Simple Slopes for Continuous Measured and Latent Variable Interactions

Simple slopes (sometimes "conditional effects") are used to probe the nature of a significant interaction. They examine the relationships between X and Y for particular values of Z, the moderator. Although other values can be used, the values most commonly used for the moderator are -1 standard deviation below the mean, the mean, and +1 standard deviation above the mean. See the handout "Simple Slopes" from my multiple regression course, http://web.pdx.edu/~newsomj/mvclass and Aiken and West (1991) and Cohen, Cohen, West, and Aiken (2003) for more details.

Data from this project come from a recent manuscript coauthored with Emily Denning, Ben Shaw, Kristin August, and Scott Strath on social relationships and physical activity (Newsom et al., 2022). The interactions tested below examine the interaction between physical activity-related emotional support (`emo`) and personal norms that value physical activity (`persnorm`) as predictors of intention to engage in physical activity (`intent`). Only Mplus is illustrated for the plots because `lavaan` does not have simple slope plotting functions (although similar constraints to obtain simple slope values are illustrated below).

Continuous Measured Variable Interaction with Simple Slopes Example
Mplus

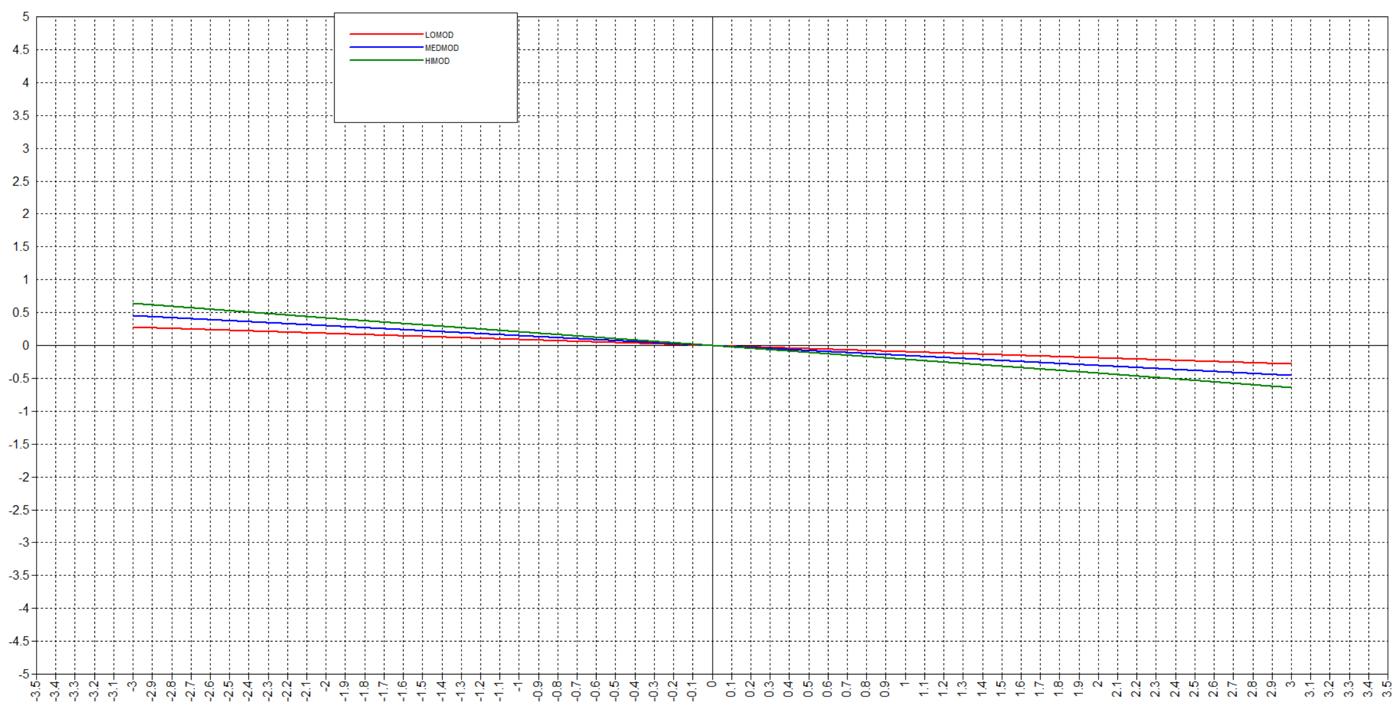
Although this interaction is not significant, I estimated and plotted the simple slopes to illustrate the process. Normally, if the interaction is not significant, simple slopes are not computed. Other examples can be found in Muthén, Muthén, and Asparouhov (2016).

```
title: Continuous measured varaible interaction;
data: file is norms12.dat;

variable: names are female norms subj pdesc pinj sdesc sinj intention champs
             q110 q111 q113 q114 q115 q116 q117 q118 q120 q121 q122 q103 q104r q106 q107 q108
        q123 q124 q125 q126 q130 q131 q132 q133 q137 q138 q139 q140 q151 q152 q153 q154
        marstat married widowed educ race nonwhite income incomead age educ2;

        missing are all (-99);

        usevariables = q103 q104r q106 q107 q108
        persnorm emo emoxnorm;

        define:
        pinj = mean (q115 q116);
        pdesc = mean (q113 q114);
        subj = mean(q110 q111);
        persnorm = mean (pinj pdesc subj);
        emo = mean (q123 q124 q125 q126);
        center persnorm emo (grandmean);
        emoxnorm = emo*persnorm;

!random estimation and integration needed for latent interactions;
!straight ml recommended by Cham et al. 2012, 2017;
analysis: type=general;  estimator=mlr;

model:
  intent by q103 q104r q106 q107 q108;

 !main effects
   intent on emo (b1);
   intent on persnorm (b2);
   intent on emoxnorm (b3);
   persnorm (pers);

Model constraint:

  !SIMPLE SLOPES COMPUTATIONS;
  ! persnorm mean is 4.692 obtained from prior analysis (var=1.493, SD=1.222);

  !declare new names for W values and simple slopes;
  NEW(LOW_W MED_W HIGH_W SIMP_LO SIMP_MED SIMP_HI);

  !simple slope equations;
  LOW_W = 4.692 - 1*(sqrt(pers)) ; !-1 SD below mean of W;
```

```
    MED_W = 4.692 ; ! mean of W;
    HIGH_W = 4.692 + 1*(sqrt(pers)); ! +1 SD below mean of W;

   ! Now calc simple slopes for each value of W;
    SIMP_LO = b1 + b3*LOW_W;
    SIMP_MED = b1 + b3*MED_W;
    SIMP_HI = b1 + b3*HIGH_W;

    ! Use loop plot to plot slopes of X on Y for low, med, high values of W
    ! NOTE - values from -3 to 3 in LOOP() statement since
    ! X is factor with mean set at default of 0
    !From user guide on loop function: "The LOOP option names
    !the variable that will be plotted on the x-axis, gives
    !the numbers that are the lower and upper values of the variable, and the
    !incremental value of the variable to be used in the computations;
   PLOT(LOMOD MEDMOD HIMOD);
   LOOP(XVAL,-13,13,1);
   LOMOD = (b1 + b3*LOW_W)*XVAL;
   MEDMOD = (b1 + b3*MED_W)*XVAL;
   HIMOD = (b1 + b3*HIGH_W)*XVAL;

  PLOT:
   TYPE = plot2;

  output: stdyx stand sampstat tech4;


Continuous measured varaible interaction;


SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                         216

Number of dependent variables                                    5
Number of independent variables                                  3
Number of continuous latent variables                            1


Estimator                                                      MLR


THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters                       20

Loglikelihood

          H0 Value                       -1430.162
          H0 Scaling Correction Factor      3.1808
            for MLR
          H1 Value                       -1384.886
          H1 Scaling Correction Factor      2.3642
            for MLR

Information Criteria

          Akaike (AIC)                    2900.323
          Bayesian (BIC)                  2967.829
          Sample-Size Adjusted BIC        2904.452
            (n* = (n + 2) / 24)

Chi-Square Test of Model Fit

          Value                             60.180*
          Degrees of Freedom                    19
          P-Value                           0.0000
          Scaling Correction Factor         1.5047
            for MLR

*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
    for chi-square difference testing in the regular way.  MLM, MLR and WLSM
```

```
    chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
    and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.100
          90 Percent C.I.                    0.072  0.129
          Probability RMSEA <= .05           0.002

CFI/TLI

          CFI                                0.830
          TLI                                0.776

Chi-Square Test of Model Fit for the Baseline Model

          Value                            267.094
          Degrees of Freedom                    25
          P-Value                           0.0000

SRMR (Standardized Root Mean Square Residual)

          Value                              0.116

MODEL RESULTS
                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 INTENT   BY
    Q103               1.000      0.000    999.000    999.000
    Q104R              0.486      0.125      3.893      0.000
    Q106               1.076      0.123      8.730      0.000
    Q107               1.169      0.125      9.386      0.000
    Q108               0.665      0.101      6.613      0.000

 INTENT   ON
    EMO                0.106      0.045      2.348      0.019
    PERSNORM           0.245      0.080      3.074      0.002
    EMOXNORM          -0.055      0.047     -1.159      0.246

 Means
    PERSNORM           0.000      0.074      0.000      1.000

 Intercepts
    Q103               4.391      0.064     68.380      0.000
    Q104R              4.746      0.043    110.859      0.000
    Q106               4.533      0.065     69.606      0.000
    Q107               4.483      0.072     62.294      0.000
    Q108               4.069      0.065     62.680      0.000

 Variances
    PERSNORM           1.186      0.177      6.697      0.000

 Residual Variances
    Q103               0.340      0.082      4.127      0.000
    Q104R              0.322      0.087      3.694      0.000
    Q106               0.158      0.090      1.762      0.078
    Q107               0.193      0.093      2.083      0.037
    Q108               0.701      0.082      8.551      0.000
    INTENT             0.443      0.103      4.296      0.000

New/Additional Parameters
    LOW_W              3.603      0.081     44.305      0.000
    MED_W              4.692      0.000      0.000      1.000
    HIGH_W             5.781      0.081     71.092      0.000
    SIMP_LO           -0.092      0.154     -0.597      0.550
    SIMP_MED          -0.152      0.205     -0.740      0.460
    SIMP_HI           -0.212      0.257     -0.823      0.410

STANDARDIZED MODEL RESULTS
STDYX Standardization
                                                     Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value
 INTENT   BY
    Q103               0.784      0.061     12.784      0.000
```

```
    Q104R              0.534      0.108      4.933      0.000
    Q106               0.894      0.059     15.096      0.000
    Q107               0.891      0.050     17.728      0.000
    Q108               0.505      0.071      7.130      0.000

 INTENT   ON
    EMO                0.200      0.091      2.185      0.029
    PERSNORM           0.362      0.089      4.073      0.000
    EMOXNORM          -0.122      0.104     -1.176      0.240

 Means
    PERSNORM           0.000      0.068      0.000      1.000

 Intercepts
    Q103               4.676      0.376     12.429      0.000
    Q104R              7.077      0.894      7.919      0.000
    Q106               5.115      0.523      9.785      0.000
    Q107               4.638      0.440     10.539      0.000
    Q108               4.194      0.262     15.981      0.000

 Variances
    PERSNORM           1.000      0.000    999.000    999.000

 Residual Variances
    Q103               0.385      0.096      4.009      0.000
    Q104R              0.715      0.116      6.189      0.000
    Q106               0.201      0.106      1.904      0.057
    Q107               0.207      0.089      2.313      0.021
    Q108               0.745      0.071     10.426      0.000
    INTENT             0.817      0.070     11.590      0.000

R-SQUARE
    Observed                                        Two-Tailed
    Variable        Estimate       S.E.  Est./S.E.    P-Value

    Q103               0.615      0.096      6.392      0.000
    Q104R              0.285      0.116      2.466      0.014
    Q106               0.799      0.106      7.548      0.000
    Q107               0.793      0.089      8.864      0.000
    Q108               0.255      0.071      3.565      0.000

     Latent                                         Two-Tailed
    Variable        Estimate       S.E.  Est./S.E.    P-Value
    INTENT             0.183      0.070      2.601      0.009
```



lavaan

Note: Using the mimic = “Mplus” option on the sem function fixes a discrepancy in how the scaling correc -tion factor is computed

```
> #create measured variables for interaction
> library(tidyverse)
> mydata$emo<-rowMeans(mydata[, c("q123", "q124", "q125","q126")], na.rm=T)
> mydata$persnorm<-rowMeans(mydata[, c("q115", "q116", "q113","q114","q110","q111")], na.rm=T)
>
> #center predictors
> #mydata$emo <- mydata$emo - mean(mydata$emo)
> #mydata$persnorm <- mydata$persnorm - mean(mydata$persnorm)
> library(QuantPsyc)
> mydata$emo = meanCenter(mydata$emo)
> mydata$persnorm = meanCenter(mydata$persnorm)
> mydata$emoxnorm = mydata$emo*mydata$persnorm
> #be sure to check that centering worked by looking at descriptives
>
>
> #to match Mplus which had N=216, listwise for vars used
> mydata = mydata[complete.cases(mydata[,c("emo","persnorm")]),]
> #mydata = mydata[complete.cases(mydata[,c("q103","q104r","q106","q107","q108")]),]
>
> library(lavaan)
> model = '
+        intent =~ q103 + q104r + q106 + q107 + q108
+        intent ~ b1*emo + b2*persnorm + b3*emoxnorm
+        persnorm~~pers*persnorm
+
+ #constraints for simple slopes
+
+ #NEW(LOW_W MED_W HIGH_W SIMP_LO SIMP_MED SIMP_HI);
+
+   #simple slope equations;
+   LOW_W := 4.692 - 1*(sqrt(pers)) ; #-1 SD below mean of W;
+   MED_W := 4.692 ; # mean of W;
+   HIGH_W := 4.692 + 1*(sqrt(pers)); # +1 SD below mean of W;
+
+  # Now calc simple slopes for each value of W;
+   SIMP_LO := b1 + b3*LOW_W;
+   SIMP_MED := b1 + b3*MED_W;
+   SIMP_HI := b1 + b3*HIGH_W;
+
+
+ '
>
> #Below, MLR is used to request Yuan-Bentler scaled chi-square and SEs
> #robust standard errors and scaled chi-square
> fit = sem(model, data = mydata, fixed.x=FALSE,  mimic = "mplus", estimator="mlr")
> summary(fit,fit.measures=TRUE, rsquare=TRUE, standardized=TRUE)
lavaan 0.6.15 ended normally after 41 iterations

  Estimator                                         ML
  Optimization method                           NLMINB
  Number of model parameters                        25

  Number of observations                           216
  Number of missing patterns                         7

Model Test User Model:
                                              Standard      Scaled
  Test Statistic                                90.471      60.035
  Degrees of freedom                                19          19
  P-value (Chi-square)                           0.000       0.000
  Scaling correction factor                                  1.507
    Yuan-Bentler correction (Mplus variant)

Model Test Baseline Model:

  Test statistic                               669.592     269.090
  Degrees of freedom                                27          27
  P-value                                        0.000       0.000
  Scaling correction factor                                  2.488

User Model versus Baseline Model:

  Comparative Fit Index (CFI)                    0.889       0.830
  Tucker-Lewis Index (TLI)                       0.842       0.759

  Robust Comparative Fit Index (CFI)                         0.904
  Robust Tucker-Lewis Index (TLI)                            0.864

Loglikelihood and Information Criteria:
```

```
  Loglikelihood user model (H0)             -2220.187   -2220.187
  Scaling correction factor                                 2.910
      for the MLR correction
  Loglikelihood unrestricted model (H1)     -2174.952   -2174.952
  Scaling correction factor                                 2.304
      for the MLR correction

  Akaike (AIC)                               4490.374    4490.374
  Bayesian (BIC)                             4574.756    4574.756
  Sample-size adjusted Bayesian (SABIC)      4495.535    4495.535

Root Mean Square Error of Approximation:

  RMSEA                                         0.132       0.100
  90 Percent confidence interval - lower        0.105       0.077
  90 Percent confidence interval - upper        0.160       0.124
  P-value H_0: RMSEA <= 0.050                   0.000       0.000
  P-value H_0: RMSEA >= 0.080                   0.999       0.927

  Robust RMSEA                                              0.121
  90 Percent confidence interval - lower                    0.086
  90 Percent confidence interval - upper                    0.158
  P-value H_0: Robust RMSEA <= 0.050                        0.001
  P-value H_0: Robust RMSEA >= 0.080                        0.970

Standardized Root Mean Square Residual:

  SRMR                                          0.109       0.109

Parameter Estimates:

  Standard errors                            Sandwich
  Information bread                          Observed
  Observed information based on               Hessian

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  intent =~
    q103              1.000                               0.736    0.784
    q104r             0.486    0.125    3.893    0.000    0.358    0.534
    q106              1.076    0.123    8.734    0.000    0.792    0.894
    q107              1.169    0.125    9.389    0.000    0.861    0.891
    q108              0.665    0.101    6.614    0.000    0.490    0.505

Regressions:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  intent ~
    emo       (b1)    0.105    0.045    2.345    0.019    0.143    0.199
    persnorm  (b2)    0.245    0.080    3.072    0.002    0.332    0.362
    emoxnorm  (b3)   -0.055    0.047   -1.160    0.246   -0.075   -0.122

Covariances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  emo ~~
    emoxnorm          0.108    0.221    0.486    0.627    0.108    0.047

Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .q103              4.392    0.064   68.447    0.000    4.392    4.676
   .q104r             4.746    0.043  110.975    0.000    4.746    7.077
   .q106              4.534    0.065   69.661    0.000    4.534    5.116
   .q107              4.484    0.072   62.351    0.000    4.484    4.639
   .q108              4.069    0.065   62.681    0.000    4.069    4.194
    emo              -0.000    0.095   -0.000    1.000   -0.000   -0.000
    persnorm         -0.003    0.074   -0.039    0.969   -0.003   -0.003
    emoxnorm          0.721    0.111    6.492    0.000    0.721    0.442
   .intent            0.000                               0.000    0.000

Variances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    persnrm (pers)    1.186    0.177    6.688    0.000    1.186    1.000
   .q103              0.340    0.082    4.132    0.000    0.340    0.386
   .q104r             0.322    0.087    3.695    0.000    0.322    0.715
   .q106              0.158    0.090    1.761    0.078    0.158    0.201
   .q107              0.193    0.093    2.083    0.037    0.193    0.207
   .q108              0.701    0.082    8.552    0.000    0.701    0.745
   .intent            0.443    0.103    4.294    0.000    0.817    0.817
    emo               1.938    0.136   14.286    0.000    1.938    1.000
    emoxnrm           2.666    0.537    4.962    0.000    2.666    1.000

R-Square:
                   Estimate
    q103              0.614
    q104r             0.285
    q106              0.799
```

```
    q107              0.793
    q108              0.255
    intent            0.183

Defined Parameters:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    LOW_W             3.603    0.081   44.262    0.000    3.603    3.692
    MED_W             4.692                               4.692    4.692
    HIGH_W            5.781    0.081   71.013    0.000    5.781    5.692
    SIMP_LO          -0.093    0.155   -0.600    0.549   -0.126   -0.251
    SIMP_MED         -0.153    0.206   -0.742    0.458   -0.207   -0.373
    SIMP_HI          -0.213    0.258   -0.825    0.409   -0.289   -0.495
```

`lavaan` does not have the same type of plotting function as Mplus, so plots would need to be generated in R outside of `lavaan`

Latent Variable Interaction with Simple Slopes Example

The latent variable interaction approach in Mplus is illustrated below. The Mplus `xwith` command is used for implementing the LMS approach to latent variable interactions (Klein & Moosbrugger, 2000). Plotting examples are available from Chris Stride and colleagues at http://offbeat.group.shef.ac.uk/FIO/mplusmedmod.htm. Code for this example was developed by Em Trubits (fka Emily Denning).

Some output omitted

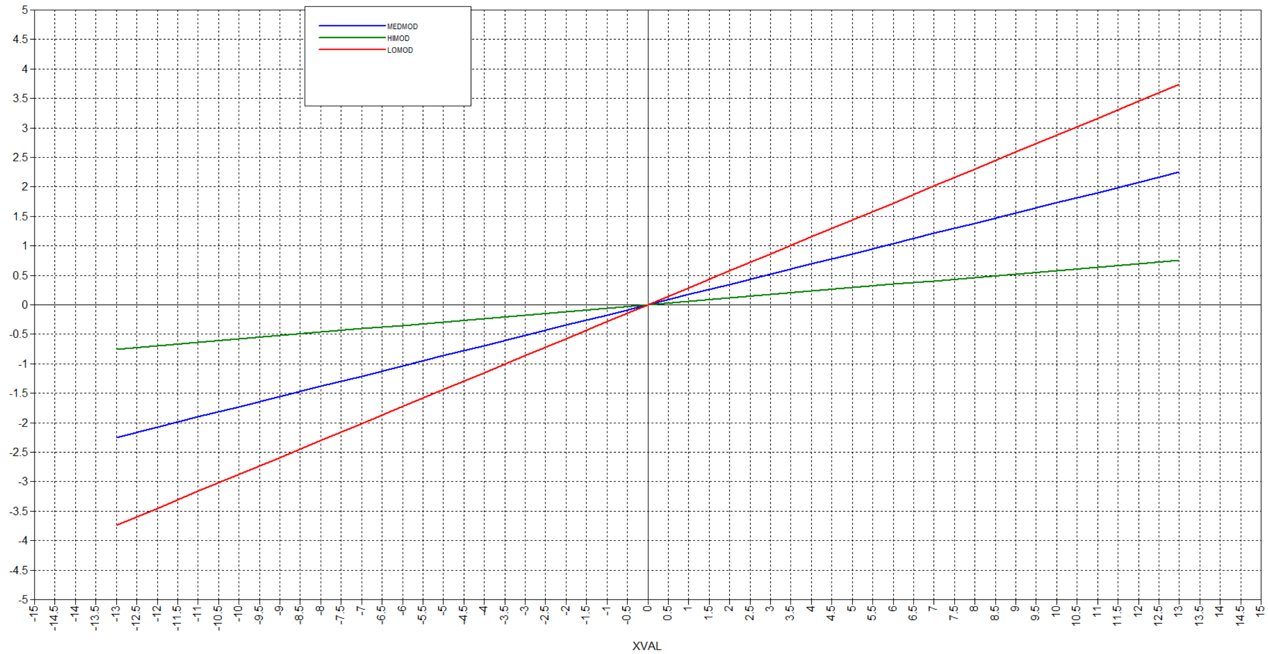
```
INPUT INSTRUCTIONS

  title:
  data: file is norms12.dat;

  variable: names are female norms subj pdesc pinj sdesc sinj intention champs
               q110 q111 q113 q114 q115 q116 q117 q118 q120 q121 q122 q103 q104r q106 q107 q108
          q123 q124 q125 q126 q130 q131 q132 q133 q137 q138 q139 q140 q151 q152 q153 q154
          marstat married widowed educ race nonwhite income incomead age educ2;

          missing are all (-99);

          usevariables = q103 q104r q106 q107 q108
          q123 q124 q125 q126
          pinj pdesc subj;

          define:
          pinj = mean (q115 q116);
          pdesc = mean (q113 q114);
          subj = mean(q110 q111);

  !random estimation and integration needed for latent interactions;
  !straight ml recommended by Cham et al. 2012, 2017;
  analysis: type=random;  estimator=ml;
        ALGORITHM=INTEGRATION;

  model:
  !effects coding is used for scaling latent variables used in the interaction,
  !labels correspond to model constraint statements for scaling each factor.
  !labels start with ly7 because this was adapted from another model;
  emo by q123* (ly7)
      q124 (ly8)
      q125 (ly9)
      q126 (ly10);

  intent by q103 q104r q106 q107 q108;
  persnorm by pinj* (ly11)
      pdesc (ly12)
      subj (ly13);

  !measurement intercepts and factor means;
      [q123](t7);
      [q124](t8);
      [q125](t9);
      [q126](t10);
      [pinj] (t11);
      [pdesc] (t12);
```

```
      [subj] (t13);

      [persnorm];
       emo;
       intent;
       persnorm (pers);

   !main effects
     intent on emo (b1);
     intent on persnorm (b2);

   !latent interaction variable
     emoxpersnorm | emo xwith persnorm;
     intent on emoxpersnorm (b3);

  Model constraint:
    ly7 = 4 - ly8 - ly9 - ly10;
    ly11 = 3 - ly12 - ly13;
    t7 = 0 - t8 - t9 - t10;
    t11 = 0 - t12 - t13;

    !SIMPLE SLOPES COMPUTATIONS;
    ! persnorm mean is 4.692 obtained from prior analysis (var=1.493, SD=1.222);

    !declare new names for W values and simple slopes;
    NEW(LOW_W MED_W HIGH_W SIMP_LO SIMP_MED SIMP_HI);

    !simple slope equations;
    LOW_W = 4.692 - 1*(sqrt(pers)) ; !-1 SD below mean of W;
    MED_W = 4.692 ; ! mean of W;
    HIGH_W = 4.692 + 1*(sqrt(pers)); ! +1 SD below mean of W;

   ! Now calc simple slopes for each value of W;
    SIMP_LO = b1 + b3*LOW_W;
    SIMP_MED = b1 + b3*MED_W;
    SIMP_HI = b1 + b3*HIGH_W;

    ! Use loop plot to plot slopes of X on Y for low, med, high values of W
    ! NOTE - values from -3 to 3 in LOOP() statement since
    ! X is factor with mean set at default of 0
    !From user guide on loop function: "The LOOP option names
    !the variable that will be plotted on the x-axis, gives
    !the numbers that are the lower and upper values of the variable, and the
    !incremental value of the variable to be used in the computations;
   PLOT(LOMOD MEDMOD HIMOD);
   LOOP(XVAL,-13,13,1);
   LOMOD = (b1 + b3*LOW_W)*XVAL;
   MEDMOD = (b1 + b3*MED_W)*XVAL;
   HIMOD = (b1 + b3*HIGH_W)*XVAL;

  PLOT:
   TYPE = plot2;

  output: stdyx stand sampstat tech4;


*** WARNING in PLOT command
  Note that only the first 8 characters of variable names are used in plots.
  If variable names are not unique within the first 8 characters, problems
  may occur.
   1 WARNING(S) FOUND IN THE INPUT INSTRUCTIONS


SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                         217

Number of dependent variables                                   12
Number of independent variables                                  0
Number of continuous latent variables                            4


SUMMARY OF DATA
```

```
     Number of missing data patterns           15

MODEL FIT INFORMATION

Number of Free Parameters                      39



Loglikelihood

          H0 Value                      -3445.628

Information Criteria

          Akaike (AIC)                   6969.256
          Bayesian (BIC)                 7101.072
          Sample-Size Adjusted BIC       6977.486
            (n* = (n + 2) / 24)

MODEL RESULTS
                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 EMO      BY
    Q123               0.983      0.044     22.381      0.000
    Q124               0.992      0.038     25.991      0.000
    Q125               1.064      0.035     30.646      0.000
    Q126               0.961      0.044     21.753      0.000

 INTENT   BY
    Q103               1.000      0.000    999.000    999.000
    Q104R              0.479      0.059      8.136      0.000
    Q106               1.079      0.073     14.776      0.000
    Q107               1.171      0.079     14.852      0.000
    Q108               0.670      0.086      7.741      0.000

 PERSNORM BY
    PINJ               1.038      0.039     26.685      0.000
    PDESC              0.992      0.042     23.912      0.000
    SUBJ               0.969      0.048     20.068      0.000

 INTENT     ON
    EMO                0.613      0.197      3.109      0.002
    PERSNORM           0.460      0.090      5.115      0.000
    EMOXPERSNO        -0.094      0.034     -2.723      0.006

 PERSNORM WITH
    EMO                2.052      0.350      5.861      0.000

 Means
    PERSNORM           4.686      0.118     39.821      0.000

 Intercepts
    Q103               1.726      0.459      3.757      0.000
    Q104R              3.472      0.254     13.673      0.000
    Q106               1.655      0.478      3.461      0.001
    Q107               1.359      0.518      2.627      0.009
    Q108               2.283      0.362      6.312      0.000
    Q123               0.723      0.104      6.961      0.000
    Q124               0.007      0.089      0.078      0.938
    Q125              -0.414      0.081     -5.115      0.000
    Q126              -0.315      0.105     -2.996      0.003
    PINJ              -0.009      0.212     -0.044      0.965
    PDESC             -0.231      0.226     -1.023      0.306
    SUBJ               0.241      0.263      0.913      0.361

 Variances
    EMO                5.852      0.584     10.018      0.000
    PERSNORM           1.499      0.228      6.588      0.000

 Residual Variances
    Q103               0.341      0.040      8.571      0.000
    Q104R              0.323      0.032      9.973      0.000
    Q106               0.158      0.026      6.117      0.000
    Q107               0.192      0.030      6.317      0.000
```

```
    Q108               0.698      0.070      9.979      0.000
    Q123               1.059      0.127      8.346      0.000
    Q124               0.665      0.092      7.241      0.000
    Q125               0.474      0.084      5.653      0.000
    Q126               1.099      0.127      8.637      0.000
    PINJ               0.186      0.049      3.778      0.000
    PDESC              0.416      0.058      7.224      0.000
    SUBJ               0.826      0.091      9.038      0.000
    INTENT             0.417      0.064      6.554      0.000

New/Additional Parameters
    LOW_W              3.468      0.093     37.315      0.000
    MED_W              4.692      0.000  *********      0.000
    HIGH_W             5.916      0.093     63.668      0.000
    SIMP_LO            0.288      0.085      3.387      0.001
    SIMP_MED           0.173      0.053      3.266      0.001
    SIMP_HI            0.058      0.046      1.275      0.202

STANDARDIZED MODEL RESULTS
STDYX Standardization
                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value
 EMO      BY
    Q123               0.918      0.013     69.320      0.000
    Q124               0.947      0.009     99.931      0.000
    Q125               0.966      0.007    133.862      0.000
    Q126               0.912      0.014     65.603      0.000

 INTENT   BY
    Q103               0.894      0.030     29.330      0.000
    Q104R              0.700      0.069     10.205      0.000
    Q106               0.953      0.015     63.184      0.000
    Q107               0.952      0.015     61.967      0.000
    Q108               0.682      0.071      9.610      0.000

 PERSNORM BY
    PINJ               0.947      0.016     59.012      0.000
    PDESC              0.883      0.023     37.832      0.000
    SUBJ               0.794      0.035     22.656      0.000

 INTENT     ON
    EMO                1.275      0.260      4.901      0.000
    PERSNORM           0.485      0.064      7.605      0.000
    EMOXPERSNO        -0.239      0.060     -3.954      0.000

 PERSNORM WITH
    EMO                0.693      0.058     11.847      0.000

 Means
    PERSNORM           3.827      0.365     10.475      0.000

R-SQUARE
    Observed                                        Two-Tailed
    Variable        Estimate       S.E.  Est./S.E.    P-Value
    PINJ               0.897      0.030     29.506      0.000
    PDESC              0.780      0.041     18.916      0.000
    SUBJ               0.631      0.056     11.328      0.000

     Latent                                         Two-Tailed
    Variable        Estimate       S.E.  Est./S.E.    P-Value
    INTENT             0.692      0.096      7.205      0.000
```

The figure shows that the relationship between emotional support and intention to engage in physical activity is stronger when personal norms are low.



Latent Variable Interactions with `lavaan`

The lavaan package does not have the LMS interaction approach, although see match-paired indicator approach to latent variable interaction (Marsh, Wen, & Hau, 2004) under development in R using the `semTools` package, the `indProd` function for computing the indicators, and the `probe2WayMC` function for computing simple slopes and plotting.

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