Overview
Moderation occurs when the effect of one independent variable (X) on a dependent variable (Y) depends on the level of a third independent variable (Z). This is also known as an interaction. This guide focuses on moderation in Structural Equation Modeling (SEM). In multiple linear regression (MLR) moderation is investigated by computing product terms for the interaction. For example, to investigate the interaction between X and Z, a new term would be created that equals X*Z and this would be entered into the MLR, for more information on moderation in linear regression see (http://quantpsy.org/interact/interactions.htm). However, latent variables cannot be multiplied and different procedures must be used to investigate moderation in the SEM context. This guide will focus on two different situations, when the moderator (Z) is a categorical variable and when Z is a continuous variable.

When Z is Categorical
When a moderator is categorical, a multiple group SEM can be used to assess moderation. Each level of the moderator should be specified as a different group in a multiple group SEM. Different relationships between latent variables in different groups is evidence of moderation, and these differences can be tested by constraining relationships to be equal and using a chi square difference test (testing if the model without the equality constraint fits better than the model with the equality constraint).

When Z is Continuous
When the moderator is continuous, a multiple group SEM is not appropriate and other measures are needed to investigate moderation. There are several techniques for assessing moderation with two latent variables. Some of these techniques require complex constraints, making them difficult to implement (e.g, Joreskog & Yang, 1996; Kenny & Judd, 1984), or are only available on certain software packages (e.g., Klein & Moosbrugger, 2000; Muthen & Muthen, 1998-20074). This guide describes two techniques that do not require complex constraints and can be implemented by almost any software: orthogonalizing (Little, Bovaird, & Widaman, 2006) and unconstrained means centering (Marsh, Wen, & Hau, 2004). And one technique only available in the program Mplus (Muthen & Muthen, 1998-2007): the LMS/QML method (Klein & Moosbrugger, 2000). All three techniques result in a model with similar forms, which involves estimating a latent interaction term (XZ) and regressing the interaction term onto the dependent variable (Z). For the orthogonalizing and unconstrained approach, the latent interaction term has indicators which are composed of combinations of indicators from X and Z.
**Orthogonalizing**

Orthogonalizing involves separating the variance in a product term into variance related to the direct effect of X on Y (and Z on Y) and the effect of the interaction between X and Z on Y. This is accomplished by regressing each indicator of X and Z (x1, x2, x3, z1, z2, z3) onto a product term of two indicators (x1z1) and saving the residual. This residual contains all the variance in the product term related to the interaction without any variance related to main effects. This process is repeated for all product terms. There is an R function to compute orthogonalized indicators available at: [http://crmda.ku.edu/main/KUant_Tools](http://crmda.ku.edu/main/KUant_Tools). See below for LISREL syntax.

**Unconstrained Mean Centering (UMC)**

The UMC approach is similar to using product terms in MLR. All indicators are mean centered and three possible product terms of indicators are computed. The product terms should represent each indicator of X and W (e.g. x1z1, x2z2, x3z3). These product terms are used as indicators for the latent variable representing the interaction. See below for LISREL syntax.

**LMS/QML**

The LMS/QML approach does not require the user to create separate indicators for the latent variable representing the interaction using finite mixtures of normal distributions of latent variables. See below for Mplus syntax.
References
Example Syntax for Latent Variable Moderation

LISREL Syntax for the Orthogonalizing Approach

The orthogonalizing approach requires nine indicators of the interaction latent variable and correlated error terms for the interaction latent variable (indicators with the same variables are correlated, e.g. o_{x1z1} and o_{x1z2} would have correlated error terms). However, the orthogonalizing approach does not involve estimating a mean structure.

```
TI: Interaction between latent variables X and Z using the orthogonalizing approach
DA NI=18 NO=??? MA=CM
RA = ???
LA
x1 x2 x3 z1 z2 z3
o_{x1z1} o_{x1z2} o_{x1z3} o_{x2z1} o_{x2z2} o_{x2z3} o_{x3z1} o_{x3z2} o_{x3z3}
y1 y2 y3
MO NY=18 NE=4 LY=FU,FI PS=SY,FI BE=FU,FI TE=SY,DI
FR LY(1,1) LY(2,1) LY(3,1)
FR LY(4,2) LY(5,2) LY(6,2)
FR
LY(7,3) LY(8,3) LY(9,3) LY(10,3) LY(11,3) LY(12,3) LY(13,3) LY(14,3) LY(15,3)
FR LY(16,4) LY(17,4) LY(18,4)
FR TE(8,7) TE(9,7) TE(9,8)
FR TE(11,10) TE(12,10) TE(12,11)
FR TE(14,13) TE(15,13) TE(15,14)
FR TE(10,7) TE(13,10) TE(13,7)
FR TE(11,8) TE(14,11) TE(14,8)
FR TE(12,9) TE(15,12) TE(15,9)
VA 1 PS(1,1) PS(2,2) PS(3,3) PS(4,4) !Identifying, establishing scale
FR PS(2,1) !Correlation between X and Z
FR BE(4,1) BE(4,2) BE(4,3)
LE
X Z XZ Y
OU ND=3 SO SC
```

LISREL Syntax for the UMC Approach

The UMC approach only uses three indicators of the interaction latent variable and does not require correlated error terms, however it requires estimating and constraining mean structures.

```
TI: Interaction between latent variables X and Z using the UMC approach
DA NI=12 NO=??? MA=CM
RA = ???
LA
x1 x2 x3 z1 z2 z3
x1z1 x2z2 x3z3
y1 y2 y3
MO NY=12 NE=4 LY=FU,FI PS=SY,FI BE=FU,FI TE=SY,DI AL=FR TY=FR
FR LY(1,1) LY(2,1) LY(3,1)
FR LY(4,2) LY(5,2) LY(6,2)
FR LYL(7,3) LYL(8,3) LYL(9,3)
```
Identifying, establishing scale

Correlation between X and Z

Correlation between X and XZ and Z and XZ; only needed when X and Z are non-normal

Means of X and Z set to 0

One constraint is needed to estimate the model

Mplus Syntax for the LMS/QML Approach

The LMS/QML approach does not use any indicators for the interaction latent variable. The interaction latent variable is specified with the XWITH command.

```
TITLE: Interaction between latent variables X and Z using the LMS/QML approach
DATA: FILE IS ;
VARIABLE: NAMES ARE x1 x2 x3 z1 z2 z3 y1 y2 y3;
ANALYSIS: TYPE=RANDOM;
ALGORITHM=INTEGRATION;
MODEL:
x by x1* x2 x3;
z by z1* z2 z3;
y by y1* y2 y3;

!Identifying and setting scale
x@1; z@1; y@1;
x with z;

!XWITH command creates latent interaction variable
xz|x XWITH z;

y on x z xz;

OUTPUT: TECH1; TECH4;
```