative approaches to identifying mediating variables.
- Exposure to Statistical software to conduct mediation analysis.
- Realize mediation is fun.

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Collaborators

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2 trillion words from 15 million books, about 12% of every book in every language published since the Gutenberg Bible in 1450 (Bohannon, J. (2010 December 17, Google opens books to new cultural studies. *Science*, *330*, 1600).

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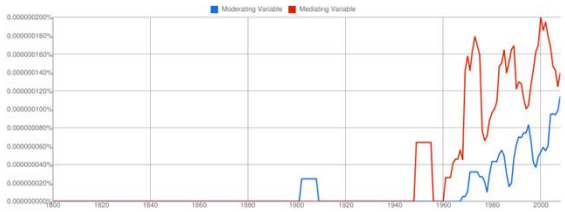
Moderating and Mediating Variable



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Chapter 1: Introduction

- Overview
- Examples
- Definitions
- History

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Three Ways to Specify a Model

- Verbal description: A variable M is intermediate in the causal sequence relating X to Y.
- Diagram
- Equations

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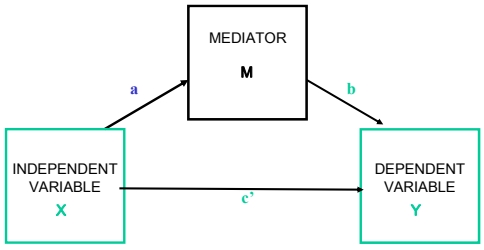
Single Mediator Model



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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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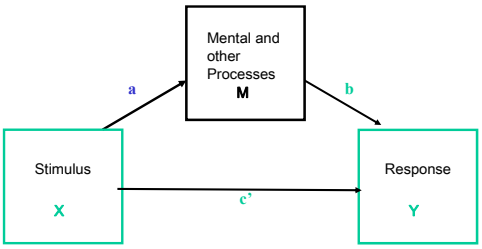
S-O-R Mediator Model



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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, teams, schools, 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 a measurement problem.

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The Panama Canal I

- Yellow fever and malaria prevented the French from building the Panama Canal from 1889-98. Too many workers became sick or died to continue the project.
- The US continued the project and developed a public health attack on yellow fever and malaria.
- William Gorgas was put in charge of the public health of the region so that work could continue.
- Actions to reduce the number of mosquitoes were to drain standing water, improve plumbing, increase the number of animals that eat mosquitoes, and screening sleeping quarters.

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The Panama Canal II

- Actions were designed to change the mediator, human exposure to mosquitoes, under the theory that mosquitoes carried yellow fever, i.e., the number of mosquitoes was related to the number of yellow fever cases.
- The number of deaths owing to yellow fever was drastically reduced and the canal was built.
- Example of the use of mediation in the development and application of prevention and treatment programs. Note the mediators were considered known and strategies were used to change them to change an outcome variable.

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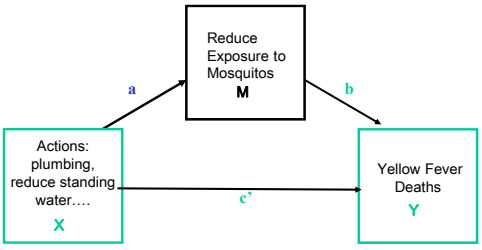
Health Intervention Mediator Model



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Mediation Statements

- If norms become less tolerant about smoking then smoking will decrease.
- If you increase positive parental communication then there will be reduced symptoms among children of divorce.
- 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 pregnant women know the risk of alcohol use for the fetus then they will not drink alcohol during pregnancy.

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Mediating Variable

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

Attitudes cause intentions which then cause behavior (Azjen & Fishbein, 1980)

Prevention programs change norms which promote healthy behavior (Judd & Kenny, 1981)

Increasing exercise skills increases self-efficacy which increases physical activity (Bandura, 1977)

Exposure to an argument affects agreement with the argument which affects behavior (McGuire, 1968)

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Clinical Mediation Examples

Psychotherapy induces catharsis, insight, and other mediators which lead to a better outcome (Freedheim & Russ, 1992)

Psychotherapy changes attributional style which reduces depression (Hollon, Evans, & DeRubies, 1990)

Parenting programs reduce parents' negative discipline which reduces symptoms among children with ADHD (Hinshaw, 2002).

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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

Many interesting statistical and mathematical issues

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Two, three, 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., $X \rightarrow Z \rightarrow M \rightarrow Y$

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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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Other names for Mediators and the Mediated Effect

- Intervening variable is a variable that comes in between two others.
- Process variable because it represents the process by which X affects Y.
- Intermediate or surrogate endpoint is a variable that can used in place of an ultimate endpoint.
- Indirect Effect for Mediated Effect to indicate that there is a direct effect of X on Y and there is an indirect effect of X on Y through M.

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Other names for Variables in the Mediation Model

- Initial to Mediator to Outcome (Kenny, Kashy & Bolger, 1998)
- Antecedent to Mediating to Consequent (James & Brett, 1984)
- Program to surrogate (intermediate) endpoint to ultimate endpoint
- Independent to Mediating to Dependent used here.

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Mediator versus Confounder

- Confounder is a variable related to two variables of interest that falsely obscures or accentuates the relation between them (Meinert & Tonascia, 1986)
- The definition below is also true of a confounder because a confounder also accounts for the relation but it is not intermediate in a causal sequence.
- In general, a mediator is a variable that accounts for all or part of the relation between a predictor and an outcome (Baron & Kenny, 1986, p.1176)

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Mediator versus Moderator

- Moderator is a variable that affects the strength of the relation between two variables. The variable is not intermediate in the causal sequence so it is not a mediator.
- Moderator is usually an interaction, the relation between X and Y depends on a third variable. There are other more detailed definitions of a moderator.

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Mediator versus Covariate

- Covariate is a variable that is related to X or Y, or both X and Y, but is not in a causal sequence between X and Y, and does not change the relation between X and Y. Because it is related to the dependent variable it reduces unexplained variability in the dependent variable.
- A covariate is similar to a confounder but does not appreciably change the relation between X and Y so it is related to X and Y in a way that does not affect their relation with each other.

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Summary: Mediator, Confounder, Moderator, and Covariate

- Mediator-a variable that is intermediate in a causal sequence such that X causes the mediator and the mediator causes Y. The relation between X and Y changes when adjusted for the mediator.
- Confounder-a variable that is related to both X and Y but is not in a causal mediation sequence. The relation between X and Y changes when adjusted for the confounder.
- Covariate- a variable that is related to X or Y or both. The relation between X and Y does not appreciably change when adjusted for the covariate.
- Moderator-a variable where the relation of X to Y is different at different values of the moderator.

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Mediator, Moderator, Covariate or Confounder?

- The effect of age is removed from the relation between stress and health symptoms.
- Effect of dissonance on a court decision depends on whether the court case was a sexual harassment or product liability case.
- Physical fitness affects feelings of athletic competence which then affects body image.
- The relation between stress and health symptoms is compared across ages.

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Mediator, Confounder, Moderator, or Covariate

- Relation of health and income is negative. When age is included the relation is positive.
- Marriage changes expectations regarding alcohol and alcohol expectations affect alcohol use.
- Exposure to violent themes in a music video increases aggressiveness but only among males.
- The relation of stress to cortisol differs in the morning compared to the evening.

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Historical Roots of Mediation I

- Deities as Mediators
- Causation, Aristotle's efficient causes, Hume regularity of events, spatial/temporal contiguity, constant conjunction.
- Genetic Mediation Theory, Process by which parent traits leads to offspring traits.
- Atomic Mediation Theory, How chemical input leads to chemical output, conservation of mass and proportion of elements remain.

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History: Wright's Path Analysis

- Sewall Wright (1923) developed path analysis to investigate hereditary and environmental influences on the color patterns of piebald guinea pigs. Path analysis was based on correlations among measures. Equations and path diagrams were used to represent the path models. Mediation was described as products of coefficients, "**the correlation between two variables can be shown to equal the sum of the products of the chains of path coefficients**." p. 330.

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History: Criticisms of Wright

- Niles (1922) criticized path analysis as a general formula to deduce causal relations.
- Wright (1923) responds, "..combination of knowledge of causal relations and knowledge of correlation is different from deducing causal relations from correlations." He divides application of theory into three cases: **(1) causal relations are considered known, (2) enough is known to warrant a hypothesis or alternative hypothesis, and (3) even a hypothesis is not justified.** Path analysis is justified in cases 1 and 2 but not 3 because there is nothing to be combined with knowledge of correlations.

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History: Modern Mediation Analysis

- Sociologist O. D. Duncan rediscovers Path Analysis as a way to investigate systems of relations.
- Jöreskog and others combine psychometric tradition of factor analysis with path analysis models to form Covariance Structure Modeling.
- Alwin & Hauser (1975) describe methods of effect decomposition. Sobel (1982) derives standard error of the mediated effect. Judd & Kenny (1981) and Baron & Kenny (1986) describe mediation analysis in psychology and MacKinnon & Dwyer (1993) describe mediation in prevention.
- Holland (1986) causal mediation model, Bollen & Stine (1990) Resampling methods

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History V (Now)

- Best methods for significance tests and confidence intervals, such as distribution of the product and resampling methods.
- Comprehensive mediation models
- Development and evaluation of longitudinal mediation models.
- Mediation analysis for nonlinear models when the dependent variable is not normally distributed such as a binary or count variables.
- Detailed causal inference for mediation models. Including tests of assumptions for causal inference.
- Best program of research to investigate mediation relations…

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Quotes

Nursing ".. Should consider hypotheses about mediators …. that could provide additional information about why an observed phenomenon occurs" (Bennett, 2000).

Children's programs ".. Including even one mediator ….. in a program theory and testing it with the evaluation .. will yield more fruit…." (Petrosino, 2000)

Child mental health "rapid progress … depends on efforts to identify … mediators of treatment outcome. We recommend randomized clinical trials routinely include and report such analyses" (Kraemer et al., 2002).

"Everyone talks about the weather but nobody does anything about it." (Mark Twain)

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