



UNIVERSITY OF
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How do contextual factors influence causal processes? Conditional Process Models



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Why Study Mediation & Moderation?

- + Guides theory-driven program evaluation; lends insight into construct validity of programs.
- + Studying mechanisms of change directs evidence-based intervention
 - + Sheds light on how intervention does/not achieve its effects
 - + Critically contributes to science of prevention via role in understanding determinants of behavior and etiological roots of behavioral pathways
- + Investigating moderator variables helps elucidate the external validity of interventions.
- + Analyzing mediators and moderators simultaneously enables research questions such as:
 - + “Is the process by which a program achieves its effects the same across different types of participants or in different contexts?”
 - + “Can a mediating mechanism explain an interaction effect in my program?”

Mediator and Moderator Variables

- + Mediator variables describe how or why two variables are related, illustrating the *mechanism* by which the variables relate.
 - + Describes causal pathway through which program impacts outcomes
 - + Lends itself well to program evaluation where causal assumptions linking program activities, intermediate outcomes and ultimate goals are considered
- + Moderator variables describe the conditions under which, or for whom, two variables relate.
 - + Early references described moderators as specification variables that improved prediction of an outcome from a predictor at certain values
 - + By definition moderator effects yield differential prediction of an outcome at different values of the moderator variable (can affect strength and/or direction)

Mediation by design vs. for explanation

- + Mediation for explanation probes underlying mechanisms of an effect after it has occurred.
 - + e.g., childhood physical abuse relates to patterns of violence later in adulthood; relation explained by physically abused children acquiring deviant patterns of processing social information, which in turn predict aggressive behavior in adulthood (Dodge et al., 1990)
 - + Approach vulnerable to capitalizing on chance findings but useful to consider how effects occur/can guide future mediation by design studies.
- + Mediation by design identifies mediators a priori and designs intervention to manipulate mediating variable(s) with intention of ultimately impacting outcome(s)
 - + Successful manipulation of mediators should change target behavior.

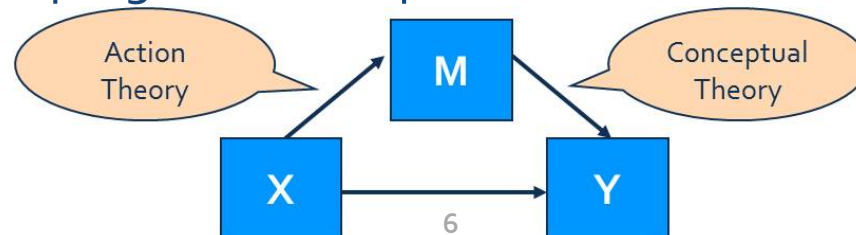
Mediation by design embodies heart of prevention/intervention programming and is the foundation of instigating behavioral change in an intervention context.

Mediation by Design: Historical Examples

- + Building of Panama Canal one of the earliest applications of mediation by design in intervention programming
 - + Based on theory that mosquitoes were yellow fever carriers, doctors implemented measures to reduce workers' mosquito exposure (e.g., screened in sleeping quarters, improved water drainage).
 - + Intervention driven by hypothesis that human exposure to mosquitoes mediated yellow fever occurrence.
 - + Intervention sought to manipulate mosquito exposure, with the intention of ultimately impacting yellow fever onset
- + John Snow's intervention in the mid 19th century London cholera epidemic is another mediation by design example.
 - + Snow theorized that the disease was being propagated by a contaminated water pump in the city and had officials shut it down.
 - + By removing the contaminated water supply, he manipulated mediator of disease and was able to interrupt the outbreak

Importance of Action & Conceptual Theory in Mediation by Design Studies

- + Evaluation of action and conceptual theory directs stakeholder action in the face of unexpected effects or program failure.
- + Action theory failure may dictate exploring additional resources/ alternative design strategies to enhance manipulation; moderation here identifies elements that impact program implementation and delivery.
- + Conceptual theory failure may lead researchers to reconsider underlying determinants of behavior believed to impact outcome (note sleeper effects); moderation identifies contexts under which relation does not hold
- + The effectiveness of any given program hinges on the quality of both components and understanding success/failure of each piece guides future steps in program development (Fairchild & MacKinnon, 2014).



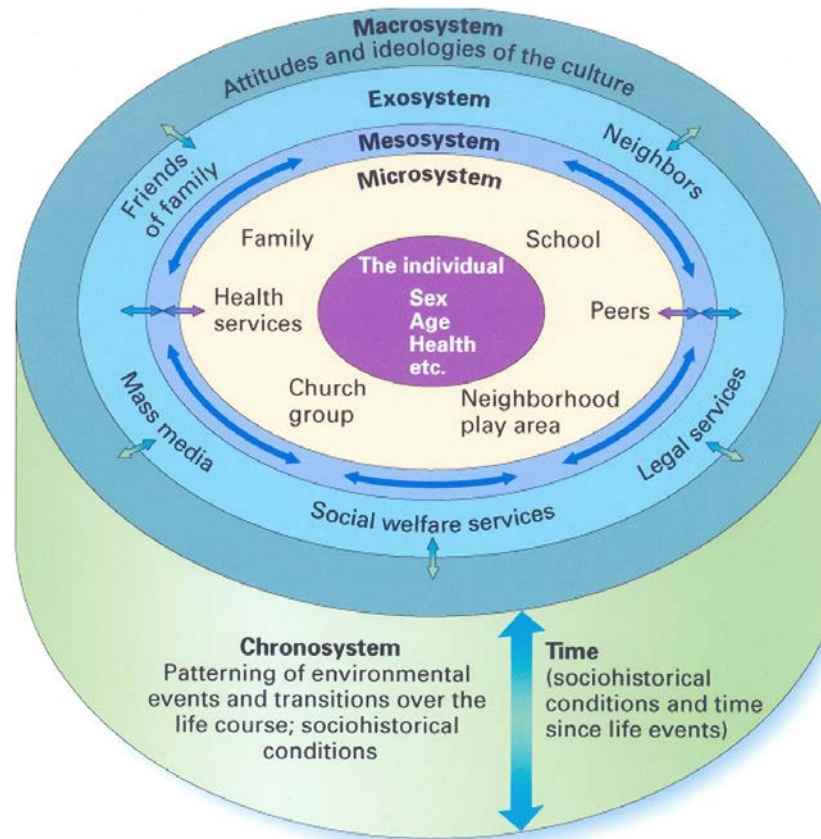
Moderation effects in program evaluation

- + Contextual effects can enhance or detract from the efficacy of program components and underlying mediation processes.
- + Investigating moderator variables is an important aspect of streamlining and refining prevention and intervention programs
 - + Can identify participants for whom the intervention is most effective, and whether underlying pathways of behavior are consistent across subgroups
 - + Can compare relative effectiveness of different delivery or implementation strategies; can identify characteristics of environment that may exert differential influences on program
- + Different program stakeholders may have different research questions regarding moderation of intervention effects and mediating processes.
 - + e.g., do contextual factors affect effective delivery of the intervention or are there factors that enhance or detract from treatment fidelity among participants

Moderation analysis in program evaluation

- + Moderator variables can be continuous or categorical, mutable or constant, and may stem from a variety of different sources.
 - + Baseline measures of outcome variables may moderate mediation effects by driving baseline by treatment interactions.
 - + Different facets of the environment in which the program is implemented can affect mediating mechanisms as well, such as type of school (i.e., public vs. private) or geographical location.
 - + Characteristics of the participant/service provider interactions and/or treatment fidelity may also moderate mechanisms.
- + Useful to consider Bronfenbrenner's Ecological Systems Theory (1979) to put these varied sources into context.

Bronfenbrenner's Ecological Systems Theory (1979)



Example Moderator Variables from the Ecological System

- + **Individual** (system center):
 - + e.g., age, sex, genetic phenotypes, baseline levels of outcome
- + **Microsystem** (proximal factors outside individual; e.g., family, school):
 - + e.g., exposure to deviant peers or participant/service provider interaction
- + **Exosystem** (social influences beyond an individual's proximal contexts; e.g., neighborhood):
 - + e.g., availability of community resources (i.e., structural social support)
- + **Macrosystem** (larger cultural context to which an individual is exposed):
 - + e.g., SES or prevailing political ideology in community
- + **Chronosystem** (temporal context representing dynamic influence of personal and/or environmental change):
 - + e.g., timing of parental divorce (disruptive effects for children have been noted to be higher in certain timeframes).

Simultaneously examining mediation and moderation: conditional process models

- Simultaneously evaluating mediation and moderation effects in a conditional process modeling framework enables research hypotheses not accommodated by either model individually
- Can consider moderation of:
 - indirect effects
 - direct effects
 - component paths in the mediation model (i.e., moderation of either action and/or conceptual theory)
 - overall effect to explore why an interaction effect exists

Moderators within vs. outside the mediation process

- + Moderation effects can be due to variables within the mediation chain, such as the mediator or outcome
 - + Hallmark example: baseline by treatment interaction effects
- + Moderation effects can be due to variables outside of the mediating chain (i.e., not X, M or Y)
 - + Examples: gender, age, ethnicity, etc.

Terminology you may have heard

+ “Moderated-mediation”

- + A mediated effect differs across levels of a moderator variable
- + The moderator can be within or outside the mediation chain
- + This is just the moderation of an indirect effect

+ “Mediated-moderation”

- + An interaction effect is explained by a mediating mechanism
- + Effectively supposes an interaction effect in the “a” path (i.e., $X \rightarrow M$) of the mediation model
 - + Muller et al. (2005) argued a significant overall interaction effect is necessary for mediation-moderation, but logic is fallible in same way requiring a significant overall effect is necessary to explore indirect effects

More on Conditional Process Models

- + Combined models for mediation and moderation often have been a source of confusion for substantive researchers due to terminology.
- + Placing focus on which effects (i.e., overall vs. direct vs. indirect) and/or which paths in the mediation model are moderated avoids this confusion while encouraging the researcher to focus on specific research hypotheses (Edwards & Lambert 2007).
- + Focused approach valuable in program evaluation work as it facilitates explicit examination of heterogeneity in program action and conceptual theories
 - + e.g., explore whether a program impacts behavioral determinants in the same way across different groups of participants
 - + e.g., ask whether the mediator is related to the outcome in the same way across different groups of participants

Estimation Approach for Conditional Process Models

- + With continuous moderators, researcher can estimate a single, combined groups mediation model by incorporating applicable interaction terms (e.g., MacKinnon 2008; Preacher et al., 2007).
 - + Significant interaction effects in either the a or the b path of the model imply moderation of the indirect effect across some range of the continuous moderator (Fairchild et al. 2009).
- + With categorical moderators, researcher can alternatively apply an individual-groups model by estimating separate mediation models at each level of the categorical moderator variable and testing parameters of interest for equivalency across subgroups.
- + Analyzing simple mediation effects at different levels of the moderator variable is an important aspect of these analyses (Hayes, 2013; Morgan-Lopez et al., 2003, 2006; Tein et al., 2004)

Basic Model Equations

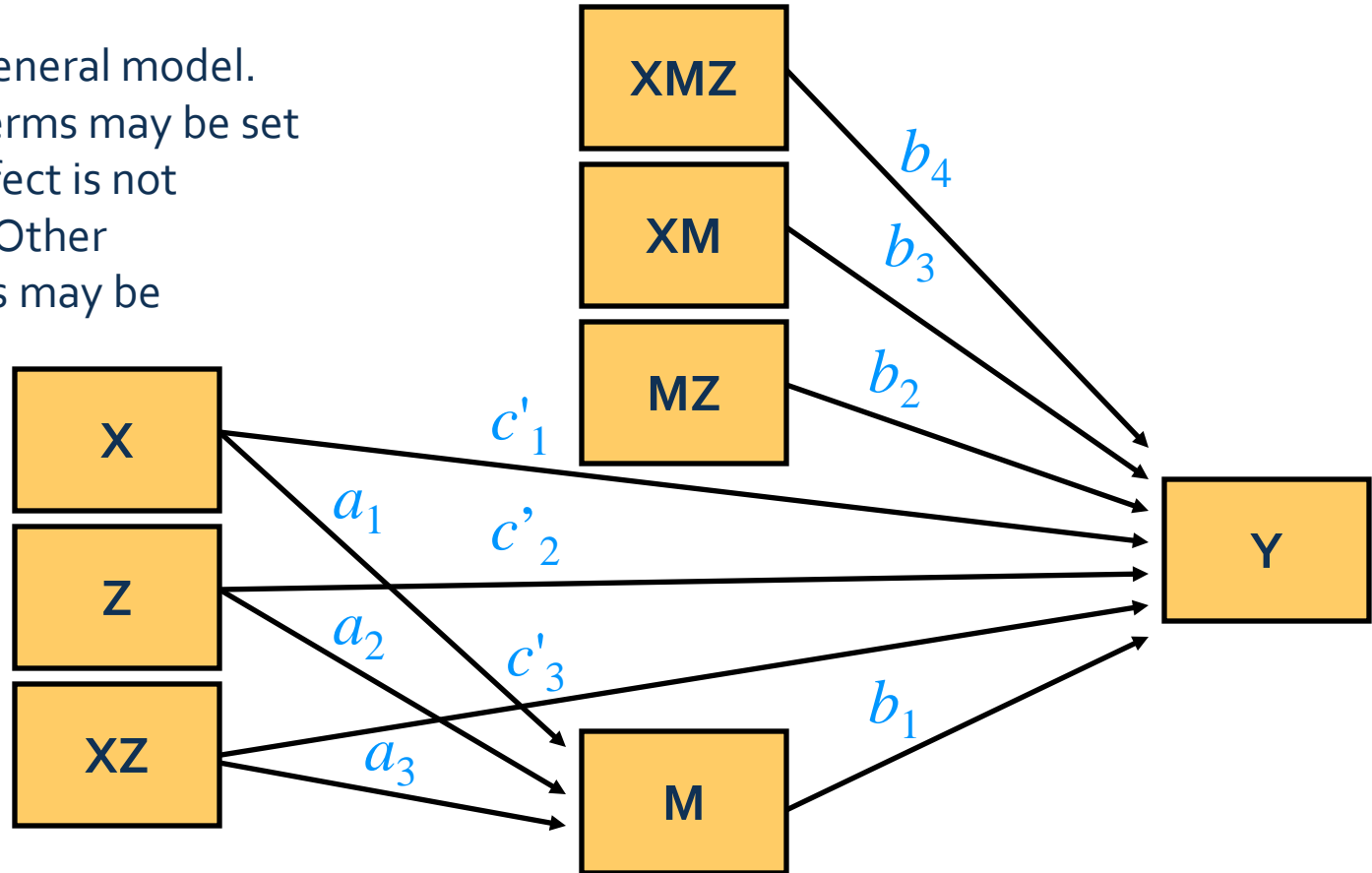
$$Y = i_1 + c_1 X + c_2 Z + c_3 XZ + e_1$$

$$M = i_2 + a_1 X + a_2 Z + a_3 XZ + e_2$$

$$Y = i_3 + c'_1 X + c'_2 Z + c'_3 XZ + b_1 M \\ + b_2 MZ + hXM + jXMZ + e_3$$

Basic Path Diagram

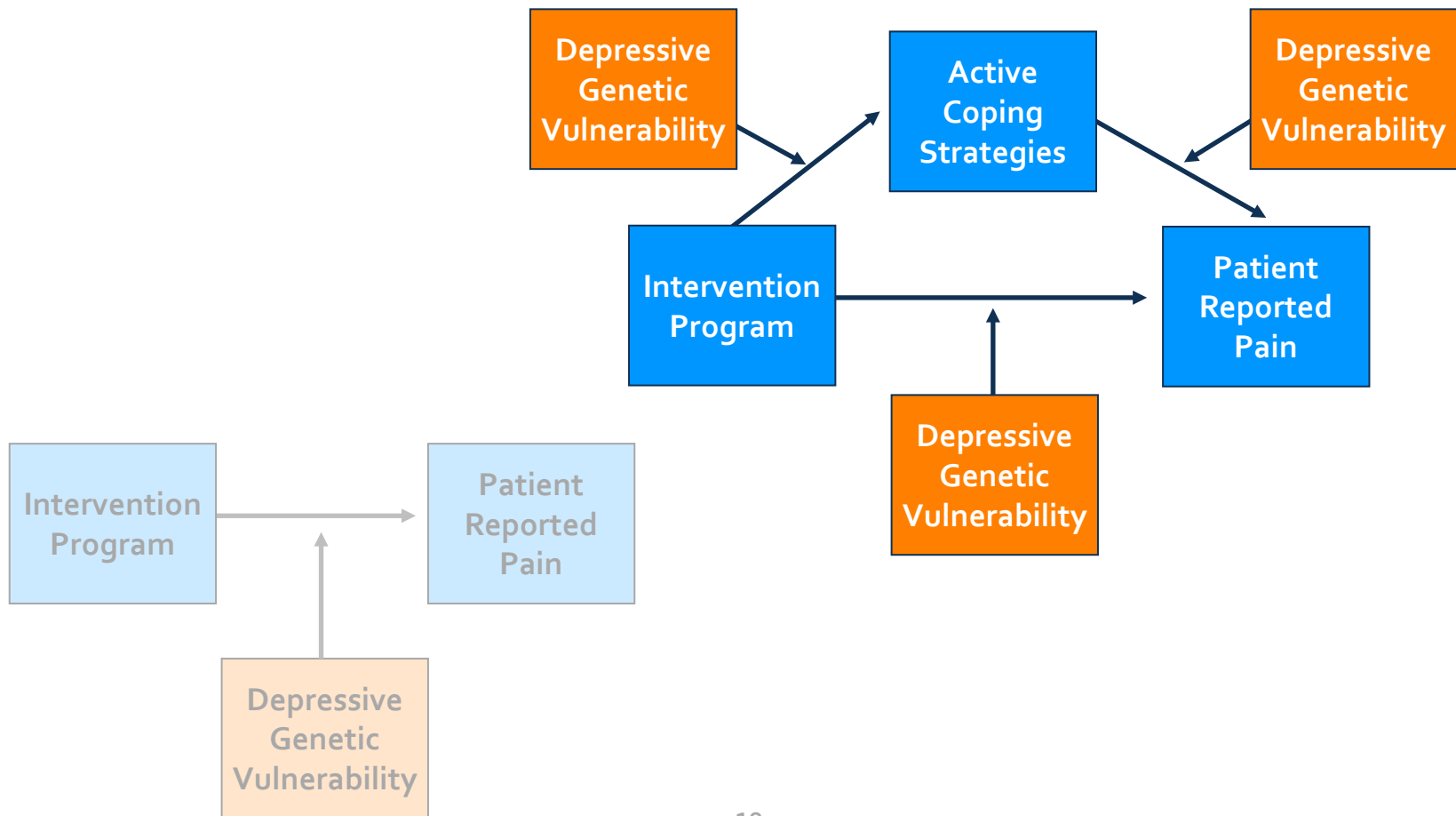
This is only a general model. One or more terms may be set to zero if an effect is not hypothesized. Other terms/variables may be integrated.



A Conditional Process Example

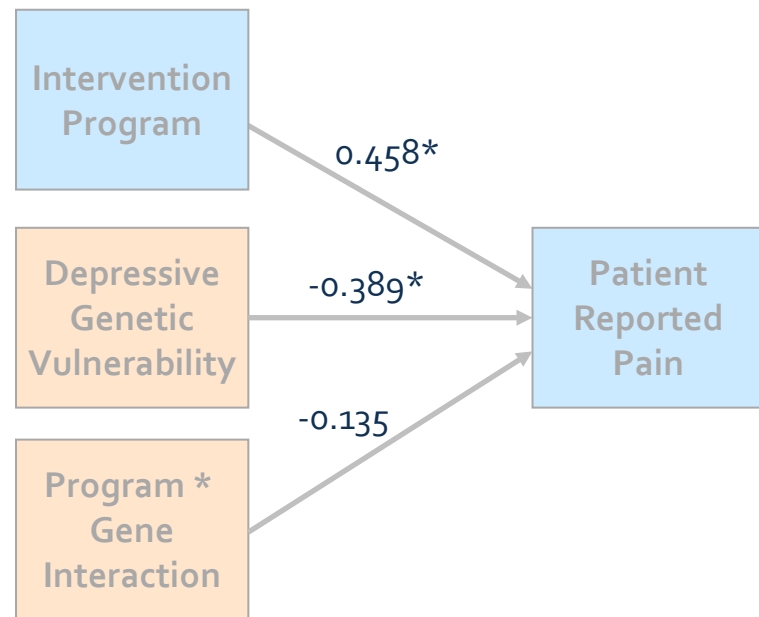
- + Researchers implement an intervention program to increase active coping strategies in sickle cell disease patients, in an effort to aid pain management
- + It is hypothesized that the presence of genetic predisposition to depression may moderate the mechanism by which the program achieves effects

A Conditional Process Example: Possible Moderation Relations to Consider



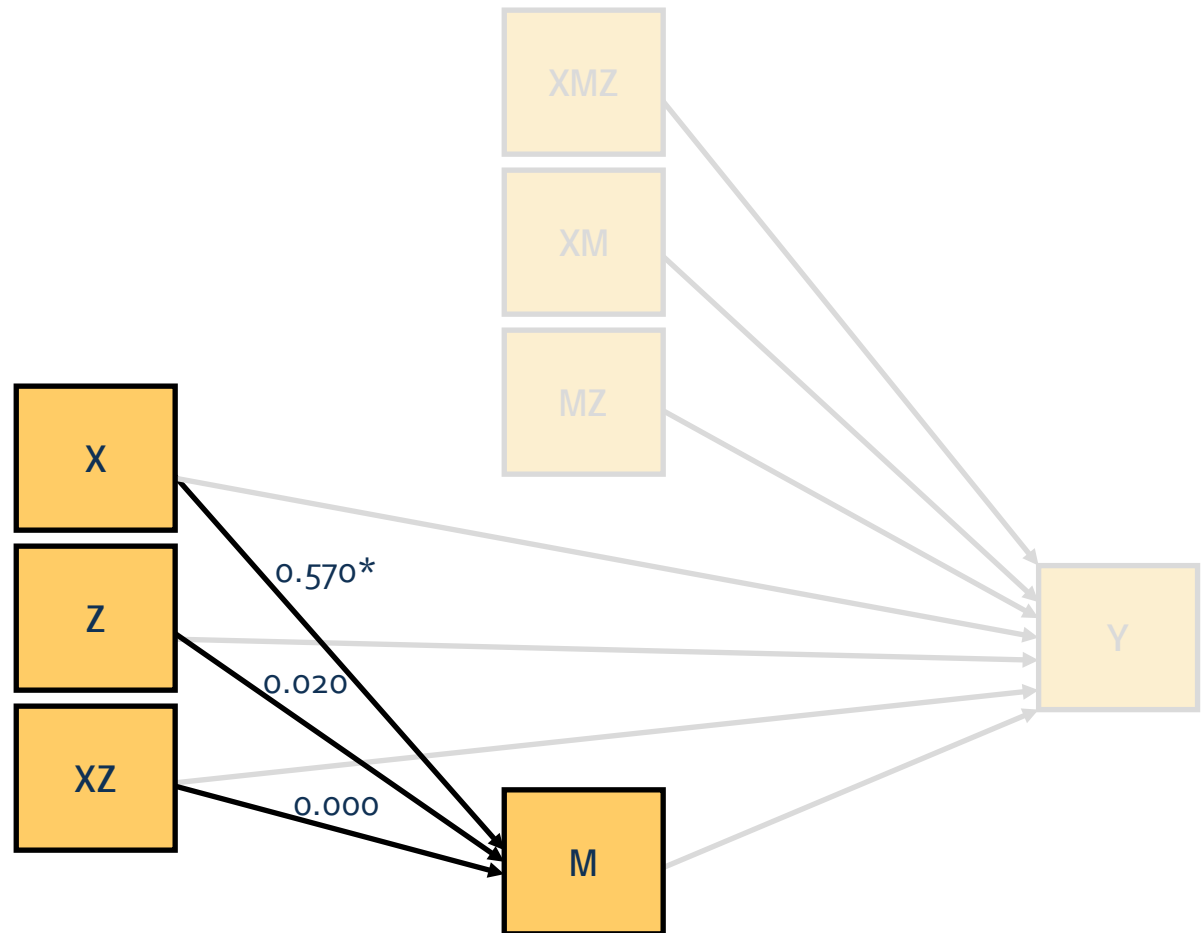
A Conditional Process Example: Is the overall program effect moderated?

There are significant overall effects of the program and genetic predisposition on reported pain; there is not a significant overall interaction effect of the program*gene on reported pain



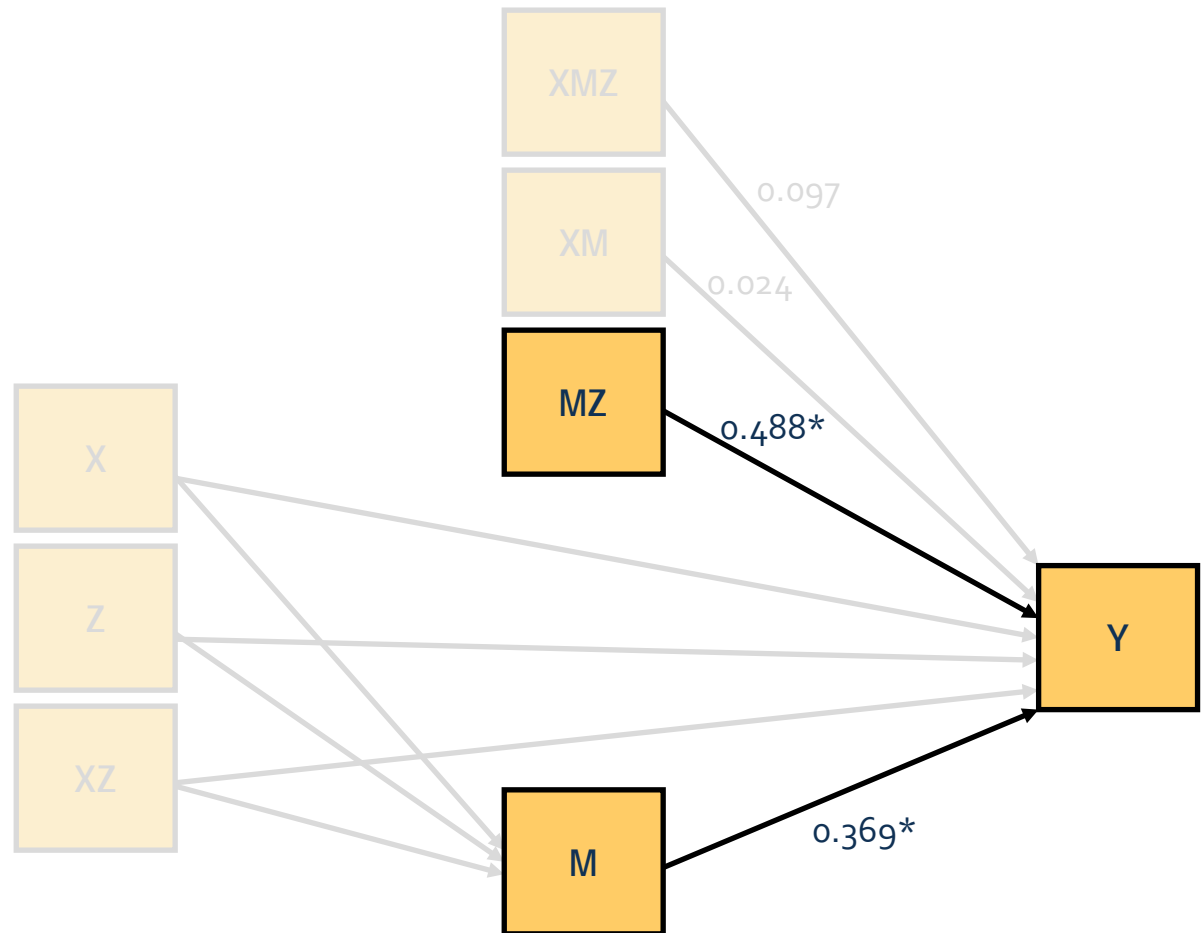
A Conditional Process Example: Do we have moderation in the action theory?

There is a main effect of the program on active coping, but no significant program*gene interaction, so there is no moderation of the action theory



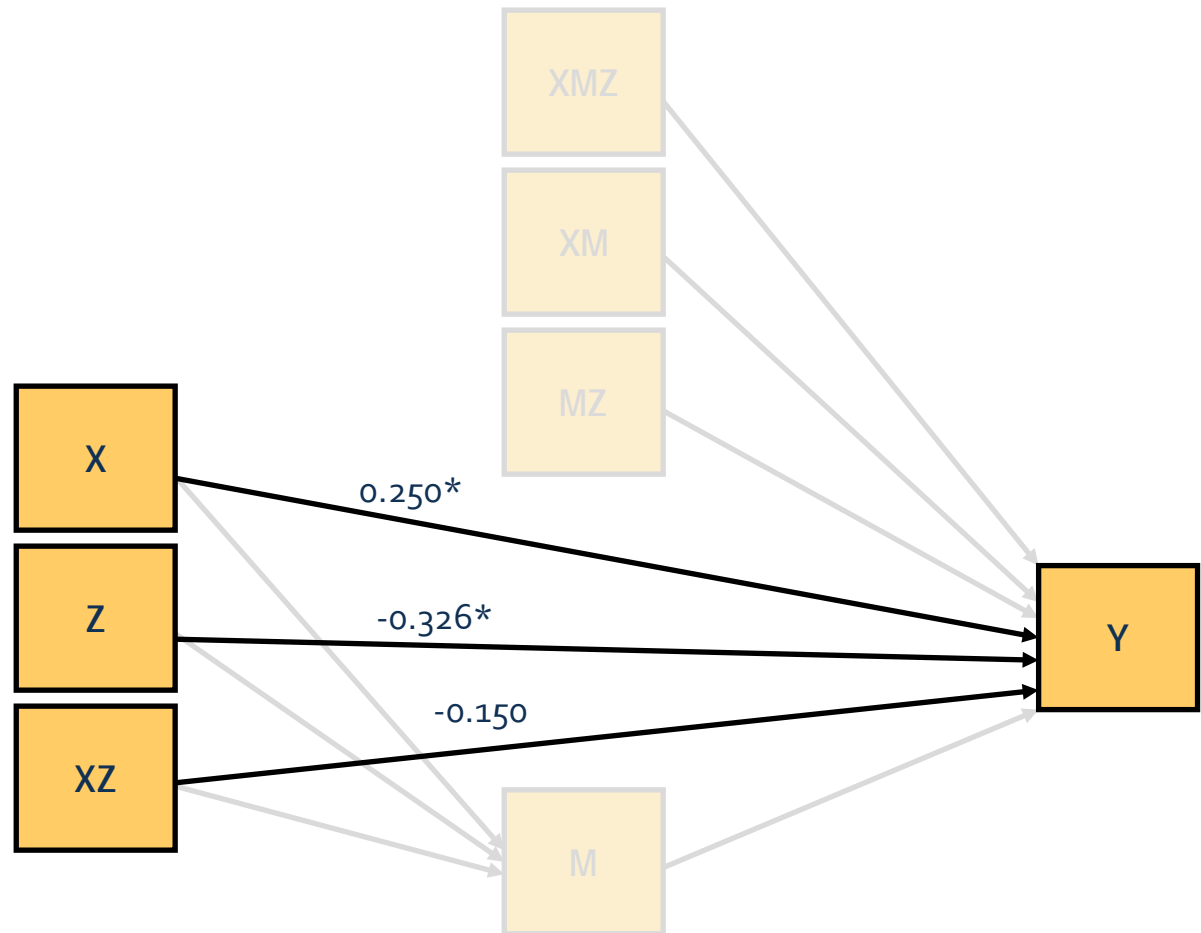
A Conditional Process Example: Do we have moderation in conceptual theory?

There is a main effect of active coping on reported pain, as well as an active coping*gene interaction on reported pain; so the conceptual theory is moderated



A Conditional Process Example: Do we have moderation of the direct effect?

There are significant direct effects of the program and genetic predisposition toward depression on reported pain; the interaction is not significant. Thus there is no moderation of the direct effect.



A Conditional Process Example: Do we have moderation of the indirect effect?

- + Because we found significant moderation in the b path of the mediation model (i.e., the conceptual theory), we have significant moderation of the indirect effect, ab
- + Given this finding, we can estimate simple mediated effects at each level of the moderator variable (i.e., estimate separate mediation models for the gene and no gene subgroups) to characterize the differences

A Conditional Process Example: Simple Mediated Effects and their Difference

- + Simple mediated effect for participants without a genetic predisposition toward depression:
 $ab = .177(.040)$
 - + a path (i.e., action theory coeff.) = .449
 - + b path (i.e., conceptual theory coeff.) = .395
- + Simple mediated effect for participants with a genetic predisposition toward depression:
 $ab = .400(.078)$
 - + a path (i.e., action theory coeff.) = .455
 - + b path (i.e., conceptual theory coeff.) = .880

A Note on Options for Estimating Conditional Process Models in Practice

- + The “mediation: R package for Causal Mediation Analysis”
 - + Estimates basic moderated mediation models in a causal framework (Tingley et al., 2013; Imai et al., 2008; 2009; 2011)
- + Hayes (2013) has an integrated macro facility called “PROCESS” for SPSS and SAS to estimate a variety of regression-based mediation models including moderated mediation
- + Mplus 7.2 estimates moderated mediation analyses in SEM framework (also accommodates causal modeling)

Concluding Remarks

- + Mediation and moderation analyses have the ability to impact and encourage all levels of prevention efforts (i.e., universal, selective and indicated efforts).
- + Commitment to a dynamic process of continual evaluation and development is critical to maximize our ability to affect behavioral change across all of these levels.
- + Evaluating program mediators and moderators contributes to prevention/intervention research goals by promoting thoughtful curriculum development based on internal and external validity of program components.
- + Researchers can ameliorate prevention programming by using mediation and moderation analyses to iteratively refine interventions in an open system where program theory and empirical application are considered in tandem.

Thank you.