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Special Article

Mediator and Moderator Effects in Developmental and Behavioral Pediatric Research

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ABSTRACT. The terms *mediation* and *moderation* are defined and clarified with particular emphasis on the role of mediational and moderational analyses in developmental and behavioral pediatric research. The article highlights the applicability of mediational and moderational analyses to longitudinal, intervention, and risk and protective factor research, and it provides basic information about how these analyses might be conducted. Also included is a discussion of various ways that both mediator and moderator variables can be incorporated into a single model. The article concludes with extended examples of both types of analyses using a longitudinal pediatric study for illustration. The article provides recommendations for applying mediational and moderational research in clinical practice. *J Dev Behav Pediatr 25:58–67, 2004.* Index terms: *mediation, moderation, risk and protective factors, intervention research, pediatric research.*

OVERVIEW

In recent years, researchers who study pediatric populations have begun to posit complex theoretical models to explain developmental and psychological phenomena of interest. These models include longitudinal developmental pathways, risk and protective factors, and cognitive appraisal and coping processes.[1] This increase in theoretical complexity has necessitated an increase in terminological sophistication and the use of multivariate statistical strategies. One of the authors of this paper has recently discussed applications (and misapplications) of two terms that are frequently invoked by scholars who study children with chronic illness, namely, mediation and moderation.[2–5] Research based on mediational and moderational models has emerged as a critical method for testing competing theories about developmental pathways and other concepts central to developmental and behavioral pediatrics. The current paper extends the discussions offered in earlier papers by focusing on mediator and moderator effects in longitudinal research, intervention and outcome studies, and the study of risk and protective factors. Definitions of terms and examples are provided, including a complete illustration of a three-way moderational interaction effect. We also discuss situations in which the same variable may serve both a moderational and a mediational role. Finally, more complex uses of these terms (e.g., moderated mediation, mediated moderation) are discussed.

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DEFINITIONS OF MEDIATION AND MODERATION

Mediators

A mediator is an explanatory link in the relationship between two other variables (Figure 1 [See Table 1 for definitions of all important terms.]). Often a mediator variable is conceptualized as the mechanism through which one variable (i.e., the predictor) influences another variable (i.e., the criterion).[2–4] Suppose, hypothetically, that a researcher finds that parental intrusive behavior is negatively associated with child adherence to a medical regimen. Although interesting, this finding does not tell us very much about processes that underlie the relationship between intrusiveness and adherence. By testing for mediational effects, a researcher can explore whether a third variable (e.g., child independence) might account for or explain the relationship between these variables. Continuing with the example, suppose that child independence mediates the relationship between intrusiveness and adherence (more intrusive parenting → less child independence → less medical adherence). That is, parental intrusiveness impacts negatively on level of child independence, which in turn contributes to poor medical adherence (See a recent article by Holmbeck, Johnson, and colleagues for a similar example.[6])

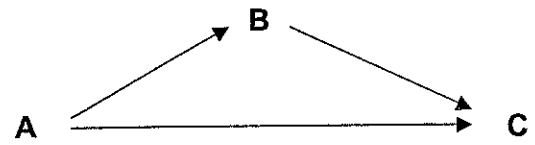

FIGURE 1. Mediated relationship among variables (A = predictor; B = mediator; C = criterion/outcome).

It is critical to note that a mediational model is, by its nature, a causal model. Even if one's data does not permit causal conclusions (e.g., the data are cross-sectional and nonexperimental), the theory that underlies such a model is still inherently causal because it suggests a direction of influence. It is important to distinguish between a *causal* model and a *temporal* model.[2] In the past, investigators have often provided graphical illustrations of pathways that are temporal in nature (See the 1996 book by Thompson and Gustafson for several examples of temporally-oriented models.[1]) For example, one might provide a "flow chart," whereby a stressor is followed in time by various coping processes that are, in turn, followed by changes in psychosocial adjustment (i.e., stressor $\longrightarrow$ coping $\longrightarrow$ adjustment). Flow charts like these are temporal (rather than mediational) in nature because they specify a time-based sequence of events rather than a causal sequence of events. For example, this type of model could illustrate how a stressor, a coping process, and changes in psychosocial adjustment are all placed *in time* relative to each other. The model only becomes causal (and mediational) if the investigator posits causal associations among the variables. The model just discussed would become mediational if the investigator hypothesized that the stressor actually impacted on or changed the way a person copes (e.g., the stressor causes a person to use more avoidance coping) which, in turn, impacted on subsequent levels of adjustment. Because researchers do not usually expect a stressor to influence the style with which a person copes, coping is not usually viewed as a mediational variable. However, it is often viewed as a moderational variable, as will be illustrated in more detail in the discussion of moderators below.

One additional clarification about mediator variables is warranted: Typically, mediator mechanisms are proposed only after a predictor $\longrightarrow$ criterion effect has been fairly well established in the literature (i.e., indicating that there is, in fact, an effect to mediate). In other words, one does not typically begin study in a new research area by proposing mediational models. Such models are usually a more natural extension of a well-established body of literature. Continuing with the earlier example, if one was interested in examining variables that mediate the link between parental intrusiveness and child medical adherence, one would want to be very confident that this link would be significant in one's own data set, based on past research conducted on the variables.

Moderators

Unlike a mediator, a moderator is a variable that influences the strength or the direction of a relationship between a predictor variable and a criterion variable (Figure 2). Suppose a researcher finds that familial stress (e.g., in the context of a child's chronic illness) is negatively associated with child psychological adjustment. Although this finding may be of interest to the researcher, it may be that the effect becomes more or less robust in the presence of other contextual variables. In fact, the researcher may develop specific theories about conditions that determine the strength of the relationship between stress and adjustment. For example, the strength or the direction of the relationship between stress and adjustment may depend on the type of coping used by the family. That is, a significant association may emerge *only* when a child copes in a maladaptive manner. By testing coping style as a moderator of the relationship between stress and outcome, the researcher can specify certain conditions under which family stress predicts child adjustment. This would not only allow for more precise conclusions, but would likely have implications for future interventions.

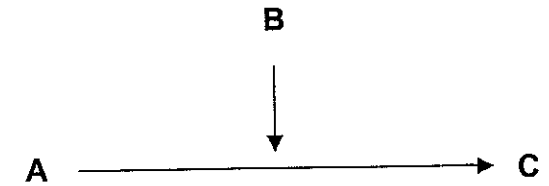

FIGURE 2. Moderated relationship among variables (A = predictor; B = moderator; C = criterion/outcome).

TESTING COMPETING MODELS: MEDIATOR VERSUS MODERATOR

Interestingly, the same variable can serve as either a mediator or a moderator (or both), depending on the research question. In a 1992 book chapter, Quittner provides a useful example of how a single construct (i.e., social support) could

Table 1. Definition of Terms

Term	Definition
Mediator	The variable or mechanism by which a predictor influences an outcome variable (Figure 1)
Moderator	A variable that influences the strength or direction of a relationship between a predictor and an outcome (Figure 2)
Moderated mediation	A mediational model is significant only at certain levels of a moderator variable (Figure 3)
Mediated moderation	A moderational (or interaction) effect is mediated by another variable (Figure 4)
Protective factor	A variable that decreases the likehood of a negative outcome under adverse conditions (Figure 6)
Resource factor	A variable that positively influences outcome, regardless of the presence of adversity (Figure 6)
Vulnerability factor	A variable that increases the likelihood of a poor outcome under adverse conditions (Figure 7)
Risk factor	A variable that negatively influences outcome regardless of the presence of adversity (Figure 7)

potentially serve as either a mediator *or* a moderator.[7] She proposed two competing theoretical models in an attempt to study the role of social support in the relationship between parenting-related stress and psychological distress in parents of children with hearing impairment and seizure disorder. She reasoned that parenting stress is more likely to have adverse effects on adjustment when parents have low levels of social support (i.e., social support is a moderator). On the other hand, it could also be that parenting stress undermines one's ability to garner social support, which in turn impacts on parental adjustment (i.e., social support is a mediator).

In her analyses, Quittner found that the relationship between parental stress and psychological distress did not vary as a function of level of social support.[7] Put another way, social support did not *moderate* or alter the strength or direction of the relationship between parental stress and psychological distress. Having ruled out social support as a possible moderator, she tested social support as a mediator. Initially, she found that parenting stress (the predictor) was significantly associated with psychological distress (the outcome). Parenting stress was also a significant predictor of social support (mediator). Specifically, those parents who experienced more stress tended to have fewer social contacts and perceive their selves as less supported. Moreover, Quittner found a significant relationship between social support (the mediator) and psychological distress (the outcome), such that less social support was associated with higher distress ratings. When she tested the relationship between parental stress and psychological distress in the presence of this mediator, the strength of this previously significant relationship dropped significantly. She was able to conclude that the relationship between stress and psychological functioning is mediated by social support (parenting stress $\longrightarrow$ social support $\longrightarrow$ psychological distress), and that reduced social support may be one mechanism by which parental stress is linked with parental psychological distress.

COMPLEX MODELS: MODERATED MEDIATION AND MEDIATED MODERATION

Other types of theoretical models can be proposed that include both mediational and moderational effects. For example, with a "moderated mediational" model (Figure 3), a researcher can test whether a mediational model is significant only at certain levels of a moderator variable. Building on the earlier mediational example (i.e., parental intrusiveness $\longrightarrow$ child independence $\longrightarrow$ medical adherence), we might hypothesize that the entire mediational relationship will hold only for one gender and not the other. If this were found to be the case, this mediational model would be moderated by gender (i.e., moderated mediation). Similarly, "mediated moderation" is possible (Figure 4). For example, suppose that the association between intrusiveness and adherence is moderated by child gender (i.e., intrusiveness $\times$ gender $\longrightarrow$ medical adherence [See discussion below regarding statistical methods for testing moderator effects as interaction terms.]). The investigator may then be interested in determining the mediational processes (e.g., child independence) that account for this significant moderational effect. One then tests whether the significant interaction (moderational) effect is mediated by child independence. Although statistically similar, it is important to note that moderated mediation and mediated moderation are not equivalent hypotheses when viewed conceptually. The former is based on the notion that an entire mediational model is significant only at certain levels of a moderator. The latter is based on the notion that a significant moderational effect is mediated by some variable of interest.

MEDIATORS AND MODERATORS IN DEVELOPMENTAL AND BEHAVIORAL PEDIATRIC RESEARCH

Now that mediators and moderators have been defined and differentiated, the next portion of this paper focuses on the relevance and importance of mediator and moderator analyses in developmental and behavioral pediatric research. Interestingly, the study of mediators and moderators can be applied to a wide range of research programs. Specifically, mediational and moderational processes can be proposed in correlational and regression-oriented predictive utility studies, group differences research, longitudinal investigations, complex model testing (with structural equation modeling), studies of interventions including randomized clinical trials, and temporal relationship models in which "What precedes what?" questions are of interest. In this section, we discuss the application of mediation and moderation across three types of developmental and behavioral pediatric research studies: longitudinal studies, risk and protective factor research, and intervention trials.

Mediators and Moderators in Longitudinal Research

Longitudinal mediational analyses allow researchers to test specific causal theories about time-ordered relationships among variables, and the particular mechanism or pathway by which a relationship occurs. Such analyses differ from standard mediational analyses only insofar as they include variables gathered at different points in time. For example, information gathered using longitudinal data can improve what is known about the development of health behaviors, psychopathology, and problem behavior by allowing researchers to test the degree to which more immediate or "proximal" etiological factors can explain links between more remote or "distal" risk factors and adjustment, thereby contributing to intervention and prevention efforts.[8] Furthermore, longitudinal analyses allow for a lifespan developmental perspective, which is helpful in understanding variability in adjustment trajectories.[9] In recent years,

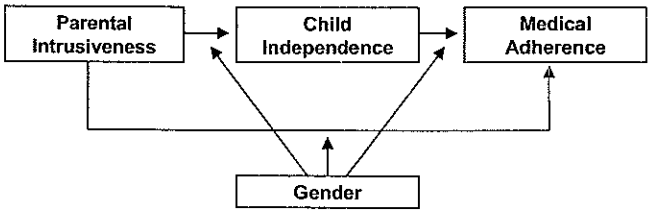

FIGURE 3. Moderated mediation.

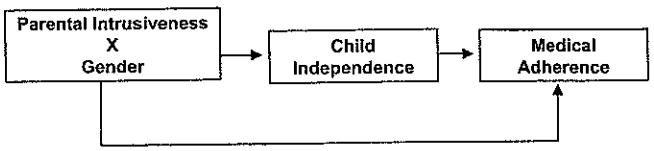

FIGURE 4. Mediated moderation.

longitudinal mediational analyses have been used creatively to explain developmental pathways to resilience or maladjustment, beginning in early childhood and continuing through late adolescence.[10] Knowledge of high-risk time points or critical transitional periods in child development may also facilitate the development of more effective treatments and interventions (a point that will be discussed in more detail below).[8]

Unlike research that is based solely on cross-sectional data, the use of mediational models with multiple data points enables the researcher to clarify the temporal sequencing of causal processes by ruling out bidirectional pathways.[2] Continuing with the mediational example discussed earlier, an investigator can propose a longitudinal hypothesis by arguing that high levels of parental intrusiveness are likely to be associated with *subsequent* decreases in child independence. The researcher might also hypothesize that low levels of child independence are likely to be associated with *subsequent* decreases in medical adherence. Longitudinal data would not only permit an examination of these hypotheses but would also allow the investigator to rule out the possibility that lower levels of child independence or lower levels of adherence are associated with *subsequent* increases in parental intrusiveness (an equally plausible scenario with a causal direction opposite from that which was proposed in the original model). Such hypotheses could not be tested with cross-sectional data.

At a minimum, two data points are needed to begin testing causal time-ordered mediational hypotheses (although, three or more are preferred).[11] To test the predictor $\longrightarrow$ mediator link, initial Time 1 data are used for the predictor and Time 2 data are used for the mediator *after* controlling for Time 1 mediator data. More generally, partialling out the Time 1 dependent variable data from the Time 2 dependent variable data essentially converts the Time 2 dependent measure into a residual change variable. That is, a given participant's residual score represents the change in rank for this participant (relative to the other participants in the sample) on the dependent measure between Time 1 and Time 2. Similarly, when examining the mediator $\longrightarrow$ outcome link, initial Time 1 data are used for the mediator and Time 2 data are used for the criterion outcome, after controlling for the Time 1 data on the criterion outcome.[11] One continues in this way when testing all pathways in the mediational model. It is important to note that if one has three waves of data, one could use Time 1 data for the predictor, Time 2 data for the mediator (controlling for Time 1 mediator data), and Time 3 data for the criterion outcome (controlling for Time 2 criterion outcome data).

Longitudinal data can also be useful for testing moderator effects within a longitudinal or developmental framework. Once again, it is necessary to control for earlier levels of the outcome variable when testing the relationship between a predictor (or a predictor-moderator interaction) and a later outcome. Finally, one can reduce common method variance between predictor, mediator, and criterion by using different respondents and/or methods for each variable in the model.[12]

Mediators and Moderators in Risk and Protective Factor Research

Developmental and behavioral pediatric researchers often posit mediational and moderational processes when conducting studies of risk and protective factors. Generally, research on risk and protective factors is focused on understanding the adjustment of youth who are exposed to varying levels of adversity. There is evidence that both contextual factors (e.g., socioeconomic status, family-level functioning, peer relationships) and developmental variables (e.g., cognitive skills, autonomy development) can significantly influence outcomes for individuals living under adverse conditions, and thus serve a moderational role.[10,13–16] Risk and protective processes have been explored in the study of "resilience," a term used with increasing frequency in developmental and pediatric research. Resilience refers to the process by which youth successfully navigate stressful situations or adversity and attain developmentally relevant competencies.[17] Appropriate application of the terms commonly used to identify processes that influence the adjustment of youth exposed to adversity is necessary to promote terminological consistency. Thus, a brief description of several terms, and their relevance to moderational analyses, is presented below using hypothetical examples (presented in Figures 5 and 6).

Protective versus resource factors. A protective factor either ameliorates negative outcomes or promotes adaptive functioning. To isolate a true "protective factor," however, there must be a particular stressor that influences the sample under investigation. The protective factor serves its protective role only in the context of adversity; a protective factor does not operate in low adversity conditions.

Protective factors are contrasted with resource factors. Specifically, a factor that has a positive impact on the sample *regardless* of the presence or absence of a stressor is a "resource factor."[16] For example, if a positive father-child relationship reduces behavior problems only in children of depressed mothers, but has no impact for children of nondepressed mothers, then the father-child relationship would be conceptualized as a "protective factor" (Figure 5). However, if the positive father-child relationship reduces behavior problems in all children, regardless of mothers' level of depression, then it would be conceptualized as a "resource factor" (Figure 5).[16] A model may also identify a positive father-child relationship as both a protective and resource factor if it reduces behavior problems in children who have depressed mothers *more* than in children who have nondepressed mothers and also produces a significant reduction in behavior problems for all children, regardless of level of maternal depression. It is also important to note that a protective factor represents a moderational effect (See the statistically significant interaction effect in Figure 5; see discussion below regarding statistical methods for testing moderator effects as interaction effects.), whereas a resource

factor represents an additive effect. Statistically, a resource factor emerges as two main effects.

Risk versus vulnerability factors. "Risk" and "vulnerability" factors operate in the much same way as resource and protective factors but in the opposite direction (Figure 6). A vulnerability factor is a moderator that increases the chances for maladaptive outcomes in the presence of adversity.[16] Similar to a protective factor, a vulnerability factor only operates in the context of adversity. By contrast, a variable that negatively influences outcome regardless of the presence or absence of adversity is a risk factor.[16] For example, witnessing violence in the home environment is conceptualized as a vulnerability factor if it only increases behavior problems in children who are also exposed to a stressor, such as viewing extensive violence on television (Figure 6). A vulnerability factor is a moderator and is demonstrated statistically with a significant interaction effect. Witnessing violence in the home can be conceptualized as a risk factor if it results in an increase in child behavior problems for all children, regardless of the amount of television violence witnessed. As with resource factors, a risk factor represents an additive effect (i.e., two main effects). A model may also identify a factor as being both a risk and vulnerability factor if it increases the chance of a maladaptive outcome in samples with or without exposure to a stressor, but increases the chances for maladaptive functioning significantly more in the sample with the stressor.

To summarize, if a factor significantly promotes or impairs the chances of attaining adaptive outcomes in the face of a stressor then it operates via protective or vulnerability mechanisms, respectively. In these cases, the factor serves a moderational role. However, if a factor significantly promotes or impairs the chance of attaining adaptive outcomes without differentiating between the presence or absence of a stressor, then it is conceptualized as operating via resource or risk mechanisms, respectively. Given that new research in the field has found that predictor $\longrightarrow$ outcome effects may be moderated by developmental and contextual factors, there is an impetus for investigating these mechanisms at a more process-oriented level.

Mediators and Moderators in Intervention Research

Research that involves a randomly-assigned intervention as the predictor variable provides a particularly powerful design for drawing conclusions about causal mediational relationships.[18–19] These types of models have three important strengths. First, significant mediational models that involve interventions inform us about the mechanisms through which treatments have their impact.[20–22] Simply put, with such models one is able to ask how and why an intervention works.[20] Second, as noted by Collins and colleagues,[23] if a manipulated variable (i.e., the randomly-assigned intervention) is associated with change in the mediator, which is in turn associated with change in the outcome, there is significant support for the hypothesis that the mediator is a *causal* mechanism. One is more justified in invoking causal language when examining mediational models in which the predictor is manipulated than in mediational models in which no variables are directly manipulated. Third, when one isolates a significant mediational process, one has learned that the mediator may play a role in the maintenance of the outcome (e.g, problem behavior). In this way, knowledge about mediational processes in the context of randomized clinical trials (RCTs) informs us about etiological theories of disorders.[20] It is also important to note that when examining mediational processes in RCTs, one needs to demonstrate (via the research design and the timing of the data collections) that changes in the mediator precede changes in the treatment outcome.[24]

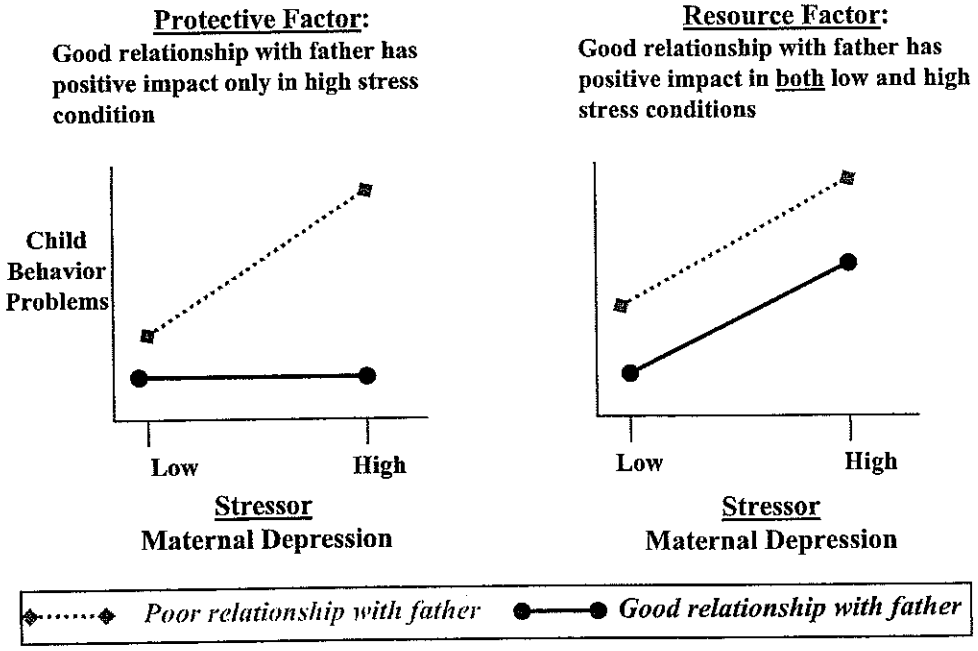

FIGURE 5. Factors associated with favorable outcomes: Protective and resource factors.

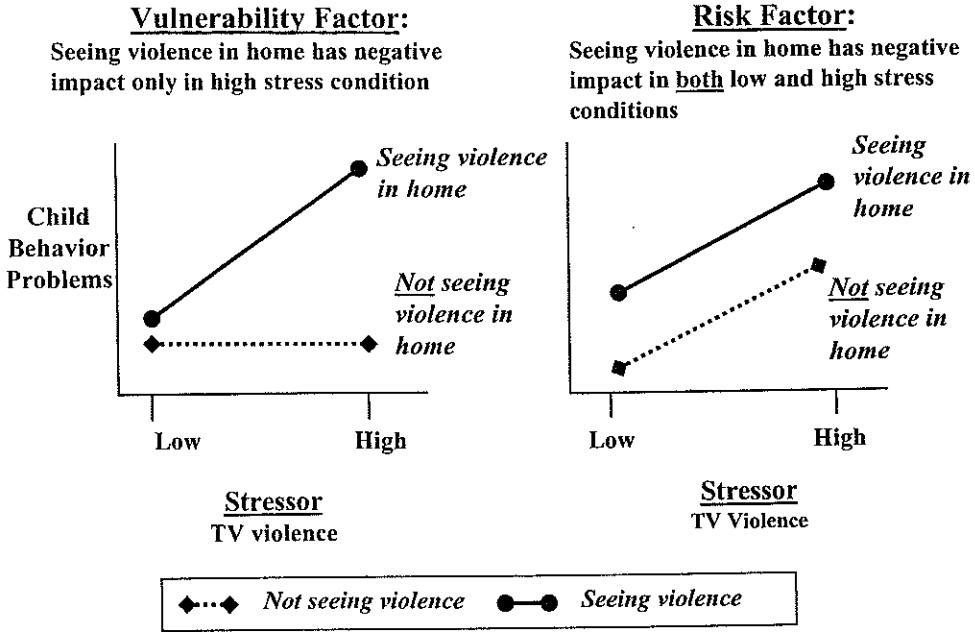

FIGURE 6. Factors associated with unfavorable outcomes: Vulnerability and risk factors.

As an example of this strategy, Forgatch and DeGarmo examined the effectiveness of a parenting-training program for a large sample of divorcing mothers with sons.[25] They also examined several parenting practices as mediators of the intervention → child outcome association (see Figure 7 for an example of this type of model). Compared to mothers in the control sample, mothers in the intervention sample showed improvement in parenting practices. Improvements in parenting practices were linked with improvements in child adjustment (Although, interestingly, the intervention did not have a direct effect on child outcome.). As indicated in Figure 7, such models not only allow one to test potential mediators within an experimental design, but such models also allow one to examine the differential utility of different mediators. In other words, one can determine which mediator best accounts for the effectiveness of a given treatment. At a more complex level of analysis, one could posit moderated mediational models. Such a model would not only suggest processes by which a treatment has an effect (i.e., a mediational process) but also which subsamples demonstrate the mediated treatment effects. Findings based on such complex models would provide important information that could be applied to modify the intervention so that it targets relevant mediational processes for specific subgroups of treatment participants.

Kraemer and colleagues have distinguished between moderators and mediators in the context of RCTs.[20] According to these authors, a moderator is present prior to treatment and a mediator occurs during the treatment process. For example, a moderator might be a pretreatment characteristic of the individual (e.g., gender, initial severity of symptoms) or a contextual treatment variable (e.g., the location or setting of the treatment). A mediator, on the other hand, is a variable that is expected to change as a result of treatment (e.g., parenting behaviors). Given these definitions in the context of RCTs, Kraemer and colleagues maintain that the same variable cannot be both a moderator and a mediator (because of their differential temporal relationship to the treatment).[20]

EXAMPLES OF MEDIATIONAL AND MODERATIONAL MODELS FROM PEDIATRIC PSYCHOLOGY

Now that the conceptual differences between mediators and moderators have been clarified and their potential application within pediatric and developmental research has been addressed, the remaining portion of the paper is devoted to a more complete discussion of how mediational and moderational effects are tested statistically. Up to this point, we have not discussed statistical methodology for examining such effects. Thus, statistical strategies are reviewed briefly here. For a more detailed overview of statistical methods as well as Statistical Package for the Social Sciences (SPSS) syntax, the reader is referred to some relevant papers by Holmbeck.[2–3] We chose these particular examples because they illustrate one of the points made earlier, namely, that a variable (in these examples, cognitive ability) may serve in either a mediational role or a moderational role, depending on the proposed model.

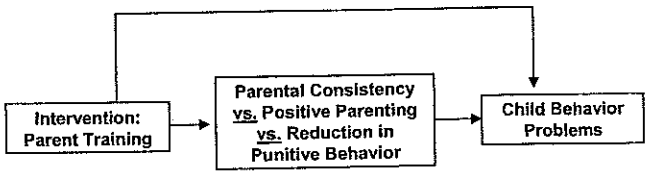

FIGURE 7. Mediators in intervention research: Parenting behaviors as mediators of the relationship between parent training (intervention) and child behavior (outcome).

Example of a Mediational Model

In a study of parental overprotection and adjustment in children with spina bifida, Holmbeck and colleagues found that parents of children with spina bifida tended to be more overprotective than parents of typically developing comparison children.[6] The authors reasoned that group-related differences in the children's cognitive ability might explain or mediate the observed group differences in parenting style because developmental and intellectual delays might elicit more protective behavior from their parents. Specifically, it was hypothesized that level of cognitive functioning would mediate the relationship between group status and parental overprotective behavior (Figure 8).

A mediational model is supported when four statistical criteria are met: (1) the predictor variable is significantly associated with the criterion outcome variable; (2) the predictor variable is significantly associated with the mediator; (3) the mediator is significantly associated with the outcome variable, after controlling for the predictor; and (4) the previously significant predictor $\longrightarrow$ outcome relationship is significantly diminished when effects of the mediator are controlled.[2–4] These four conditions can be tested with three-regression equations (with steps 3 and 4 being tested with a single regression analysis).[2–3]

In the current example, the first step involved demonstrating that the predictor variable, group status (i.e., spina bifida versus comparison sample), was significantly associated with the outcome variable, overprotection. If the predictor and outcome variables were not found to be significantly associated, there would be no effect to mediate and further testing would not be necessary. In support of their hypothesis, Holmbeck and colleagues found that group status significantly predicted parental overprotection, as measured by self-report questionnaires and observer ratings, so they proceeded to test condition 2 (the relationship between the predictor and the mediator).[6] As expected, the second regression showed that the predictor variable (group status) was significantly associated with cognitive ability (as measured by the Peabody Picture Vocabulary Test-Revised [PPVT-R]),[26] thus supporting the second criterion for mediation.

Regarding the third and fourth mediational criteria, it was necessary to show that PPVT scores significantly predicted parental overprotection when group status was held constant (condition 3) and that the strength of the group status $\longrightarrow$ overprotection effect dropped significantly when the mediator was controlled (condition 4). This was achieved by using simultaneous entry (rather than hierarchical entry) to enter group status and PPVT scores as predictors with parental overprotection as the dependent variable. The results of the analyses provided the information necessary to confirm the mediational effect. First, it was observed that the mediator (PPVT) was a significant predictor of overprotection, with group status controlled (condition 3). Second, in support of condition 4, it was shown that the relationship between group status and overprotection dropped significantly in this last analysis (when PPVT scores were controlled), as compared with the strength of the relationship observed in the first regression model (when PPVT scores were not controlled). The significance of the drop was tested using Sobel's equation.[3,27] This suggests that the mediator (PPVT score) accounted for a significant portion of the variance in the relationship between the predictor (group status) and the outcome (overprotection).

Example of a Moderational Model

The next example demonstrates how a moderational effect can be tested using multiple regression analyses. In a conference presentation drawn from the data set described above, the authors investigated the moderational influence of cognitive ability on the longitudinal relationship between early parental psychological control and adjustment in children with spina bifida two years later.[28] Psychological control, or the use of guilt induction and coercive behavior as methods of influencing a child's behavior, has been shown to have detrimental effects on child adjustment within many developmental contexts. However, it was hypothesized that psychological control might be less harmful within the context of spina bifida because children with greater physical and/or cognitive impairment tend to spend more time at home with their families and tend to be more dependent on their parents for assistance with basic needs. As a result, it is possible that they are less distressed by more intense parental involvement. Moreover, the authors predicted that intellectual ability (as approximated by PPVT score) would moderate the relationship between psychological control and adjustment, such that psychological control would be less strongly predictive of psychological maladjustment (as measured by the Children's Depression Inventory [CDI])[29] in children who were more cognitively impaired. At the most complex level, it was hypothesized that associations between psychological control and adjustment would be the least strong among those with spina bifida *and* those with low IQ and most strong among those in an able-bodied comparison sample *and* those with high IQ. Thus, 3-way interactions (i.e., moderated moderation) among psychological control, group status, and PPVT scores were tested.

To demonstrate a moderational effect using multiple regression, it is necessary to test the main effects and interaction effects of the predictor variables (i.e., group, psychological control, PPVT score) on the dependent variable (CDI score). Before the regression analyses are run, it is recommended that all continuous predictor variables be centered around zero. This helps to prevent multicollinearity

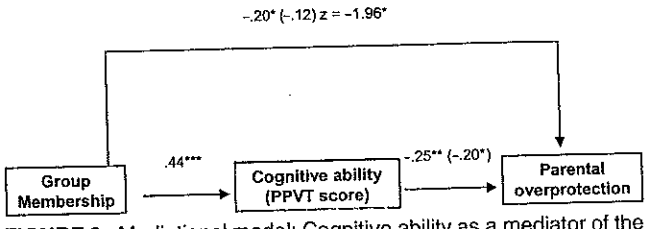

FIGURE 8. Mediational model: Cognitive ability as a mediator of the relationship between group status (spina bifida vs. comparison sample) and parental overprotection.

among the predictors and the interaction terms in the equation and to allow for proper testing of simple slopes, which will be addressed later. To do this, each predictor variable is transformed by subtracting the sample mean for that variable from all individual scores. Dichotomous variables should be recoded as 0 or 1. To allow for the testing of interaction terms, it is necessary to create new variables consisting of all possible two-way and three-way products of the centered and/or dichotomous predictor variables. These new variables are tested as interaction terms in the regression analyses. (It is important to note that these types of variable transformations have no impact on the significance or magnitude of the effects.)

Once this has been done, all predictor variables (i.e., group, psychological control, and PPVT) are entered in the first step of the regression equation to test for main effects. All possible two-way products of the predictors (i.e., group × psychological control, group × PPVT, psychological control × PPVT) are entered on the second step. Finally, if a three-way interaction is being tested (in this case, group × psychological control × PPVT), all possible three-way products of the predictors are entered in the third step.

In the current example, contrary to expectation, there were no significant two-way interactions between PPVT and psychological control. In other words, PPVT did not appear to moderate the relationship between parental psychological control and child depression across the entire sample. The other two-way interactions were also nonsignificant. However, there was a significant three-way interaction (group × PPVT × psychological control), indicating that that there was a significant difference in the interactions among the predictor variables (PPVT × psychological control) for the two groups. Once significant interactions are identified, simple regression slopes representing the predictor → outcome relationship at high and low levels of the moderator variable can be plotted and tested for significance (i.e., whether each slope differs significantly from zero). Until this is done, it is not possible to draw definitive conclusions about the significant interaction effect. Post hoc probing of significant moderator effects is explained in detail and demonstrated in Holmbeck's 2002 article (Also see Aiken and West's 1991 text.).[3,30]

In the current example, probing of the three-way interaction showed that the interaction between psychological control and PPVT in the prediction of depression varied by subsample. At this point, it is useful to plot findings separately for each level of one of the independent variables (e.g., group). Among children with spina bifida, the association between psychological control and depression was not significantly moderated by PPVT (Figure 9). In fact, psychological control and depression were not significantly related within this condition. However, among children in the comparison sample, the interaction between psychological control and PPVT was significant (Figure 9). Consistent with the hypotheses, PPVT scores appeared to influence or moderate the relationship between psychological control and depression in this group. On the other hand, and contrary to the hypotheses, tests of the simple slopes at two levels of the moderator (high PPVT and low PPVT) showed that there was a significant positive relationship between psychological control and depression among children with *low* PPVT scores. Among children with *higher* PPVT scores, the relationship between psychological control and depression was nonsignificant. Thus, it was concluded that the effects of psychological control on depression were moderated by condition status (i.e., psychological control was not associated with depression in children with spina bifida) and by level of intellectual functioning (among comparison children, higher intellectual ability appeared to protect against the effects of psychological control on depression).

IMPLICATIONS OF MEDIATIONAL AND MODERATIONAL RESEARCH FOR CLINICAL PRACTICE

Now that the applications of mediational and moderational analyses within the field of developmental and behavioral pediatric research have been reviewed, it may be helpful to address briefly the relevance of this type of research to clinical practice. This paper has reviewed the utility of mediational and moderational research for a variety of purposes, including: confirming or refuting theories about developmental pathways, identifying circumstances that promote or inhibit successful adaptation to chronic healthy or life stressors, and identifying specific mechanisms associated with positive outcomes following a therapeutic or clinical intervention. These uses of mediation and moderation are important not only for the researcher, but also for the clinician seeking empirically validated prevention or intervention techniques.

For example, suppose that a clinician is treating a young child with a chronic illness (such as diabetes). The child lives with a single parent who is suffering from major depression and unable to provide consistent care. Mediational and moderational research can be of tremendous use to a clinician treating a child living under these circumstances. First, mediational research involving random assignment to intervention conditions can provide information about the relative efficacy of various treatments or combinations of treatments (e.g., medication, dietary changes, exercise, and all possible combinations of these). Mediational research can also clarify which specific aspects of long-used or traditionally accepted treatments are most responsible for observed changes, so that unnecessary components of the treatment may be eliminated. Mediational research, such as this, allows the clinician to make more informed decisions about treatment (e.g., which treatment is best, based on the means by which the treatment is shown to operate) and also provides information about critical points for intervention in a child's development.

Moderational research is also readily applicable to the clinical setting. First, it can clarify whether a treatment is equally effective when applied in the presence of various demographic, genetic, and environmental factors (e.g., child gender, family medical history, level of parental involvement). For example, perhaps a treatment found to be most effective in a sample of children in a rural setting is not very effective when applied to children living in an urban area.

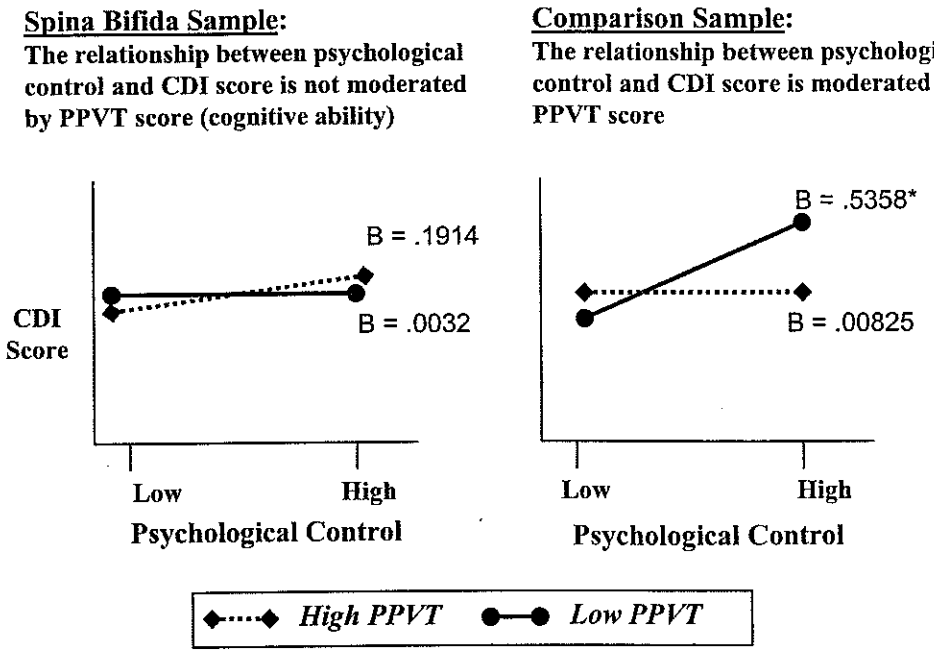

FIGURE 9. Three-way moderational model: In children with spina bifida there was no relationship between parental psychological control and child depressive symptoms. However, in the comparison sample, the relationship between psychological control and depressive symptoms was moderated by cognitive ability of the child (i.e., the relationship was significantly positive among children with relatively low PPVT-R scores).

Or perhaps risk and protective factor research suggests that an intervention is only beneficial under particular conditions or circumstances. By considering these issues, moderational research fine-tunes the conclusions drawn from typical intervention studies. Through awareness of the variables that moderate the appropriateness of a given treatment, a clinician can tailor interventions to the individual, rather than providing a "one size fits all" treatment.

CONCLUSIONS

In this paper, we provided definitions of mediated and moderated effects and also discussed how such effects can be examined in longitudinal, intervention, and risk and protective factor research. It is hoped that this paper, along with its more statistically-focused companion papers,[2–3] will encourage more widespread use of these concepts and techniques to enhance the scientific contribution of developmental and behavioral pediatric research. To conclude, we provide a list of ten important concepts pertaining to mediational and moderational research. This list, which incorporates the major points of this and earlier papers focused on mediational and moderational research, is intended to serve as a guide and inspiration point for future mediational and moderational research.

(1) If a researcher is interested in examining a relationship between two variables, the use of mediational and moderational models can lead to deeper and more comprehensive knowledge about the relationship by providing information about the conditions under which the two variables will be associated (moderation) and also about the intervening processes that help to explain the association (mediation).

(2) The same variable can either mediate *or* moderate a relationship between a predictor and an outcome, depending on the nature of the research question and the role the variable is thought to play in the relationship.

(3) Mediational models are usually proposed after an association between the variables is well established in the literature. If there is no established relationship, there is no need to explain the pathway by which two variables are related.

(4) Mediational models are causal models that illustrate a pathway of influence among variables. They are not just temporal models.

(5) Risk, protective, vulnerability, and resource factors can all be identified and illustrated with the use of a moderational model.

(6) Mediational models are particularly informative and compelling when they are tested with longitudinal data and/or when they are tested within a randomized clinical treatment research design.

(7) The statistical strategies used to test mediational and moderational effects are distinct. The models differ both conceptually and statistically.

(8) It is possible to propose complex theoretical models that include mediated moderation and moderated mediation.

(9) Mediated and moderated models are not only useful to researchers. Because they can provide information about developmental pathways and conditions affecting treatment efficacy, these models can be very useful to clinicians as well.

(10) With the use of mediational and moderational models, researchers can test competing theories about relationships among variables of interest. By directly testing two or more alternative models, a researcher can determine statistically which theoretical model best captures or explains an observed relationship among variables.

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REFERENCES

1. Thompson RJ, Gustafson KE. *Adaptation to Chronic Childhood Illness*. Washington, DC: American Psychological Association; 1996.
2. Holmbeck GN. Toward terminological, conceptual, and statistical clarity in the study of mediators and moderators: examples from the child-clinical and pediatric psychology literatures. *J Consult Clin Psychol*. 1997;65:599–610.
3. Holmbeck GN. Post-hoc probing of significant moderational and mediational effects in studies of pediatric populations. *J Pediatr Psychol*. 2002;27:87–96.
4. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol*. 1986;51:1173–1182.
5. James LR, Brett JM. Mediators, moderators, and tests for mediation. *J Appl Psychol*. 1984;69:307–321.
6. Holmbeck GN, Johnson SZ, Wills KE, et al. Observed and perceived parental overprotection in relation to psychosocial adjustment in preadolescents with a physical disability: the mediational role of behavioral autonomy. *J Consult Clin Psychol*. 2002;70:96–110.
7. Quittner, AL. Re-examining research on stress and social support: the importance of contextual factors. In: La Greca AM, Siegel LJ, Wallander JL, Walker CE, eds. *Stress and Coping in Child Health*. New York: Guilford Press; 1992:85–115.
8. Weisz JR, Hawley KM. Developmental factors in the treatment of adolescents. *J Consult Clin Psychol*. 2002;70:21–43.
9. Cicchetti D, Rogosch FA. A developmental psychopathology perspective on adolescence. *J Consult Clin Psychol*. 2002;70:6–20.
10. Masten AS, Hubbard JJ, Gest SD, Tellegen A, Garmezy N, Ramirez M. Competence in the context of adversity: pathways to resilience and maladaptation from childhood to late adolescence. *Dev Psychopathol*. 1999;11:143–169.
11. Cole DA, Maxwell SE. Testing mediational models with longitudinal data: myths and tips in the use of structural equation modeling. *J Abnorm Psychol*. In press.
12. Holmbeck GN, Li ST, Schurman JV, Friedman D, Coakley RM. Collecting and managing multisource and multimethod data in studies of pediatric populations. *J Pediatr Psychol*. 2002;27:5–18.
13. Holmbeck GN, Westhoven VC, Phillips W, et al. A multi-method, multi-informant, and multi-dimensional perspective on psychosocial adjustment in pre-adolescents with spina bifida. *J Consult Clin Psychol*. 2003;71:782–796.
14. Holmes CS, Yu Z, Frentz J. Chronic and discrete stress as predictors of children's adjustment. *J Consult Clin Psychol*. 1999;67:411–419.
15. Millstein Coakley R, Holmbeck GH, Friedman D, Neff Greenley R, Welborn Thill A. A longitudinal study of pubertal timing, parent-child conflict, and cohesion in families of young adolescents with spina bifida. *J Pediatr Psychol*. 2002;27:461–473.
16. Rutter M. Psychosocial resilience and protective mechanisms. In: Rolf J, Masten A, Ciccheti D, Nuechterlein K, Weintraub S, eds. *Risk and Protective Factors in the Development of Psychopathology*. Cambridge: Cambridge University Press; 1990:181–214.
17. Masten A. Ordinary magic: resilience processes in development. *Am Psychol*. 2001;56:227–238.
18. Clingempeel WG, Henggeler SW. Randomized clinical trials, developmental theory, and antisocial youths: guidelines for research. *Dev Psychopathol*. 2002;14:695–711.
19. Howe GW, Reiss D, Yuh J. Can prevention trials test theories of etiology? *Dev Psychopathol*. 2002;14:673–694.
20. Kraemer HC, Wilson T, Fiarburn CG, Agras WS. Mediators and moderators of treatment effects in randomized clinical trials. *Arch Gen Psychiatry*. 2002;59:877–883.
21. Rutter M, Pickles A, Murray R, Eaves L. Testing hypotheses on specific environmental causal effects on behavior. *Psychol Bull*. 2001;127:291–324.
22. Weersing VR, Weisz JR. Mechanisms of action in youth psychotherapy. *J Child Psychol Psychiatry*. 2002;43:3–29.
23. Collins WA, Maccoby EE, Steinberg L, Hetherington EM, Bornstein MH. Contemporary research on parenting: the case for nature and nurture. *Am Psychol*. 2000;55:218–232.
24. Kraemer HC, Stice E, Kazdin A, Offord D, Kupfer D. How do risk factors work together? Mediators, moderators, and independent, overlapping, and proxy risk factors. *Am J Psychiatry*. 2001;158:848–856.
25. Forgatch MS, DeGarmo DS. Parenting through change: an effective prevention program for single mothers. *J Consult Clin Psychol*. 1999;67:711–724.
26. Dunn LM, Dunn LM. *Peabody Picture Vocabulary Test—Revised*. Circle Pines, MN: American Guidance Service; 1981.
27. Sobel ME. Direct and indirect effects in linear structural equation models. In: Long JS, ed. *Common Problems/Proper Solutions: Avoiding Error in Quantitative Research*. Beverly Hills, CA: Sage; 1988:46–64.
28. Rose BM, Buck C, Hagstrom J, Skelnik N, Stafiej S. Cognitive functioning as a moderator of the relationship between parenting and adjustment in children with spina bifida. Poster presented at: the Biennial Meetings of the Society for Research on Adolescence; April 11–14, 2002; New Orleans, LA.
29. Kovacs M. *Children's Depression Inventory-Manual*. North Tonawanda, NY: Multi-Health Systems; 1992.
30. Aiken LS, West SG. *Multiple Regression: Testing and Interpreting Interactions*. Newbury Park, CA: Sage; 1991.