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Editorial: Introduction to the Special Section on Causal Inference in Cross Sectional and Longitudinal Mediation Models

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Abstract

Psychologists have long had interest in the processes through which antecedent variables produce their effects on the outcomes of ultimate interest (e.g., Woodworth's Stimulus-Organism-Response model). Models involving such mediational processes have characterized many of the important psychological theories of the 20th century and continue to the present day. However, it was not until Judd and Kenny (1981) and Baron and Kenny (1986) combined ideas from experimental design and structural equation modeling that statistical methods for directly testing such models, now known as mediation analysis, began to be developed. Methodologists have improved these statistical methods, developing new, more efficient estimators for mediated effects. They have also extended mediation analysis to multilevel data structures, models involving multiple mediators, models in which interactions occur, and an array of noncontinuous outcome measures (see MacKinnon, 2008). This work nicely maps on to key questions of applied researchers and has led to an outpouring of research testing mediational models (As of August, 2011, Baron and Kenny's article has had over 24,000 citations according to Google Scholar).

In their initial work, Judd and Kenny (1981) focused on a restricted case: (a) a randomized experiment, with (b) linear relationships between the treatment condition and the measured intervening variable (mediator) and between the mediator and the measured response variable of interest, (c) temporal precedence of the mediator before the outcome, and (d) complete transmission of the effect of the treatment on the outcome through the mediator. Baron and Kenny (1986) greatly generalized the analysis by considering cases in which all four of these restrictions were relaxed. Indeed, the antecedent variable was no longer stipulated to be a treatment but could also be a nonmanipulated variable. This generalization broadened the range of questions that could be addressed, but often came at a cost of weakening the basis for causal inference of mediational effects. Judd and Kenny and Baron and Kenny were careful to specify the assumptions of mediational analysis: the mediational model and the functional form of the relationship between variables are correctly specified, there is no measurement error in the mediator, and there is no reciprocal causation between the mediator and outcome. Judd and Kenny also included disclaimers about causal inference: "We should recognize a mediational analysis for what it really is: A correlational analysis" (p. 208). Rosenbaum (1984) described further complexities that arise from

attempting to adjust estimates of effects for the influence of variables such as mediators that are measured after treatment.

Baron and Kenny's (1986) implicit weakening of the conditions that are needed for testing mediation has been followed by a proliferation of mediational analyses in cross-sectional studies with nonmanipulated antecedent variables. This development has raised the question of what researchers can learn about mediation from cross-sectional versus stronger longitudinal designs. Cole and Maxwell (Cole & Maxwell, 2003; Maxwell & Cole, 2007) began addressing this question in a series of important papers. Focusing primarily on commonly used panel designs with equally spaced measurement waves and autoregressive longitudinal models, they showed that the conditions under which longitudinal and cross-sectional estimates of mediational effects will be identical are limited to rare special cases. The target article by Maxwell, Cole, and Mitchell (2011) extended their previous work to the more common case in which direct and indirect (mediational) effects of antecedent variables may be present on consequent variables. They found that estimates of mediational effects from cross-sectional designs may be seriously biased. Cases exist in which the cross-sectional design erroneously detects a mediational effect when it does not in fact exist, and conversely also fails to detect a mediational effect when it does exist. Such results raise grave questions about the routine use of cross-sectional mediational analyses.

Three different perspectives on Maxwell et al.'s (2011) findings are raised in the commentaries. Reichardt (2011) builds on earlier work on causal lags (e.g., Gollob & Reichardt, 1987), showing that estimates of mediational effects can easily be incorrect in longitudinal autoregressive models, even when all of the assumptions of autoregressive models are met. Three waves of data may not be sufficient to control for mediation that occurs at intermediate points not represented in the measurement design.

Shrout (2011) applies insights from his recent work on causal inference in psychopathology (Shrout, Keyes, & Ornstein, 2011). Among these are examination of the assumptions of autoregressive models, consideration of the possibility that alternative longitudinal models may map more closely onto many processes hypothesized by researchers, and consideration of differences between within- and between-individual models that may lead to different effects. Careful consideration of the science, the hypothesized nature of the processes, coupled with the inclusion of unique design elements, can limit the possible set of potential influences and strengthen causal inferences, even potentially in cross-sectional designs.

Finally, Imai, Jo, and Stuart (2011) build on their work applying Rubin's (2005) potential outcomes model to causal inference problems (e.g., Imai, Keele, & Tingley, 2010). They show conditions necessary to identify indirect (mediational) and direct effects for the special case of a binary antecedent variable producing changes in a binary mediator, which in turn produces changes in a binary outcome. Their analysis highlights the strong and untestable assumptions needed in this framework to clearly identify unambiguous causal mediational effects, even in the simplified case of binary variables. They provide an analysis of Maxwell et al.'s (2011) longitudinal approach and offer alternative design and analysis approaches using crossover designs and principal stratification using propensity scores.

This collection of articles highlights that researchers need to go beyond simply proposing and testing meditational models in a routine manner. As with any causal inference problem, careful attention to theory, previous research, research design, and measurement is needed. The application of Rubin's (2005) potential outcomes model can help clarify the assumptions and the sets of conditions needed for clear causal inference. Appropriate conditioning strategies can greatly strengthen the causal inferences that can be reached. Although not explicitly developed in this set of papers, the application of Campbell's perspective (Shadish, Cook, & Campbell, 2002) can help identify and prioritize plausible threats to internal validity; design elements can be added to the basic design the help rule out those threats and strengthen causal inference (see West & Thoemmes, 2010). The simple meditational model presents challenges both to Rubin's potential outcomes model and Campbell's perspective. These challenges only increase as more complex mediational models that researchers would like to consider are proposed. The four articles in this section provide some important steps toward meeting those challenges.

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