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Moderators and Mediators

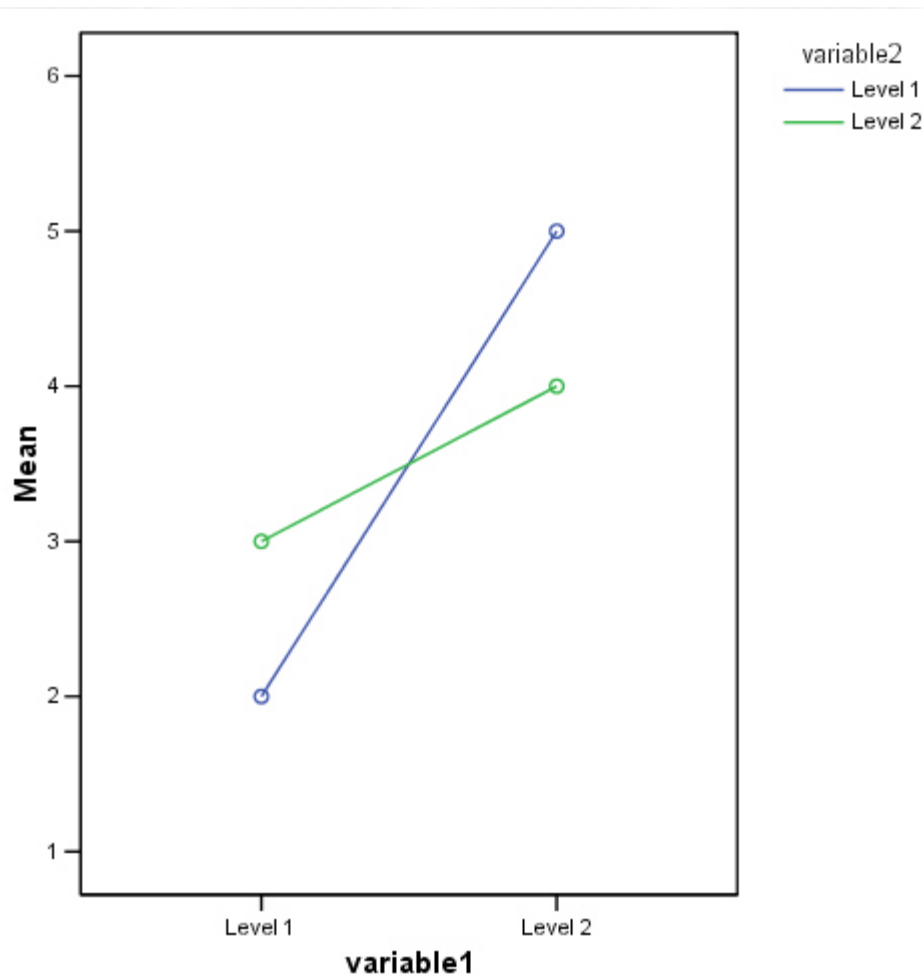
By [Dr. Mike Clark](#), Research and Statistical Support Services Consultant

As is the usual case, I offer some discussion on a topic which I am currently exploring that has come up due to requests of some who have come into the office. This time the focus is on moderators and mediator variables in multiple regression, with applications of how to implement such analyses using various resources. In multiple regression we analyze the predictive ability of two or more independent (predictor) variables for a dependent variable. We are typically interested in a measure of the total variance in the dependent variable explained by our predictors, as well as the relative importance of the various predictor variables.

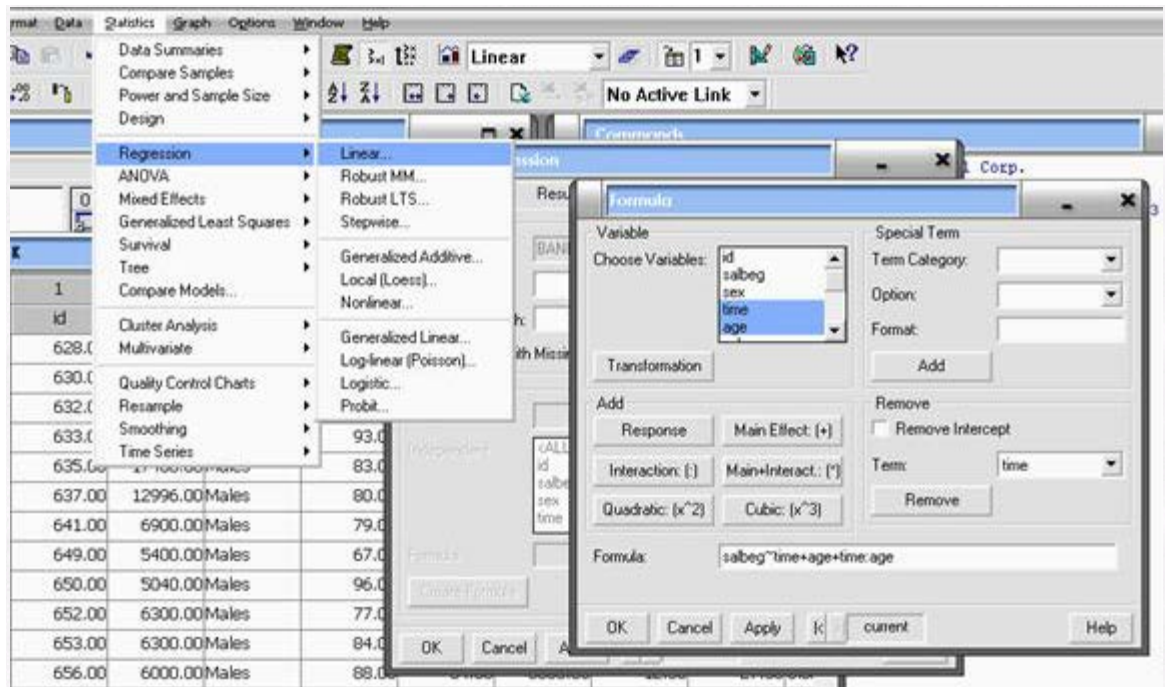
The first thing to do is to determine which type of relationship we are interested in, one that involves a moderator or mediator, and this can be somewhat confusing because some incorrectly use them interchangeably or might reference one when they mean the other. For those familiar with typical analysis of variance, a moderator will probably seem straightforward in its interpretation. It is simply a variable that interacts with another variable in predicting the dependent variable. With the mediator we have a somewhat different relationship between the predictor variables, such that one variable in effect accounts for the relationship between an independent and dependent variable. Each of these will be discussed in turn.

Moderators

As mentioned, moderators in multiple regression analysis have a parallel to interactions seen in ANOVA, the primary difference being that now we can involve continuous predictor variables. The picture below shows an example of an interaction between two two-level categorical variables in ANOVA.

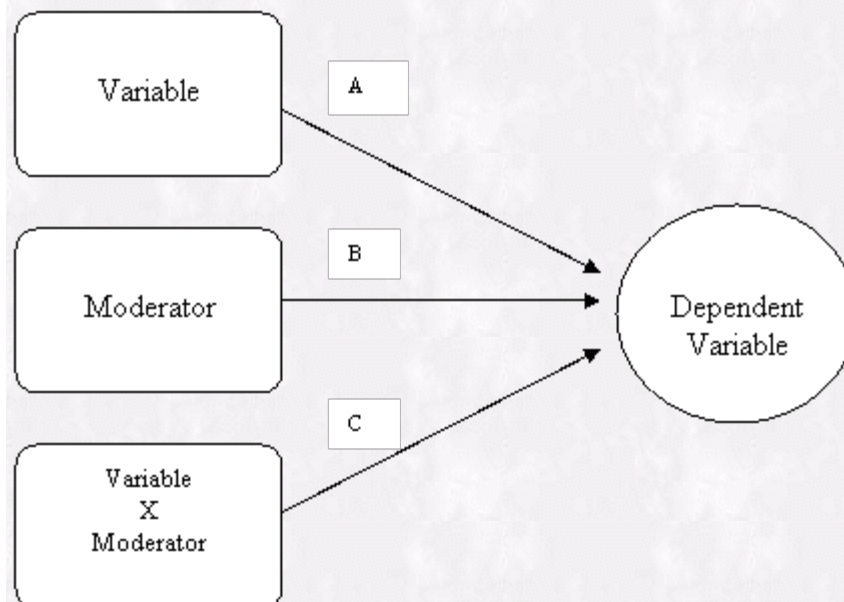


In typical analysis of variance, interactions are part of the output by default. In multiple regression, interactions are not as often looked at, and usually must be specified. Below is an example of how to do so through the menu system of S-Plus. First enter your main effects, followed by the interaction and then you are all set. Depending on the stat package used this may or may not be an option in the menu system. An alternative method is to create an interaction variable as simply the product of the two variables in question. For example in SPSS one can create the interaction term as the product of the two main effect variables, which is easily accomplished using the Transform/Compute menu.



In testing for moderators, continuous variables should be centered. This is done by simply transforming the variable to one in which the mean is subtracted from each response. In addition, categorical variables must be transformed using dummy or effects coding. Baron & Kenny (1986) even suggest that for a continuous X categorical interaction one could dichotomize the continuous variable under certain conditions. The reasons for transforming variables are somewhat technical, and rather than go into it here one is invited to consult Aiken & West (1991) for the details. The gist is that some sort of transformation of the variables will need to occur in order to test for interactions.

The diagram below offers an overview of what we are looking at in determining if a variable moderates the effects of another variable. If path c is significant then one variable can be seen to moderate another. If this is the case one must be cautious in their interpretation of significant main effects, as they can be seen as a reflection of the underlying interaction.



Mediators

Mediator variables account for the relationship between a predictor and the dependent variable. An example that might work here comes from my old job in the Counseling and Testing department here on campus, where one of the many tests proctored there is the Graduate Record Exam. Many international students take the test, and many do not do so well on the verbal portion of the exam. Rather than claim some relationship between ethnicity and verbal ability, one would probably find that English language proficiency mediates the relationship between ethnicity and scores of verbal ability. In other words, these people may in all actuality be very proficient in their general verbal skill, but as English is perhaps not their strong suit, they may have difficulty with this particular exam's way of testing that skill. Another example would be if someone administered an intelligence test to school age children and proclaimed a relationship between shoe size and intelligence. One could probably think of any number of variables that could act as mediators for that relationship.

To test for mediators, one can begin by estimating three regression equations: (1) the mediator predicted by the independent variable, (2) the dependent variable predicted by the independent variable, and (3) the dependent variable predicted by the mediator and independent variable. To begin with, we must have significant relationships found for the equations (1) and (2). Then if the effect of the IV on the DV decreases dramatically when the mediator is present (e.g., its effect becomes nonsignificant), then the mediator may be accounting for the effects of the independent variable in question. Overall power for equation (3) is diminished due to the correlation between the independent variable and mediator, and so rigid adherence to the p-value may not tell the whole story. Also look at the size of the coefficients, namely, if the coefficient for the independent variable diminishes noticeably with the addition of the mediator to the equation.

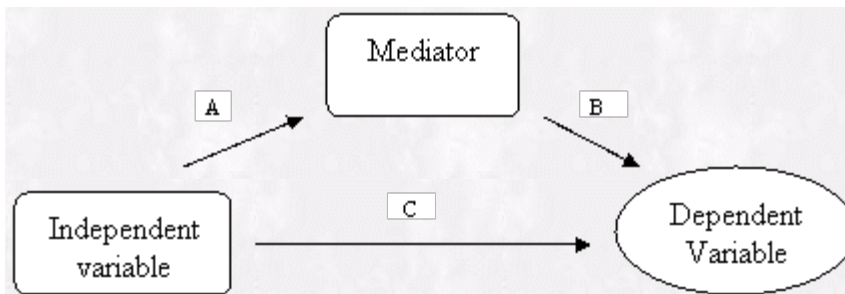
In examining possible mediation, the Sobel (1982) test offers a significance test in which a z score is calculated such that we can determine whether the indirect effect of the IV on the DV by means of the mediator is significantly different from zero. Given the output of the regression equations (1) and (3) above we have all we need to calculate the statistic. Calculate a , which equals the unstandardized coefficient of the IV when predicting the mediator by itself, and its standard error s_a . From the equation (3) take the unstandardized coefficient b for the mediator and its standard error s_b . To obtain the statistic, input those calculations in the following variant of the Sobel's original formula:

$$z = \frac{a * b}{\sqrt{b^2 s_a^2 + a^2 s_b^2 + s_a^2 s_b^2}}$$

For an online calculation of the statistic see the following website:

<http://people.ku.edu/~preacher/sobel/sobel.htm>

To summarize with a diagram as we did with moderators, see the figure below. When the relationships noted by paths A and B are controlled one should see an attenuation of the effect denoted by path C. Note that there are other means for testing mediation and other factors to consider when doing so. One is encouraged to consult the resources listed below as a starting point.



Conclusion

This month's *Benchmarks Online* article offered an introduction to moderators and mediators. Moderators and mediators may be able to offer more to the story of the relationships among variables in multiple regression. Things can get more complicated than presented here, including using both moderators and mediators in an analysis. However, if theory suggests such avenues of research, one should be able to accomplish such analyses with modern statistical packages and/or a little elbow grease.

Resources

Aiken, L.S., & West, S.G. (1991). *Multiple regression: Testing and Interpreting Interactions*. Sage Publications.

Baron, R.M., & Kenny, D.A. (1986). *The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations*. *Journal of Personality and Social Psychology*, 51(6), 1173-1182.

Holmbeck, G.N. (1997). Toward Terminological, Conceptual, and Statistical Clarity in the Study of Mediators and Moderators: Examples from the Child-Clinical and Pediatric Psychology Literatures. *Journal of Consulting and Clinical Psychology*, 65(4), 599-610.

MacKinnon, D.P., Warsi, G., Dwyer, J.H. (1995). A Simulation Study of Mediated Effect Measures. *Multivariate Behavioral Research*, 30(1), 41-62.

Schroeder, L.D., Sjoquist, D.L., & Stephan, P.E. (1986). *Understanding Regression Analysis*. Sage Publications.

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