

PSYCH 6822
Spring 2016
Mediation, Moderation, and Conditional Process Analysis

This is an interdisciplinary data analysis seminar focused on the application of principles of linear modeling in the context of linear regression analysis to exploring questions about mediated (i.e., indirect) and moderated (i.e., interaction) effects. We will spend part of the course talking about partitioning effects into direct and indirect components and how to quantify and test hypotheses about indirect effects, part talking about estimating, testing, and probing interactions in linear models, and part integrating moderation and mediation as “conditional process analysis” by discussing and how to conceptualize and test the contingencies of a mechanism. Computer applications will focus on SPSS and SAS using off-the-shelf code and the PROCESS macro available through CARMEN and www.processmacro.org. It is assumed that you have taken a course in multiple regression and have done well or are otherwise comfortable with the principles of multiple regression analysis (a review of this principles will be offered in the first week of class). No knowledge of matrix algebra is required or assumed.

Instructor

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Learning Objectives

By the end of this course, you will...

- be able to statistically partition one variable’s effect on another into its primary pathways of influence, direct and indirect.
- understand historical and modern approaches to inference about indirect effects in causal models.
- know how test competing theories of mechanisms statistically through the comparison of indirect effects in models with multiple mediators
- acquire an understanding of how to build flexibility into a regression model that allows a variable’s effect to be a function of another variable in a model.
- understand how scaling of variables influence parameter estimates and their interpretation.
- have the ability to visualize and probe interactions in regression models.
- have learned how to integrate models involving moderation and mediation into a conditional process model.
- have learned how to estimate the contingencies of mechanisms through the computation and inference about conditional indirect effects.
- know how to determine whether a mechanism is dependent on a moderator variable.
- be able to apply the methods discussed in this course using readily-available statistical software
- be in a position to talk and write in an informed way about the mechanisms and contingencies of causal effects.

What We Will and Will Not Cover

Topics covered:

- Path analysis: Direct, indirect, and total effects in mediation models.
- Estimation and inference about indirect effects in single mediator models.
- Multiple mediator models (parallel and serial).
- Mediation analysis with a multicategorical independent variable.
- Estimation of moderation and conditional effects.
- Probing and visualizing interactions.
- Multicategorical moderators and independent variables in moderation analysis.
- The effects of variable scaling and model parameterization on interpretation.
- Conditional Process Analysis (also known as “moderated mediation”)
- Quantification of and inference about conditional indirect effects.
- Testing a moderated mediation hypothesis and comparing conditional indirect effects
- Moderation in serial mediation models
- Mediation analysis in the two-condition within-participant design.

What is not covered:

- Dichotomous, ordinal, or count variable models or other models not based on OLS regression.
- Models involving latent variables or other methods requiring an SEM program.
- Nested data (i.e., multilevel models)
- Longitudinal data problems involving more than two waves of data

Required Readings and Other Materials

- Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York: Guilford Press.
- A laptop computer with a version of SPSS **or** SAS installed (available at no charge through the web page of the Office of the Chief Information Officer). Bring this to class with you every day, in the event it is needed for an occasional in-class activity. Make sure your laptop is charged sufficiently to make it through class.
- Data files available on CARMEN that have been downloaded on to your laptop.
- Various readings that are generally supplementary, in PDF form available through CARMEN.

Note: If there is no way you can get access to a laptop that you can bring to class regularly, see the instructor.

Evaluation

Your grade will be calculated based on a weighting of three components ranging between 0 and 100, using the weighting below. Grading scale: 92+ = A; 89-91: A-; 82-88 = B+; 75-81 = B; 70-74 = B-; 65-69 = C+; 60-64 = C; 50-59 = C-; 45-49 = D+; 40-45 = D; <40 = E. I do not “curve” my grading.

Attendance (25%)

You are expected to attend class, participate with your own questions when you have them, and contemplate the questions of others and my answers. At least some material not included in the book or my lectures will be delivered in response to questions, and you will benefit from hearing those questions and answers. Thus, you will learn merely by attending class regularly even if you are just a passive observer of others most of the time. Attendance will be taken at the beginning of class, and it is worth 25% of your course grade. You do not need to have a perfect attendance record in order to receive full attendance credit.

In-Class Activities (25%)

Occasional activities will be provided in class and being there to experience these will aid in your learning of the material. These will take the form of very short quizzes or brief data analysis problems and/or interpretation of output. Sometimes these will be announced in the course prior to their administration, and sometimes they will be unannounced. Sometimes you will be required to work alone, and sometimes you may be allowed to work with one classmate. Your lowest activity mark will be discarded from the computation of your in-class activities grade. On occasions (if any) when you are allowed to work with another person, you will turn in the activity with both your names and you will receive the same mark regardless of who contributed to the answer and in what proportion. Your worst activity mark will be dropped from the derivation of this component of your grade (including if you received a zero on the activity because you were absent).

Data Analysis Project or In-Class Final Exam (50%)

Fifty percent of your grade will be based on **either** the completion of a data analysis project of your design and choosing, **or** the completion of an in-class final exam.

Data Analysis Project: If you choose this option, you will complete a data analysis project using either your own data or data available to you through an advisor or through a public archive. This assignment is detailed in a separate section at the end of this syllabus. The paper reporting your project is due no later than **noon on May 2nd**. A hard copy is required, as well as an electronic copy submitted to the drop box on CARMEN. Your project will be graded on a scale from 0 to 100. The project must be completed independently, without consulting with other students or your faculty advisor when it is being prepared. All writing must be your own. You should not cut and paste any material (such as method sections or introductions) you have already published in a journal or presented at an academic conference into your final paper unless you are the sole author of that work. Furthermore, you cannot turn in material you have submitted for credit in another course or have already published. If I am suspicious that you have violated this rule, I will turn all relevant material to the Committee on Academic Misconduct for investigation.

In-Class Final Exam: If you choose this option, you will take an in-class final examination on the day and time the registrar has assigned for this class. This date and time is **Monday May 2 at 12:00-**

1:45PM. This final exam will contain a variety of different question types, including multiple choice, fill in the blank, and short answer formats. If you choose the final exam option over the data analysis project option, you should inform the instructor by the end of class on Monday April 25th.

Policies

Late or Absent Assignments

The data analysis project will not be accepted late without penalty unless you can document that an unforeseen circumstance prevented you from turning in the assignment on time. An unforeseen circumstance is something just prior to the due date that you did not anticipate and could not control. A failure to turn in an assignment on time will result in a penalty of 5 points off your grade for that assignment for each 12 hours it is late.

Academic Misconduct

By faculty Rule 3335-5-487, "...it is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term 'academic misconduct' includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee."

Violations of the Code of Student Conduct in this class, especially pertaining to academic misconduct, will be aggressively prosecuted through the procedures the university has set up to deal with violations of the Code. If I believe you have violated the Student Code, your case will be referred to the Committee on Academic Misconduct (see <http://oaa.osu.edu/coam.html>). Make sure that you understand the Code of Student Conduct, and familiarize yourself with "Ten Suggestions for Preserving Academic Integrity" available online at <http://oaa.osu.edu/coamtensuggestions.html>. A common sanction for violation of the academic section of the Code of Student Conduct by graduate students is failure in the course and suspension from the university. Repeat offenses and especially egregious violations of the Code can result in dismissal from the University.

The Code of Student Conduct can be found at <http://studentaffairs.osu.edu/csc/>.

Cell Phones and General Politeness

A ringing cell phone is annoying and a distraction to the instructor and others in the room. Please be respectful of those around you by silencing your cell phone prior to the start of class. If you anticipate that you will need to leave class early, please select a seat near the edge of a row or in the front of the room to avoid disrupting others when you leave. To maintain an atmosphere conducive to learning, please be courteous to other members of the class and treat them with the dignity and respect that you expect from others.

Use of Electronic Mail

There may be occasions where I will need to get in touch with you outside of regular class hours. Email will usually be the first means by which contact will be initiated. It is important that you check your OSU email account regularly, and make sure you purge your account of unneeded email so that new email can get through. If you do not use your OSU email address as your primary email account, please

arrange to have your OSU email forwarded to your preferred account. For email forwarding, go to <https://my.osu.edu/>

Emergencies

In the event of an emergency, please carefully follow the directions of the teaching staff or, if deemed prudent by your own judgment, contact 9-1-1 or the University Police at 614-292-2525. Non emergencies requiring police intervention can be directed to 614-292-2121.

Tentative Nature of this Syllabus

Events that transpire over the term may require me to modify the administration of this course and therefore the syllabus. In the event I need to modify the syllabus, I will announce the modification in class and on CARMEN. Ultimately, it is your responsibility to keep up with any such modifications and be aware of current policies, deadlines, etc.

Students with Special Needs

Students with disabilities that have been certified by the Office for Disability Services will be appropriately accommodated and should inform the instructor as soon as possible of their needs. The Office for Disability Services is located in 150 Pomerene Hall, 1760 Neil Avenue; telephone 292-3307, TDD 292-0901, www.ods.ohio-state.edu

Schedule of Lectures and Readings

This course is organized into units rather than individual lectures. We will spend what time is needed on each unit before progressing to the next, adjusting as needed with the goal of covering all of the material by the end of the semester in mind. The sequence of units and relevant readings can be found below. You are encouraged to read the book more than once as you will learn something new after each reading. You will also benefit from reading the supplementary readings available on CARMEN, although doing so is optional (though students in the quantitative psychology doctoral program should consider these required reading as well). Some of the material in this class has no corresponding supplementary reading.

UNIT 0: OVERVIEW AND REVIEW OF REGRESSION CONCEPTS

This unit reviews the principles of ordinary least squares linear regression analysis, including the least squares criterion, construction and interpretation of the regression model, interpretation of model coefficients, and statistical inference.

Required reading

Hayes (2013), Chapters 1, 2, and 3

UNIT 1: STATISTICAL MEDIATION ANALYSIS I

This unit introduces the basic concepts of statistical mediation analysis. Elementary path analysis rules and the estimation of total, direct, and indirect effects is covered for the simple mediation model (i.e., one mediator). The PROCESS macro for SPSS and SAS is introduced. Various approaches to inference

about indirect effects, estimation of effect size, and the interpretation of the indirect and direct effect in standardized and unstandardized form are topics in this unit.

Required reading

Hayes (2013), Chapters 4 and 6

Supplementary readings for your interest

(listed in order of relevance to lecture sequence)

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, and Computers*, 36, 717-731.

MacKinnon, D. P., & Fritz, M. S., & Williams, J. & Lockwood, C. M. (2007). Distribution of the product confidence limits for the indirect effect: Program PRODCLIN. *Behavior Research Methods*, 39, 384-389.

Preacher, K. J., & Selig, J. P. (2012). Advantages of Monte Carlo confidence intervals for indirect effects. *Communication Methods and Measures*, 6, 77-98.

Hayes, A. F., & Scharkow, M. (2013). The relative trustworthiness of inferential tests of the indirect effect in statistical mediation analysis: Does method really matter? *Psychological Science*, 24, 1918-1927.

Preacher, K. J., & Kelley, K. (2011). Effect size measures for mediation models: Quantitative strategies for communicating indirect effects. *Psychological Methods*, 16, 93-115.

UNIT 2: MODERATION ANALYSIS I

This unit describes the use of linear regression analysis for examining the contingencies of an effect. It focuses on the linear moderation model that allows one variables effect on another to be a linear function of another variable in the model. The conditional effect is defined. Methods of estimating such conditional effects, “probing” evidence of moderation, and visualizing moderated effects are described. Various myths about moderation analysis are described and debunked.

Required reading

Hayes (2013), Chapters 7, 8, and 9 (you may skip section 9.4)

Supplementary readings for your interest

(listed in order of relevance to lecture sequence)

Hayes, A. F., & Matthes, J. (2009). Computational procedures for probing interactions in OLS and logistic regression: SPSS and SAS implementations. *Behavior Research Methods*, 41, 924-936.

Bauer, D. J., & Curran, P. J. (2005). Probing interactions in fixed and multilevel regression: Inferential and graphical techniques. *Multivariate Behavioral Research*, 40, 373-400. (stop at page 387)

Hayes, A. F., Glynn, C. J., & Hude, M. E. (2012). Cautions in the interpretation of coefficients and hypothesis tests in linear models with interactions. *Communication Methods, and Measures*, 6, 1-12.

Irwin, J. R., & McClelland, G. H. (2001). Misleading heuristics and moderated regression models. *Journal of Consumer Research*, 38, 100-109.

Kromrey, J. D., & Foster-Johnson, L. (1998). Mean centering in moderated multiple regression: Much ado about nothing. *Educational and Psychological Measurement*, 58, 42-67.

UNIT 3: CONDITIONAL PROCESS ANALYSIS I

This unit combines the material from Unit 1 and Unit 2 into an integrated analytical model for examining the moderation of mechanisms. Topics include conditioning direct and indirect effects on moderators, quantifying the relationship between a moderator and indirect and direct effects, and approaches to testing whether a mechanism is moderated.

Required reading

Hayes (2013), Chapters 10, 11, and 12

Hayes, A. F. (2015). An index and test of linear moderated mediation. *Multivariate Behavioral Research*, 50, 1-22 (just skim the more complex examples)

Supplementary readings for your interest

Edwards, J. R., & Lambert, L. S. (2007). Methods for integrating moderation and mediation: A general analytical framework using moderated path analysis. *Psychological Methods*, 12, 1-22.

Preacher, K. J., Rucker, D. D., & Hayes, A. F. (2007). Assessing moderated mediation hypotheses: Theory, methods, and prescriptions. *Multivariate Behavioral Research*, 42, 185-227.

UNIT 4: STATISTICAL MEDIATION ANALYSIS II

This unit extends the principles of mediation analysis introduced in Unit I to models with multiple mediators, including the parallel and serial multiple mediator model. Also covered is the comparison of indirect effects, mediation analysis when the independent variable is multicategorical rather than dichotomous or continuous, and mediation analysis in the two-condition within-subject design.

Required reading

Hayes (2013), Chapter 5

Hayes, A. F., & Preacher, K. J. (2014). Statistical mediation analysis with a multicategorical independent variable. *British Journal of Mathematical and Statistical Psychology*, 67, 451-470.

Montoya, A. K., & Hayes, A. F. (2015). Two-condition within-participant statistical mediation analysis: A path-analytic framework. *Manuscript in review*

Supplementary readings for your interest

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling methods for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*, 879-891.

Taylor, A. B., MacKinnon, D. P., & Tein, J. Y. (2008). Tests of the three-path mediated effect. *Organizational Research Methods, 11*, 241-269.

UNIT 5: MODERATION ANALYSIS II

This unit extends the moderation analysis principles introduced in Unit 2 to more complex models involving a multicategorical focal predictor or moderator. Also covered in this unit are models with more than one moderator, including “moderated moderation” (aka three-way interaction) and comparing conditional effects when conditioning on more than one variable.

Required reading

Hayes (2013), Chapter 9 section 9.4

Hayes, A. F. (2014). Comparing conditional effects in moderated multiple regression: Implementation using PROCESS for SPSS and SAS. *Unpublished white paper*.

Another Hayes reading to be made available through CARMEN when it is ready.

UNIT 6: CONDITIONAL PROCESS ANALYSIS II AND MISCELLANEOUS TOPICS

This unit addresses moderation of indirect effects in the serial multiple mediator model, conditional process models with multicategorical independent variables or moderators, and other miscellaneous advanced topics as time allows.

Required reading

Hayes, A. F. (2015). An index and test of linear moderated mediation. *Multivariate Behavioral Research, x*, 1-22. (read again, paying attention this time to the more complex examples)

Supplementary readings for your interest

Hayes, A. F., & Preacher, K. J. (2013). Using structural equation modeling to examine contingent causal processes. In G. R. Hancock and R. O. Mueller (Eds). *Structural equation modeling: A second course* (2nd Ed). Charlotte, NC: Information Age Publishing

Data Analysis Project Option

In this class we have devoted considerable attention to statistically modeling moderated (or “interactive”) effects, indirect effects (a.k.a. “mediation”) and combinations of moderation and mediation (“conditional process analysis”). For this assignment you are to illustrate your ability to apply the principles we discussed in this class to any data set of your choosing. I am placing no constraint on the topic or the source of the data. It can be on any topic, and it can be based on data you have collected, perhaps an advisor has given you access to, or data that are publicly available. The only requirements are that your analysis involves a system of relationships between at least **four** variables and that your analysis illustrates your understanding of the concepts of mediation, moderation, and conditional process analysis and evidences ability to conduct such analyses and interpret correctly.

I expect your answer to take the form of a results section as well as a method section and some description of the purpose of the analysis (i.e., the questions you are attempting to answer with your analysis), as if you were writing this for publication. You need not provide a formal introduction or discussion section as would typically be included in a paper, although you may do so if you like. You want to make sure that measurement details and coding of categorical variables is made clear in your method section, and that you provide the information I will need to make sense of the analysis you report in your results section.

In your analysis of moderation, make sure you probe the interaction (if significant), and provide some kind of figure or table to depict the interaction. Make sure that in your mediation analysis, you make it clear what method you are using, and when possible provide estimates of indirect effect(s) and inferential tests. Make tables and figures look nice and be of publication quality. Follow the conventions of your field (e.g., communication and psychology tend to use APA format) and format the sections as you would if you were submitting it for publication.

I am often asked about how to write up analyses of this sort. I don’t believe there is any single correct way to talk about data analysis. You should tell a good story, be engaging, and make your findings clear to the reader. So I am reluctant to provide a list of dos and do nots. Having said that, some good models to follow can be beneficial. So on CARMEN you will find a few articles I contributed to in the last couple of years that may sharpen your thinking a bit.

Your grade will be based on both the clarity of your writing and the quality of the analysis, and whether I can ascertain what you found and how you went about analyzing the data. I will grade your assignment very holistically, focusing on whether I can understand the purpose of the analysis, how you went about conducting the analysis, what you found, and how well you have described it. You will be penalized for excessively poor grammar, sloppy presentation, multiple spelling errors, and so forth. Pay attention to detail, and remember that your reader (me) will not know as well as you do just what you did. Do not leaving me guessing, or I am likely to end up confused.

There is no formal page length for this assignment. If you are writing a full research paper, with introduction, method, results, discussion, references, and so forth, then obviously your paper will be

much longer than would someone's who only conducts a results section and provides a methodological overview. I encourage you to write a full length paper if you have the time—something you could submit to an academic conference, for example. Most likely, your next conference deadline is approaching, so why not get a head start on preparing something for that conference?

All this said, in the past I have received the occasional paper from a student in this class only three or four pages long, that could have been written by someone who had never taken this course, and that certainly did not read like the work of someone who had been spending an entire academic term studying mediation and moderation analysis. Such a product from a graduate student is disappointing to receive, does not reflect well on the student, and will result in a poor grade. Don't waste your time writing such a paper, and don't waste my time asking me to read it.

Note that it is perfectly acceptable to report null results (i.e., interactions that are not statistically significant), although you will find this exercise much more interesting and valuable if you describe an analysis where there was actually something interesting found (e.g., an effect to be mediated, a statistically significant interaction worth probing, and so forth). Do not hesitate to mine your data in search of something interesting to write about. I have no problem with "post hoc" hypothesizing for the purpose of this class. The important thing to me is that you tell a story and that your analysis is conducted soundly and communicated clearly. Be creative and be interesting. Do not write under the assumption that scientific reports are by definition boring. On the contrary, a good results section tells an interesting story as it unfolds about the process the researcher is studying and now understands better than when he or she started. I sometimes find it helpful to imagine I am speaking to an audience when I am writing. Usually, my writing is more interesting if I imagine that there is an audience there listening to me say what I am writing.

Please double space your answer, and submit it to me in hard copy by **noon on May 2nd**. Submit an electronic copy to the CARMEN drop box by this time as well.