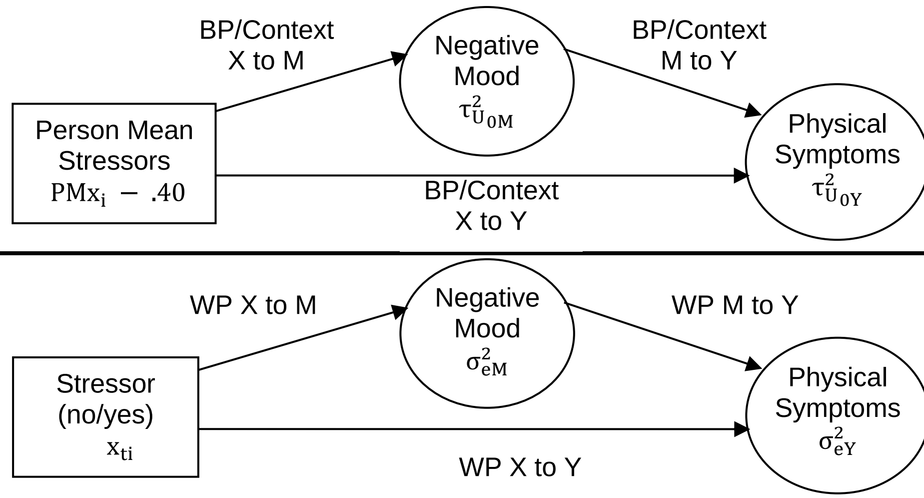
Mediation of Within-Person Fluctuation in Univariate MLM in SAS PROC MIXED Relative to Multivariate MLM in Mplus v.8

The limitations of univariate multilevel models (MLMs) (as in SAS MIXED) can be addressed by switching to “truly” multivariate MLMs (aka, multilevel SEM, or M-SEM), as in Mplus. The primary difference is that rather than obtaining between and within effects through *observed variable predictors*, in truly multivariate MLMs the between and within *variances* of any level-1 predictor can be partitioned into level-2 random intercept variances and level-1 residual variances in the model, the same as for the DV in univariate MLMs. This example features truly multivariate MLMs in which a level-1 variable can be both a predictor and an outcome simultaneously, as is necessary in order to do multilevel mediational analysis of direct and indirect fixed effects. These models use the data from Hoffman (2015) chapter 8 examining fluctuation across 5 days for 105 older adults in daily stressors, daily negative mood, and daily physical symptoms.

Level-2, Between-Person (BP) Model:

The result from multiplying the X → M and M →Y fixed effects together is called the **indirect effect**: this effect is the formal test of whether the X → Y path differs after including M → Y.

Because there are two levels of X → M and M →Y fixed effects, there are two levels of indirect effects—and mediation—too.



Careful! The level-2 fixed effects will be total BP effects *if the level-1 effect is specified directly as a fixed effect at level 1 only*, but the level-2 effects will be the contextual BP effects otherwise.

So long as their level-2 variances are included in the model (as observed person means or random intercepts), the level-1 fixed effects will be the total WP effects (they will be unsmushed).

Level-1, Within-Person (WP) Model:

There are two options for how to include variables in these models: (1) They can be treated as ***predictors***, which is the same as in univariate MLM. This means that although the model estimates their fixed effects in predicting the outcome(s), their means, variances, and covariances are *not* model parameters, and these predictors do not have distributional assumptions. This also means that because they are *not* part of the model likelihood, **any rows with missing predictors will be deleted**. (2): They can be treated as ***outcomes***, either by predicting them with other variables, or just by letting the model estimate their variances and covariances at each applicable level (and mean at the highest level). So because **outcomes are part of the model likelihood, they can have missing case-wise data given their distributional assumptions**, such that any case that has at least one outcome will still be included. Currently in Mplus, it is somewhere between difficult and impossible to turn categorical predictors into outcomes without predicting them by something else. For this reason, we will include our “X”, daily stressor (0=no, 1=yes) as an observed level-1 predictor, and its person mean (centered such that 0=.40) as an observed level-2 predictor. In contrast, our “M”, daily negative mood, and our “Y”, daily physical symptoms, will be outcomes whose variance is partitioned by the model (as shown above).

There are two ways of specifying level-1 fixed effects in Mplus, and they create different level-2 fixed effects: (1) If a level-1 fixed effect is specified directly in the level-1 %WITHIN% model, any level-2 fixed effects of the same variable will carry their total BP effects. (2) In contrast, if the level-1 placeholder syntax is used, such that the variable’s level-1 fixed and level-2 random effects show up in the level-2 %BETWEEN% model instead—regardless of whether the random slope variance is actually estimated—then the variable’s level-2 fixed effects will instead carry the BP contextual effects. We will show both versions to illustrate this result, although based on previous analyses for these data, the **WP effects in this example will be fixed only**, as no random WP effects were significant. Further, we will also examine how to specify interactions in this “truly” multivariate MLM framework, which become **latent variable interactions** for which ML estimation requires numeric integration. Finally, there is no REML within Mplus, so **we will use ML for all models**. We will first examine the effects of X and M in predicting Y separately. Then, within a full mediation model, we will examine the X → M effect and the unique effects of X and M in predicting Y.

Step 1: Fitting the Between-Person and Within-Person Stress (X) → Symptoms (Y) Effects (i.e., before controlling for M Negative Mood)

In SAS, partitioning stress into level-1 WP vs. level-2 BP contextual effects by observed variables:

```
TITLE1 "Step 1: WP and BP Contextual BP Stress
        Predicting Symptoms: X --> Y";
PROC MIXED DATA=work.Chapter8 COVTEST NOCLPRINT IC
        NAMELEN=50 METHOD=ML;
 CLASS PersonID;
 MODEL symptoms = women age80 women*age80
                  stressor PMstress40
                   / SOLUTION DDFM=SATTERTHWAITE;
 RANDOM INTERCEPT / TYPE=UN SUBJECT=PersonID;
 ESTIMATE "BP X to Y Effect" stressor 1 PMstress40 1;
RUN;
```

In Mplus, doing the exact same thing:

```
TITLE:  Predicting symptoms outcome from OBSERVED stress (so X --> Y);

DATA:    FILE = Chapter8.csv;  ! Can just list file if in same directory;
         FORMAT = free;        ! FREE or FIXED format;
         TYPE = individual;    ! Individual or matrix data as input;

VARIABLE:
! List of ALL variables in stacked data file, in order;
! Mplus does NOT know what they used to be called, though;
  NAMES ARE PersonID women age80 session symptoms mood2 stress PMstr40;
! List of ALL variables used in model (DEFINED variables at end);
  USEVARIABLES ARE symptoms women age80 stress PMstr40 agesex;
! Missing data codes (here, -999);
  MISSING ARE ALL (-999);
! Identify level-2 ID;
  CLUSTER = PersonID;
! Predictor variables with variation ONLY at level 1;
  WITHIN = stress;
! Predictor variables with variation ONLY at level 2;
  BETWEEN = age80 women agesex PMstr40;

DEFINE:     agesex = age80*women;     ! Create observed level-2 interaction;

ANALYSIS:   TYPE IS TWOLEVEL RANDOM; ! 2-level model with random slopes;
            ESTIMATOR IS ML;         ! Can also use MLR for non-normality;

MODEL:    ! X Stress --> Y Symptoms Model;
! Level-1, Within-Person (WP) Model;
%WITHIN%
  symptoms;                         ! L1 R: residual variance in symptoms;
  WPXtoY | symptoms ON stress;      ! Placeholder for L1 WP stress->symptoms;

! Level-2, Person-Level Model;
%BETWEEN%
 [symptoms];                        ! Fixed intercept for symptoms;
  symptoms;                         ! L2 random intercept variance in symptoms;

 [WPXtoY]              (WPXtoY);    ! L1 WP fixed effect (label) of stress->symptoms;
  WPXtoY@0;                         ! L2 G: No random stress slope variance->symptoms;

  symptoms ON women    (SextoY);    ! BP total fixed effect of women->symptoms;
  symptoms ON age80    (AgetoY);    ! BP total fixed effect of age->symptoms;
  symptoms ON agesex   (AgesexY);   ! BP total fixed effect of age*women->symptoms;
  symptoms ON PMstr40  (conXtoY);   ! Contextual BP fixed effect of stress->symptoms;

MODEL CONSTRAINT:                   ! Equivalent to ESTIMATE in SAS;
 NEW(BPXtoY);                       ! Need to name each new created fixed effect;
 BPXtoY = WPXtoY + conXtoY;         ! BP total effect of stress->symptoms;
```

SAS Univariate Results: This is the exact same model in SAS MIXED and Mplus MLM because both treat daily stressors and person mean stressors as observed predictors and symptoms as a model-estimated outcome.

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	ID	0.8376	0.1344	6.23	<.0001
Residual	ID	0.6134	0.04322	14.19	<.0001

Information Criteria

Neg2LogLike	Parms	AIC	AICC	HQIC	BIC	CAIC
1408.5	8	1424.5	1424.8	1433.1	1445.7	1453.7

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	1.5865	0.1937	115	8.19	<.0001
women	-0.5187	0.2199	105	-2.36	0.0202
age80	0.09676	0.03329	108	2.91	0.0044
women*age80	-0.1065	0.03789	107	-2.81	0.0059
stressor	0.1100	0.09487	403	1.16	0.2469
PMstressor40	1.3352	0.3019	128	4.42	<.0001

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|
BP X to Y Effect	1.4452	0.2864	104	5.05	<.0001

Mplus Univariate Results:

```
MODEL FIT INFORMATION

Number of Free Parameters                        8

Loglikelihood
          H0 Value                        -704.220

Information Criteria
          Akaike (AIC)                    1424.440
          Bayesian (BIC)                  1458.299
          Sample-Size Adjusted BIC        1432.906
            (n* = (n + 2) / 24)

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

Within Level

 Residual Variances
    SYMPTOMS           0.613      0.043     14.191      0.000

Between Level

 SYMPTOMS   ON
    WOMEN             -0.519      0.220     -2.358      0.018
    AGE80              0.097      0.033      2.906      0.004
    AGESEX            -0.106      0.038     -2.810      0.005
    PMSTR40            1.335      0.302      4.423      0.000

 Means
    WPXTOY             0.110      0.095      1.159      0.246

 Intercepts
    SYMPTOMS           1.586      0.194      8.188      0.000

 Variances
    WPXTOY             0.000      0.000    999.000    999.000

 Residual Variances
    SYMPTOMS           0.837      0.134      6.233      0.000

New/Additional Parameters
    BPSTRESS           1.445      0.286      5.046      0.000
```

Step 2: Fitting the Between-Person and Within-Person Mood (M) → Symptoms (Y) Effects (i.e., before controlling for X Symptoms)

In univariate SAS, partitioning mood into level-1 WP vs. level-2 BP contextual effects through observed variables:

```
TITLE1 "Step 2: WP and BP Contextual Mood
        Predicting Symptoms: M --> Y";
PROC MIXED DATA=work.Chapter8 COVTEST NOCLPRINT IC
         NAMELEN=50 METHOD=ML;
 CLASS PersonID;
 MODEL symptoms = women age80 women*age80 mood2 PMmood2
                  / SOLUTION DDFM=SATTERTHWAITE;
 RANDOM INTERCEPT / TYPE=UN SUBJECT=PersonID;
 ESTIMATE "BP M to Y Effect" mood2 1 PMmood2 1;
RUN;
```

SAS Results: Although this is the same idea, this is NOT the same model as in Mplus, in which mood is treated like another DV (and so its mean and two variances are model parameters, even though it is not being predicted).

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	PersonID	0.8162	0.1314	6.21	<.0001
Residual		0.6127	0.04317	14.19	<.0001

Information Criteria

Neg2LogLike	Parms	AIC	AICC	HQIC	BIC	CAIC
1405.7	8	1421.7	1422.0	1430.3	1442.9	1450.9

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	3.2655	0.3458	106	9.44	<.0001
women	-0.5181	0.2175	105	-2.38	0.0190
age80	0.06690	0.03349	108	2.00	0.0483
women*age80	-0.09176	0.03764	107	-2.44	0.0164
mood2	0.1591	0.1277	404	1.25	0.2136
PMmood2	1.8110	0.3910	132	4.63	<.0001

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|
BP M to Y Effect	1.9701	0.3687	105	5.34	<.0001

In multivariate Mplus, partitioning mood into WP vs. BP Contextual in the MODEL using placeholder syntax for level-1 effects:

```
TITLE:  Predicting symptoms outcome from mood OUTCOME (so M --> Y);
( DATA is the same )
VARIABLE:
! List of ALL variables in stacked data file, in order;
! Mplus does NOT know what they used to be called, though;
  NAMES ARE PersonID women age80 session symptoms mood2 stress PMstr40;
! List of ALL variables used in model (DEFINED variables at end);
  USEVARIABLES ARE symptoms women age80 mood2 agesex;
! Missing data codes (here, -999);
  MISSING ARE ALL (-999);
! Identify level-2 ID;
  CLUSTER = PersonID;
! Predictor variables with variation ONLY at level 1 -- none now;
  WITHIN = ;
! Predictor variables with variation ONLY at level 2 -- no PMmood2;
  BETWEEN = age80 women agesex;

( DEFINE and ANALYSIS are the same )

MODEL:   ! M Mood --> Y Symptoms Model;
! Level-1, Within-Person (WP) Model;
%WITHIN%
  symptoms;                           ! L1 R: residual variance in symptoms;
  mood2;                              ! L1 R: residual variance in mood;
  WPMtoY | symptoms ON mood2;         ! Placeholder for L1 WP mood--> symptoms;

! Level-2, Person-Level Model;
%BETWEEN%
 [symptoms];                          ! Fixed intercept for symptoms;
  symptoms;                           ! L2 random intercept variance in symptoms;
 [mood2];                             ! Fixed intercept for mood;
  Mood2;                              ! L2 random intercept variance in mood;

 [WPMtoY]              (WPMtoY);      ! L1 WP fixed effect (label) of mood ->symptoms;
  WPMtoY@0;                           ! L2 G: No random mood slope variance-->symptoms;
  symptoms ON women    (SextoY);      ! BP total fixed effect of women ->symptoms;
  symptoms ON age80    (AgetoY);      ! BP total fixed effect of age ->symptoms;
  symptoms ON agesex   (AgesexY);     ! BP total fixed effect of age*women ->symptoms;
  symptoms ON mood2    (conMtoY);     ! Contextual BP fixed effect of mood ->symptoms;

MODEL CONSTRAINT:                     ! Equivalent to ESTIMATE in SAS;
 NEW(BPMtoY);                         ! Need to name each new created fixed effect;
 BPMtoY = WPMtoY + conMtoY;           ! BP total fixed effect of mood ->symptoms;
```

Mplus Multivariate Results using Placeholder Syntax: underlined values indicate the 3 parameters not estimated in univariate SAS MIXED version

```
MODEL FIT INFORMATION
Number of Free Parameters                      11

Loglikelihood
          H0 Value                       -890.792

Information Criteria
          Akaike (AIC)                   1803.583
          Bayesian (BIC)                 1850.140
          Sample-Size Adjusted BIC       1815.225
            (n* = (n + 2) / 24)
```

Model fit is the same either way, but without placeholder syntax, absolute fit tests also now appear, which are relative to a saturated (unstructured) matrix of variances per level.

Let's see how the results differ based on the syntax: bolded terms that are missing are noted in ( )

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
(SYMPTOMS ON				
MOOD2)				
Variances				
MOOD2	0.093	0.007	14.156	0.000
Residual Variances				
SYMPTOMS	0.613	0.043	14.185	0.000
Between Level				
SYMPTOMS ON				
WOMEN	-0.540	0.220	-2.458	0.014
AGE80	0.074	0.034	2.181	0.029
AGESEX	-0.098	0.038	-2.582	0.010
MOOD2	**2.340**	0.558	4.196	0.000
Means				
MOOD2	-0.795	0.026	-30.456	0.000
WPMTOY	**0.167**	**0.128**	**1.303**	**0.193**
Intercepts				
SYMPTOMS	3.710	0.463	8.020	0.000
Variances				
MOOD2	0.052	0.010	5.174	0.000
WPMTOY	**0.000**	**0.000**	**999.000**	**999.000**
Residual Variances				
SYMPTOMS	0.754	0.140	5.405	0.000
New/Additional Parameters				
BPMTOY	**2.506**	0.530	4.728	0.000

Same model specifying level-1 fixed effect in %WITHIN% instead:

```
( all previous commands are the same )
MODEL:    ! M Mood --> Y Symptoms Model WITHOUT THE LEVEL-1 PLACEHOLDER;
! Level-1, Within-Person (WP) Model;
%WITHIN%
  symptoms;                       ! L1 R: residual variance in symptoms;
  mood2;                          ! L1 R: residual variance in mood;
  symptoms ON mood2 (WPMtoY);     ! NO Placeholder, L1 WP mood->symptoms here;

! Level-2, Person-Level Model;
%BETWEEN%
 [symptoms];                      ! Fixed intercept for symptoms;
  symptoms;                       ! L2 random intercept variance in symptoms;
 [mood2];                         ! Fixed intercept for mood;
  Mood2;                          ! L2 random intercept variance in mood;
! References to fixed and random effects of L1 WP mood are gone;
  symptoms ON women   (SextoY);   ! BP total fixed effect of women->symptoms;
  symptoms ON age80   (AgetoY);   ! BP total fixed effect of age->symptoms;
  symptoms ON agesex  (AgesexY);  ! BP total fixed effect of age*women->symptoms;
  symptoms ON mood2   (BPMtoY);   ! NOW BP TOTAL fixed effect of mood->symptoms;

MODEL CONSTRAINT:                 ! Equivalent to ESTIMATE in SAS;
 NEW(conMtoY);                    ! Need to name each new created fixed effect;
 conMtoY = BPMtoY - WPMtoY;       ! Contextual BP fixed effect of mood->symptoms;
```

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
SYMPTOMS ON				
MOOD2	**0.167**	**0.128**	**1.303**	**0.193**
Variances				
MOOD2	0.093	0.007	14.157	0.000
Residual Variances				
SYMPTOMS	0.613	0.043	14.185	0.000
Between Level				
SYMPTOMS ON				
WOMEN	-0.540	0.220	-2.458	0.014
AGE80	0.074	0.034	2.181	0.029
AGESEX	-0.098	0.038	-2.582	0.010
MOOD2	**2.506**	0.530	4.727	0.000
Means				
MOOD2	-0.795	0.026	-30.454	0.000
(WPMTOY)				
Intercepts				
SYMPTOMS	3.710	0.463	8.020	0.000
Variances				
MOOD2	0.052	0.010	5.174	0.000
(WPMTOY)				
Residual Variances				
SYMPTOMS	0.754	0.140	5.405	0.000
New/Additional Parameters				
CONMTOY	**2.339**	0.558	4.195	0.000

Step 3: Fitting the Full Mediation Model: Between-Person and Within-Person Stress (X) → Mood (M) → Symptoms (Y)

For parallel interpretation of the level-2 fixed effects of stress, sex, age, and their interaction also now predict mood.

A full simultaneous mediation model is not possible in univariate SAS, so here is Multivariate Mplus using placeholder syntax → WP + BP Contextual effects:

```
TITLE:  Full mediation model of Stress --> Mood --> Symptoms;
( DATA is the same )
VARIABLE:
! List of ALL variables in stacked data file, in order;
  NAMES ARE PersonID women age80 session symptoms
            mood2 stress PMstr40;
! List of ALL variables used in model (DEFINED variables at end);
  USEVARIABLES ARE symptoms women age80
                   mood2 stress PMstr40 agesex;
! Missing data codes (here, -999);
  MISSING ARE ALL (-999);
! Identify level-2 ID;
  CLUSTER = PersonID;
! Predictor variables with variation ONLY at level 1;
  WITHIN = stress;
! Predictor variables with variation ONLY at level 2;
  BETWEEN = age80 women agesex PMstr40;
( DEFINE and ANALYSIS are the same )

MODEL:    ! Full X Stress --> M Mood --> Y Symptoms Mediation Model
! Level-1, Within-Person (WP) Model;
%WITHIN%
  symptoms;                     ! L1 R: residual variance in symptoms;
  mood2;                        ! L1 R: residual variance in mood;
  WPXtoM | mood2    ON stress;  ! Placeholder L1 WP stress->mood;
  WPXtoY | symptoms ON stress;  ! Placeholder L1 WP stress->symptoms;
  WPMtoY | symptoms ON mood2;   ! Placeholder L1 WP mood->symptoms;

! Level-2, Person-Level Model;
%BETWEEN%
 [symptoms];            ! Fixed intercept for symptoms;
  symptoms;             ! L2 random intercept variance in symptoms;
 [mood2];               ! Fixed intercept for mood;
  Mood2;                ! L2 random intercept variance in mood;
 [WPXtoM]   (WPXtoM);   ! L1 WP fixed effect of stress->mood;
  WPXtoM@0;             ! L2 G: No random stress slope variance->mood;
 [WPXtoY]   (WPXtoY);   ! L1 WP fixed effect of stress->symptoms;
  WPXtoY@0;             ! L2 G: No random stress slope variance->symptoms;
 [WPMtoY]   (WPMtoY);   ! L1 WP fixed effect of mood->symptoms;
  WPMtoY@0;             ! L2 G: No random mood slope variance->symptoms;

symptoms mood2 ON women ; ! BP total fixed effects women->mood, symptoms;
symptoms mood2 ON age80;  ! BP total fixed effects age->mood, symptoms;
symptoms mood2 ON agesex; ! BP total fixed effects age*women;

mood2    ON PMstr40(conXtoM); ! Context BP fixed effect stress->mood;
symptoms ON PMstr40(conXtoY); ! Context BP fixed effect stress->symptoms;
symptoms ON mood2  (conMtoY); ! Context BP effect of mood->symptoms;
```

```
!!! Getting BP total fixed effects and all indirect effects;
MODEL CONSTRAINT:
NEW(BPXtoM BPXtoY BPMtoY WPind Conind BPind);
! BP effects;
  BPXtoM = WPXtoM + conXtoM;  ! BP total effect stress->mood;
  BPXtoY = WPXtoY + conXtoY;  ! BP total effect stress->symptoms;
  BPMtoY = WPMtoY + conMtoY;  ! BP effect of mood->symptoms;
! Indirect effects;
  WPind =  WPXtoM*WPMtoY;     ! WP indirect effect;
  Conind = conXtoM*conMtoY;   ! BP contextual indirect effect;
  BPind =  BPXtoM*BPMtoY;     ! BP total indirect effect;
```

Note: MODEL INDIRECT is the usual way of obtaining indirect effects in Mplus, but is not available for multilevel models. So we are using MODEL CONSTRAINT to calculate the indirect effects ourselves to accomplish the same thing. Further, although one can get bootstrapped *p*-values and confidence intervals for single-level mediation models, they are not available for multilevel mediation models. That means the p-values from the indirect effects may be a little suspect, and other methods of assessing significance may be needed for "best practice" (see Kris Preacher's website for online tools for bootstrapping parameter estimates).

Mplus Multivariate Results:

```
MODEL FIT INFORMATION

Number of Free Parameters                       18

Loglikelihood
          H0 Value                        -864.198

Information Criteria
          Akaike (AIC)                    1764.396
          Bayesian (BIC)                  1840.580
          Sample-Size Adjusted BIC        1783.446
            (n* = (n + 2) / 24)
```

```
MODEL RESULTS

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

Within Level

 Residual Variances
    SYMPTOMS           0.612      0.043     14.184      0.000
    MOOD2              0.089      0.006     14.146      0.000

Between Level

 SYMPTOMS   ON
    WOMEN             -0.534      0.209     -2.553      0.011
    AGE80              0.070      0.033      2.121      0.034
    AGESEX            -0.094      0.036     -2.596      0.009
    PMSTR40            1.091      0.304      3.589      0.000
    MOOD2              1.852      0.606      3.058      0.002

 MOOD2      ON
    WOMEN              0.008      0.054      0.151      0.880
    AGE80              0.013      0.008      1.629      0.103
    AGESEX            -0.006      0.009     -0.628      0.530
    PMSTR40            0.124      0.079      1.561      0.119

 Means
    WPXTOM             0.162      0.036      4.486      0.000
    WPXTOY             0.085      0.097      0.872      0.383
    WPMTOY             0.141      0.131      1.077      0.281

 Intercepts
    SYMPTOMS           3.340      0.540      6.184      0.000
    MOOD2             -0.880      0.049    -17.879      0.000

 Variances
    WPXTOM             0.000      0.000    999.000    999.000
    WPXTOY             0.000      0.000    999.000    999.000
    WPMTOY             0.000      0.000    999.000    999.000

 Residual Variances
    SYMPTOMS           0.678      0.122      5.547      0.000
    MOOD2              0.040      0.008      4.802      0.000

New/Additional Parameters
    BPXTOM             0.286      0.070      4.063      0.000
    BPXTOY             1.175      0.289      4.067      0.000
    BPMTOY             1.993      0.576      3.459      0.001

    WPIND              0.023      0.022      1.048      0.295
    CONIND             0.229      0.164      1.393      0.164
    BPIND              0.570      0.217      2.630      0.009
```

Step 4: Same Model, Adding Mood*Sex Interactions → Symptoms

When I tried to estimate a latent variable interaction between level-2 observed variable women and level-2 random intercept mood2, Mplus insisted that was an observed variable interaction, which would instead be between original level-1 mood and women. So I had to create a work-around that involved renaming the mood random intercept:

```
( all previous commands are the same )

MODEL:   ! Full X Stress --> M Mood --> Y Symptoms Mediation Model + Mood*Sex
! Level-1, Within-Person (WP) Model;
%WITHIN%
  symptoms;                       ! L1 R: residual variance in symptoms;
  mood2;                          ! L1 R: residual variance in mood;
  WPXtoM | mood2    ON stress;    ! Placeholder L1 WP stress->mood;
  WPXtoY | symptoms ON stress;    ! Placeholder L1 WP stress->symptoms;
  WPMtoY | symptoms ON mood2;     ! Placeholder L1 WP mood->symptoms;

! Level-2, Person-Level Model;
%BETWEEN%
 [symptoms];           ! Fixed intercept for symptoms;
  symptoms;            ! L2 random intercept variance in symptoms;

 moodint BY mood2@1;   ! Rename mood random intercept as latent variable;
[moodint mood2@0];     ! Fixed intercept for moodint, not mood;
 moodint mood2@0;      ! L2 G: random intercept variance for moodint, not mood;
! Now moodint replaces mood2 everywhere in the syntax below;

 [WPXtoM]  (WPXtoM);   ! L1 WP fixed effect of stress->mood;
  WPXtoM@0;            ! L2 G: No random stress slope variance->mood;
 [WPXtoY]  (WPXtoY);   ! L1 WP fixed effect of stress->symptoms;
  WPXtoY@0;            ! L2 G: No random stress slope variance->symptoms;
 [WPMtoY]  (WPMtoY);   ! L1 WP fixed effect of mood->symptoms;
  WPMtoY@0;            ! L2 G: No random mood slope variance->symptoms;

symptoms moodint ON women;  ! BP total fixed effects women->mood, symptoms;
symptoms moodint ON age80;  ! BP total fixed effects age->mood, symptoms;
symptoms moodint ON agesex; ! BP total fixed effects age*women;

moodint  ON PMstr40(conXtoM);    ! Context BP fixed effect stress->mood;
symptoms ON PMstr40(conXtoY);    ! Context BP fixed effect stress->symptoms;
symptoms ON moodint  (conMtoY);  ! Context BP effect of mood->symptoms;

WPMtoY ON women    (WPMsexY);    ! Level-1 mood by sex->symptoms;
moodsex | women XWITH moodint;   ! Latent interaction of sex*context mood;
symptoms ON moodsex (conMsexY);  ! Context mood*sex->symptoms;

MODEL CONSTRAINT:
( all previous new effects stayed here )
NEW(BPMsexY);
    BPMsexY = WPMsexY + conMsexY;  ! BP mood*sex->symptoms;
```

Multivariate Mplus Results (a few minutes later): New effects are in bold

```
Number of Free Parameters                        20
Loglikelihood
          H0 Value                         -862.992

Information Criteria
          Akaike (AIC)                     1765.984
          Bayesian (BIC)                   1850.633
          Sample-Size Adjusted BIC         1787.150
            (n* = (n + 2) / 24)

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

 Residual Variances
    SYMPTOMS           0.611      0.043     14.191      0.000
    MOOD2              0.090      0.006     14.095      0.000

Between Level

 MOODINT  BY
    MOOD2              1.000      0.000    999.000    999.000

 MOODINT    ON
    WOMEN              0.006      0.054      0.119      0.905
    AGE80              0.014      0.008      1.706      0.088
    AGESEX            -0.006      0.009     -0.689      0.491
    PMSTR40            0.140      0.079      1.787      0.074

 WPMTOY     ON
    WOMEN              0.107      0.198      0.542      0.588

 SYMPTOMS   ON
    MOODINT            4.016      1.501      2.675      0.007
    MOODSEX           -2.394      1.531     -1.564      0.118

 SYMPTOMS   ON
    WOMEN             -2.529      1.325     -1.909      0.056
    AGE80              0.040      0.041      0.965      0.335
    AGESEX            -0.063      0.044     -1.422      0.155
    PMSTR40            0.987      0.310      3.180      0.001

 Means
    WPXTOM             0.156      0.036      4.309      0.000
    WPXTOY             0.085      0.097      0.881      0.378

 Intercepts
    SYMPTOMS           5.151      1.299      3.964      0.000
    MOOD2              0.000      0.000    999.000    999.000
    MOODINT           -0.876      0.049    -17.888      0.000
    WPMTOY             0.053      0.201      0.261      0.794

Variances
    WPXTOM             0.000      0.000    999.000    999.000
    WPXTOY             0.000      0.000    999.000    999.000

 Residual Variances
    SYMPTOMS           0.625      0.123      5.088      0.000
    MOOD2              0.000      0.000    999.000    999.000
    MOODINT            0.039      0.008      4.738      0.000
    WPMTOY             0.000      0.000    999.000    999.000

New/Additional Parameters
    BPXTOM             0.296      0.070      4.237      0.000
    BPXTOY             1.072      0.295      3.628      0.000
    BPMTOY             4.068      1.478      2.753      0.006
    WPIND              0.008      0.031      0.260      0.795
    CONIND             0.564      0.394      1.433      0.152
    BPIND              1.205      0.535      2.253      0.024
    BPMSEXY           -2.287      1.509     -1.516      0.130
```

Example Results Section for Steps 1 to 3:

The relationships among time-varying stressors (i.e., whether or not a stressor was reported on a given day), negative mood (constructed as the mean of five items), and physical symptoms (constructed as the sum of five reported symptoms) were examined using multivariate multilevel models (i.e., multilevel structural equation modeling) within Mplus v. 8 (Muthén & Muthén, 1998-2017) using maximum likelihood (ML) estimation. (We obtained an identical pattern of results using a robust ML estimator to account for potential non-normality and so the original ML results are reported below.) Two observed variables were used to partition the effect of binary daily stressors (0=no, 1=yes) into its contextual (level-2; incremental between-person) and within-person (level-1) effects, in which the level-2 predictor was created as the person mean of stressors centered at 40% of days ($PMstress_i - .40$) and the level-1 predictor was daily stressor variable. This same type of variance partitioning was accomplished within the model estimation for the continuous level-1 outcomes of negative mood and physical symptoms, such that random intercept variances were estimated for each at level 2, and residual variances were estimated for each at level 1. Under this specification, level-1 fixed effects indicate within-person effects, whereas level-2 fixed effects reflect contextual effects. Accordingly, MODEL CONSTRAINT command was used to obtain model-implied between-person effects and all indirect effects. Age, sex, and their interaction (with 80-year-old men as the reference group) were included as predictors in the level-2 model for both negative mood and physical symptoms. In addition, likelihood ratio revealed no significant random within-person direct effects in any of the models (all $-2\Delta LL(\sim 2) < 5.99$, $p > .05$), and so all within-person direct effects were fixed across persons. Although our eventual goal was to examine the extent to which negative mood mediated the between-person and within-person effects of stressors on physical symptoms, we began by estimating separate models for stress and mood each predicting symptoms before controlling for each effect for the other.

First, a univariate multilevel model of observed stressors predicting physical symptoms (X → Y) revealed significant positive contextual (1.335) and between-person (1.445) effects but no significant within-person effect. Thus, after controlling for age and sex but before controlling for negative mood, physical symptoms were higher on average for persons who experienced more stressor days than others (even after controlling for daily stressors), but physical symptoms on a given day were not related to whether a stressor was experienced that day. Second, a separate multivariate multilevel model of negative mood predicting physical symptoms (M → Y) revealed significant contextual (2.339) and between-person (2.506) effects but no significant within-person effect. Thus, after controlling for age and sex but before controlling for stressors, physical symptoms were higher on average for persons who reported higher negative mood than others (even after controlling for daily negative mood), but physical symptoms on a given day were not related to whether a negative mood was higher than usual that day. Thus, to summarize, significant direct effects were found between persons (at level 2) for both X → Y and M → Y, but no significant direct effects were found within persons.

Finally, the extent to which daily negative mood mediated the relationship between daily stressors and daily physical symptoms at each level was examined in a multilevel mediation model with all three variables, each specified as previously described. For comparable interpretation of the level-2 effects of stressors on mood and symptoms, level-2 effects of age, sex, and their interaction were added to predict negative mood (as well as symptoms, as before). Results are shown in Table X. At level 2, although there was a significant positive between-person effect (0.286) of observed stressors predicting negative mood (X → M), the corresponding contextual effect (0.124) was not significant, indicating that negative mood was not significantly higher in persons with more stressor days after controlling for daily stressors. In addition, the between-person effect of stressors on physical symptoms (X → Y) was significantly reduced (from 1.445 to 1.175) after controlling for the between-person effect of negative mood, as indicated by a significant between-person indirect effect of stressors on physical symptoms through negative mood. Likewise, the between-person effect of negative mood on physical symptoms (M → Y) was reduced (from 2.506 to 1.852) after controlling for stressors. Both between-person effects of stressors and negative mood predicting symptoms (and their contextual effects) remained uniquely significant. Thus, reporting more stressor days than others is related to reporting more physical symptoms than others (even after controlling for daily stressors), but this link did not result solely from a concomitant difference in negative mood. However, the contextual indirect effect was not significant, indicating that some of this mediation is reduced after controlling for daily stressors and daily negative mood. At level 1, there was a significant X → M within-person effect (0.162), indicating that greater stressors than usual on a given day did predict greater negative mood than usual that day. However, the within-person effect of stressors on physical symptoms (X → Y) was not significantly reduced (and was still not significant) after controlling for negative mood, as indicated by a nonsignificant within-person indirect effect of stressors on physical symptoms through negative mood. Thus, after controlling for people's general tendencies to do so, reporting a stressor did not predict reporting more physical symptoms that day. Finally, the within-person effect of negative mood on symptoms (M → Y) remained nonsignificant after controlling for stressors as well.