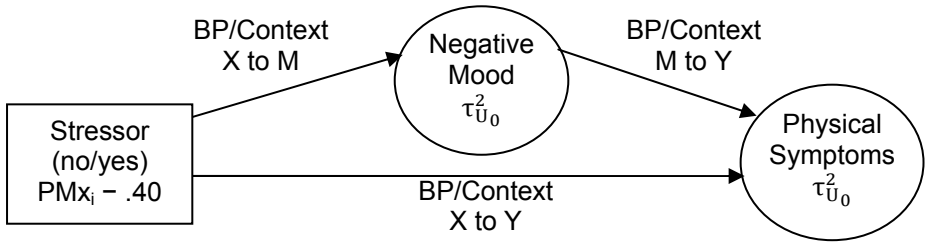
Mediation of Within-Person Fluctuation in SAS PROC MIXED vs. Mplus v. 7.11

Although multilevel models (MLM) with observed variables (such as in SAS MIXED) are useful for many things, they have some limitations that are addressed by moving to "multilevel structural equation models" (MSEM), such as in Mplus. The primary difference is that rather than obtaining separate between and within effects after adding observed variable predictors in MLM, in MSEM the between and within variances of any level-1 predictor can be partitioned into level-2 random intercept variances and level-1 residual variances directly within the model, the same as for the single DV in the usual MLM. So this is truly multivariate model in which a given variable can be both a predictor and an outcome simultaneously, as is necessary to do mediational analysis of direct and indirect effects. Here is our example from chapter 8 of fluctuation across 5 days for 105 older adults in stress, negative mood, and physical symptoms:

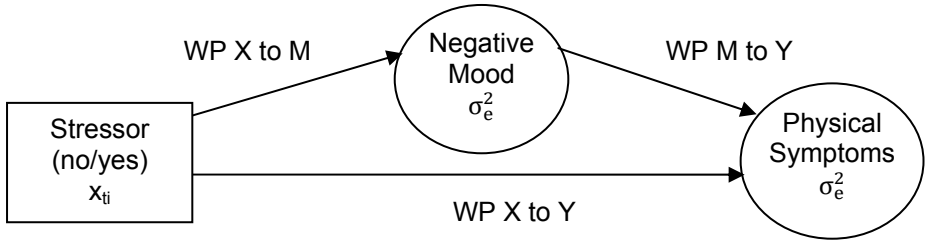
Level-2, Between-Person (BP) Model:



The level-2 effects will be the BP effects if the level-1 effect is specified directly as a fixed effect only, but the level-2 effects will be the contextual effect sotherwise.

The result from multiplying the X to M and M to Y paths is called the **indirect effect**. Because there are two levels of direct effects, there are two levels of indirect effects too.

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



So long as their level-2 variances are included in the model (as observed or latent variables), the level-1 effects will be the WP effects (unsmushed).

In treating predictors as outcomes (either by predicting them or just by letting the model partition their variance), their means and variances become part of the model likelihood. In this way, modeling predictors as outcomes in MSEM allows them to have **missing case-wise data**, because any case that has at least one of the "DVs" (now including the former "predictors") will still be included. This trick does not work as easily for categorical predictors, though, as Mplus has restrictions about those that limit how they can included. As a result, for now we will treat stressors as an observed variable that has been partitioned into its WP and contextual effects by including observed predictors for binary stressors at level 1 and its person mean (centered at .40) at level 2.

For the model- partitioned variables (e.g., negative mood here), if using the "direct" level-1 effect syntax, their level-2 effect will be a BP effect, but if using the level-1 placeholder syntax to create random slopes (regardless of whether their random slope variances are actually estimated!), then their level-2 effect will be a contextual effect instead. Based on the results from previous analyses for these data, the **WP effects in this example will be specified as fixed only** (the same results were obtained within MSEM as well).

However, MSEM is not a panacea for everything. It currently cannot readily be as readily expanded to include other sources of variance (e.g., crossed effects, three-level nested models) the way MLM can. And as we will see later, it is between cumbersome and impossible to estimate interactions among the model variables, which become **latent variable interactions** for which estimation is very complicated (i.e., requiring numeric integration). In addition, although MLM has been shown to have downwardly biased level-2 effects relative to MSEM, the level-2 effects from MSEM have greater inconsistency, especially when the level-2 sample size and the ICC are small. Finally, there is no REML within MSEM, so **all level-2 variances (and thus fixed effect SEs) may be downwardly biased** for small level-2 sample sizes. To make the models are comparable as possible, we are using ML for the corresponding SAS examples.

We will begin by examining each component of the overall model (X → M, X → Y, M → Y) and then examine the full mediation model and indirect effects.

Step 1: Fitting the Between-Person and Within-Person Stress (X) → Mood (M) Relationship

In SAS, decomposing stress into level-1 WP vs. level-2 contextual effects by brute force (observed variables):

```
TITLE1 "WP and Contextual Stress Predicting Mood: X --> M";
PROC MIXED DATA=example COVTEST NOCLPRINT NOITPRINT NOINFO
IC NAMELEN=50 METHOD=ML;
       CLASS ID;
       MODEL mood = female age80 female*age80
                    PMstress40 TVstress
             / SOLUTION DDFM=SATTERTHWAITE NOTEST;
       RANDOM INTERCEPT / TYPE=UN SUBJECT=ID;
       REPEATED / TYPE=VC SUBJECT=ID;
       ESTIMATE "Between Effect" TVstress 1 PMstress40 1;
RUN;



* How to export to .csv for use in Mplus;
PROC EXPORT DATA=work.ForMplus
       OUTFILE= "&filesave.\symptoms.csv"
       DBMS=CSV REPLACE; PUTNAMES=NO; RUN;
```

In Mplus, doing the same thing:

```
TITLE:  Predicting latent mood from OBSERVED stress  (X --> M);

DATA:    FILE = symptoms.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 symptom female age mood WPmood PMmood TVstres
              WPstres PMstres;
! List of ALL variables used in model (DEFINED variables at end);
    USEVARIABLES ARE mood female age TVstres PMstres agefem;
! Missing data codes (here, -999);
    MISSING ARE ALL (-999);
! Identify person-level nesting;
    CLUSTER = PersonID;
! Predictor variables with variation ONLY within-persons at level 1;
    WITHIN = TVstres;
! Predictor variables with variation ONLY between-persons at level 2;
    BETWEEN = age female agefem PMstres;


DEFINE:     agefem = age*female;    ! Creating level-2 interaction term;

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

MODEL:    !!!!! X Stress --> Y Symptoms Model;
! Level-1, time-level model;
%WITHIN%
        mood;                          ! Residual level-1 mood variance;
        WPXtoM | mood ON TVstres;      ! Level-1 effect of stress on mood;

! Level-2, person-level model;
%BETWEEN%
        mood;                           ! Random mood intercept variance;
        [mood];                         ! Fixed intercept for mood;
        [WPXtoM] (WPXtoM);              ! WP effect of stress on mood;
        WPXtoM@0;                       ! No random stress effect on mood;
        mood ON female (femtoM);        ! BP effect of female on mood;
        mood ON age    (agetoM);        ! BP effect of age on mood;
        mood ON agefem (agefemM);       ! BP effect of age*female on mood;
        mood ON PMstres(conXtoM);       ! Context effect of stress on mood;

 MODEL CONSTRAINT:                      ! Equivalent to ESTIMATE in SAS;
 NEW(BPstres);
 BPstres = WPXtoM + conXtoM;            ! BP effect of stress on mood;
```

SAS Results:

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	ID	0.04001	0.008296	4.82	<.0001
Residual	ID	0.08899	0.006282	14.17	<.0001

Information Criteria

Neg2LogLike	Parms	AIC	AICC	HQIC	BIC	CAIC
334.3	8	350.3	350.6	358.9	371.5	379.5

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	1.1174	0.04928	128	22.68	<.0001
female	0.01118	0.05435	105	0.21	0.8374
age80	0.01288	0.008360	110	1.54	0.1262
female*age80	-0.00525	0.009473	108	-0.55	0.5803
PMstress40	0.1244	0.07928	161	1.57	0.1187
TVstress	0.1613	0.03612	403	4.47	<.0001

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|
Between Effect	0.2857	0.07050	102	4.05	<.0001

Mplus Results: This is the same model…

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters	8
Loglikelihood	
H0 Value	-167.143
Information Criteria	
Akaike (AIC)	350.287
Bayesian (BIC)	384.146
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	358.753

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
Residual Variances				
MOOD	0.089	0.006	14.164	0.000
Between Level				
MOOD ON				
FEMALE	0.011	0.054	0.206	0.837
AGE	0.013	0.008	1.542	0.123
AGEFEM	-0.005	0.009	-0.555	0.579
PMSTRES	0.124	0.079	1.568	0.117
Means				
WPXTOM	0.161	0.036	4.464	0.000
Intercepts				
MOOD	1.117	0.049	22.689	0.000
Variances				
WPXTOM	0.000	0.000	999.000	999.000
Residual Variances				
MOOD	0.040	0.008	4.814	0.000
New/Additional Parameters				
BPSTRES	0.286	0.070	4.054	0.000

Step 2: Fitting the Between-Person and Within-Person Stress (X) → Symptoms (Y) Relationship

In SAS, decomposing stress into level-1 WP vs. level-2 contextual effects by brute force (observed variables):

```
TITLE1 "WP and Contextual Stress Predicting Symptoms:
        X --> Y";
PROC MIXED DATA=example COVTEST NOCLPRINT NOITPRINT NOINFO
IC NAMELEN=50 METHOD=ML;
       CLASS ID;
       MODEL symptom5 = female age80 female*age80
                        PMstress40 TVstress
              / SOLUTION DDFM=SATTERTHWAITE NOTEST;
       RANDOM INTERCEPT / TYPE=UN SUBJECT=ID;
       REPEATED / TYPE=VC SUBJECT=ID;
       ESTIMATE "Between Effect" TVstress 1 PMstress40 1;
RUN;
```

In Mplus, doing the same thing:

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

DATA:    FILE = symptoms.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 symptom female age mood WPmood PMmood TVstres
              WPstres PMstres;
! List of ALL variables used in model (DEFINED variables at end);
    USEVARIABLES ARE symptom female age TVstres PMstres agefem;
! Missing data codes (here, -999);
    MISSING ARE ALL (-999);
! Identify person-level nesting;
    CLUSTER = PersonID;
! Predictor variables with variation ONLY within-persons at level 1;
    WITHIN = TVstres;
! Predictor variables with variation ONLY between-persons at level 2;
    BETWEEN = age female agefem PMstres;


DEFINE:     agefem = age*female;     ! Creating level-2 interaction;

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

MODEL:    !!!!! X Stress --> Y Symptoms Model;
! Level-1, time-level model;
%WITHIN%
  symptom;                          ! Residual level-1 symptoms variance;
  WPXtoY | symptom ON TVstres;      ! Level-1 effect of stress on symptoms;

! Level-2, person-level model;
%BETWEEN%
  symptom;                          ! Random symptoms intercept variance;
  [symptom];                        ! Fixed intercept for symptoms;
  [WPXtoY]           (WPXtoY);      ! WP effect of stress on symptoms;
  WPXtoY@0;                         ! No random stress effect on symptoms;
  symptom ON female  (femtoY);      ! BP effect of female on symptoms;
  symptom ON age     (agetoY);      ! BP effect of age on symptoms;
  symptom ON agefem  (agefemY);     ! BP effect of age*female on symptoms;
  symptom ON PMstres (conXtoY);     ! Context effect of stress on symptoms;

 MODEL CONSTRAINT:                  ! Equivalent to ESTIMATE in SAS;
 NEW(BPstres);
 BPstres = WPXtoY + conXtoY;        ! BP effect of stress on symptoms;
```

SAS Results:

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	1.5828	0.1936	115	8.18	<.0001
female	-0.5149	0.2198	105	-2.34	0.0210
age80	0.09720	0.03353	108	2.90	0.0045
female*age80	-0.1069	0.03811	107	-2.81	0.0060
PMstress40	1.3367	0.3019	127	4.43	<.0001
TVstress	0.1100	0.09487	403	1.16	0.2469

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|
Between Effect	1.4468	0.2865	104	5.05	<.0001

Mplus Results: This is the same model…

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters	8
Loglikelihood	
H0 Value	-704.243
Information Criteria	
Akaike (AIC)	1424.486
Bayesian (BIC)	1458.346
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	1432.953

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
Residual Variances				
SYMPTOM	0.613	0.043	14.192	0.000
Between Level				
SYMPTOM ON				
FEMALE	-0.515	0.220	-2.342	0.019
AGE	0.097	0.034	2.898	0.004
AGEFEM	-0.107	0.038	-2.805	0.005
PMSTRES	1.337	0.302	4.428	0.000
Means				
WPXTOY	0.110	0.095	1.160	0.246
Intercepts				
SYMPTOM	1.583	0.194	8.176	0.000
Variances				
WPXTOY	0.000	0.000	999.000	999.000
Residual Variances				
SYMPTOM	0.838	0.134	6.233	0.000
New/Additional Parameters				
BPSTRES	1.447	0.286	5.050	0.000

Step 3: Fitting the Between-Person and Within-Person Mood (M) → Symptoms (Y) Relationship

In SAS, decomposing mood into level-1 WP vs. level-2 contextual effects by brute force (observed variables):

```
TITLE1 "TV and Contextual Mood Predicting Symptoms:
        M --> Y";
PROC MIXED DATA=example COVTEST NOCLPRINT NOITPRINT NOINFO
IC NAMELEN=50 METHOD=ML;
       CLASS ID;
       MODEL symptom5 = female age80 female*age80
                        PMmood2 TVmood2
              / SOLUTION DDFM=SATTERTHWAITE NOTEST;
       RANDOM INTERCEPT / TYPE=UN SUBJECT=ID;
       REPEATED / TYPE=VC SUBJECT=ID;
       ESTIMATE "Between Effect" TVmood2 1 PMmood2 1;
RUN;
```

In Mplus, decomposing mood into WP vs. Contextual in the MODEL:

```
TITLE:  Predicting latent symptoms from latent mood (so M --> Y);

DATA:    FILE = symptoms.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 symptom female age mood WPmood PMmood TVstres
              WPstres PMstres;
! List of ALL variables used in model (DEFINED variables must go at end);
    USEVARIABLES ARE symptom female age mood agefem;
! Missing data codes (here, -999);
    MISSING ARE ALL (-999);
! Identify person-level nesting;
    CLUSTER = PersonID;
! Predictor variables with variation ONLY within-persons at level 1;
    WITHIN = ;
! Predictor variables with variation ONLY between-persons at level 2;
    BETWEEN = age female agefem;

DEFINE:     agefem = age*female;     ! Creating level-2 interaction;

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

MODEL:    !!!!! X Stress --> Y Symptoms Model;
! Level-1, time-level model;
%WITHIN%
   symptom;                      ! Residual level-1 symptoms variance;
   mood;                         ! Residual level-1 mood variance;
   WPMtoY | symptom ON mood;     ! Level-1 effect of mood on symptoms;

! Level-2, person-level model;
%BETWEEN%
   symptom;                      ! Random symptoms intercept variance;
   mood;                         ! Random mood intercept variance;
   [symptom];                    ! Fixed intercept for symptoms;
   [mood];                       ! Fixed intercept for mood;
   [WPMtoY]          (WPMtoY);   ! WP effect of mood on symptoms;
   WPMtoY@0;                     ! No random effect of mood on symptoms;
   symptom ON female (femtoY);   ! BP effect of female on symptoms;
   symptom ON age    (agetoY);   ! BP effect of age on symptoms;
   symptom ON agefem (agefemY);  ! BP effect of age*female on symptoms;
   symptom ON mood   (conMtoY);  ! Context effect of mood on symptoms;

MODEL CONSTRAINT:                ! Equivalent to ESTIMATE in SAS;
NEW(BPmood);
BPmood = WPMtoY + conMtoY;       ! BP effect of mood on symptoms
```

SAS Results:

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	ID	0.8166	0.1314	6.21	<.0001
Residual	ID	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	1443.0	1451.0

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	3.2639	0.3460	106	9.43	<.0001
female	-0.5151	0.2174	105	-2.37	0.0197
age80	0.06690	0.03374	108	1.98	0.0499
female*age80	-0.09177	0.03785	107	-2.42	0.0170
PMmood2	1.8124	0.3910	132	4.63	<.0001
TVmood2	0.1591	0.1277	404	1.25	0.2136

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|
Between Effect	1.9715	0.3688	105	5.35	<.0001

Mplus Results: Although this is the same idea, this is NOT the same model, because mood is being treated like another DV (and so its mean and two variances are model parameters). This is advantageous in the event of missing data and because the level-2 effects have been corrected for WP unreliability.

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters	11

Loglikelihood

H0 Value	-890.817

Information Criteria

Akaike (AIC)	1803.635
Bayesian (BIC)	1850.192
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	1815.276

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
Variances				
MOOD	**0.093**	**0.007**	**14.157**	**0.000**
Residual Variances				
SYMPTOM	0.613	0.043	14.185	0.000
Between Level				
SYMPTOM ON				
FEMALE	-0.536	0.219	-2.445	0.014
AGE	0.074	0.034	2.167	0.030
AGEFEM	-0.098	0.038	-2.569	0.010
MOOD	2.341	0.558	4.199	0.000
Means				
MOOD	**1.205**	**0.026**	**46.159**	**0.000**
WPMTOY	0.167	0.128	1.303	0.193
Intercepts				
SYMPTOM	-1.307	0.666	-1.964	0.050
Variances				
MOOD	**0.052**	**0.010**	**5.175**	**0.000**
WPMTOY	0.000	0.000	999.000	999.000
Residual Variances				
SYMPTOM	0.754	0.140	5.404	0.000
New/Additional Parameters				
BPMOOD	2.508	0.530	4.730	0.000

Step 4: Fitting the Full Between-Person and Within-Person Stress (X) → Mood (M) → Symptoms (Y) Mediation Model

The full mediation model is not possible in SAS, but we can compare effects predicting symptoms (X, M → Y).

In SAS, partitioning stress and mood into level-1 WP vs. level-2 contextual effects by brute force (observed variables):

```
TITLE1 "GMC Mood and GMC Stressors Predicting Symptoms:
        X + M --> Y";
PROC MIXED DATA=example COVTEST NOCLPRINT NOITPRINT NOINFO IC
NAMELEN=50 METHOD=ML;
       CLASS ID;
       MODEL symptom5 = female age80 female*age80
                        PMmood2 TVmood2 PMstress40 TVstress
              / SOLUTION DDFM=SATTERTHWAITE NOTEST;
       RANDOM INTERCEPT / TYPE=UN SUBJECT=ID;
       REPEATED / TYPE=VC SUBJECT=ID;
ESTIMATE "Between Stress Effect" TVstress 1 PMstress40 1;
ESTIMATE "Between Mood Effect"   TVmood2 1 PMmood2 1;
RUN;
```

Mplus code, continued under %BETWEEN%:

```
mood    ON PMstres (conXtoM);  ! Context effect of stress on mood;
symptom ON PMstres (conXtoY);  ! Context effect of stress on symptoms;
symptom ON mood    (conMtoY);  ! Context effect of mood on symptoms;

!!! Getting BP effects and indirect effects at each level;
MODEL CONSTRAINT:
NEW(BPXtoM BPXtoY BPMtoY WPind Conind BPind);
! BP effects;
  BPXtoM = WPXtoM + conXtoM;        ! BP effect of stress on mood;
  BPXtoY = WPXtoY + conXtoY;        ! BP effect of stress on symptoms;
  BPMtoY = WPMtoY + conMtoY;        ! BP effect of mood on symptoms;
! Indirect effects;
  WPind = WPXtoM*WPMtoY;            ! WP indirect effect;
  Conind = conXtoM*conMtoY;         ! Context indirect effect;
  BPind = BPXtoM*BPMtoY;            ! BP 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 (see Kris Preacher's website for online tools to do so).

In Mplus, partitioning WP vs. contextual for stress by brute force, but for mood within the MODEL:

```
TITLE:  Full mediation model of Stress --> Mood --> Symptoms;
DATA:    FILE = symptoms.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 symptom female age mood WPmood PMmood TVstres
              WPstres PMstres;
! List of ALL variables used in model (DEFINED variables at end);
    USEVARIABLES ARE symptom female age mood TVstres PMstres agefem;
! Missing data codes (here, -999);
    MISSING ARE ALL (-999);
! Identify person-level nesting;
    CLUSTER = PersonID;
! Predictor variables with variation ONLY within-persons at level 1;
    WITHIN = TVstres;
! Predictor variables with variation ONLY between-persons at level 2;
    BETWEEN = age female agefem PMstres;

DEFINE:     agefem = age*female;     ! Creating level-2 interaction;
ANALYSIS:   TYPE IS TWOLEVEL RANDOM; ! 2-level model with random slopes;
            ESTIMATOR IS ML;         ! Can use MLR for non-normality;
MODEL:     !!!!! Stress --> Mood --> Symptoms Mediation Model;
! Level-1, time-level model;
%WITHIN%
   mood;                            ! Residual level-1 mood variance;
   symptom;                         ! Residual level-1 symptoms variance;
   WPXtoM | mood on TVstres;        ! Level-1 effect of stress on mood;
   WPXtoY | symptom ON TVstres;     ! Level-1 effect of stress on symptoms;
   WPMtoY | symptom ON mood;        ! Level-1 effect of mood on symptoms;

! Level-2, person-level model;
%BETWEEN%
   mood;                            ! Random mood intercept variance;
   symptom;                         ! Random symptoms intercept variance;
   [mood];                          ! Fixed intercept for mood;
   [symptom];                       ! Fixed intercept for symptoms;
   [WPXtoM]           (WPXtoM);     ! WP effect of stress on mood;
   WPXtoM@0;                        ! No random effect of stress on mood;
   [WPXtoY]           (WPXtoY);     ! WP effect of stress on symptoms;
   WPXtoY@0;                        ! No random stress effect on symptoms;
   [WPMtoY]           (WPMtoY);     ! WP effect of mood on symptoms;
   WPMtoY@0;                        ! No random effect of mood on symptoms;
   mood ON female     (femtoM);     ! BP effect of female on mood;
   mood ON age        (agetoM);     ! BP effect of age on mood;
   mood ON agefem     (agefemM);    ! BP effect of age*female on mood;
   symptom ON female  (femtoY);     ! BP effect of female on symptoms;
   symptom ON age     (agetoY);     ! BP effect of age on symptoms;
   symptom ON agefem  (agefemY);    ! BP effect of age*female on symptoms;
```

SAS Results: This is just X + M → Y

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	ID	0.7138	0.1172	6.09	<.0001
Residual	ID	0.6116	0.04310	14.19	<.0001

Information Criteria

Neg2LogLike	Parms	AIC	AICC	HQIC	BIC	CAIC
1392.8	10	1412.8	1413.3	1423.6	1439.4	1449.4

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	2.7813	0.3520	109	7.90	<.0001
female	-0.5094	0.2053	105	-2.48	0.0147
age80	0.07313	0.03194	108	2.29	0.0240
female*age80	-0.09388	0.03577	107	-2.62	0.0099
PMmood2	1.3435	0.3970	133	3.38	0.0009
TVmood2	0.1339	0.1305	404	1.03	0.3056
PMstress40	0.9443	0.3032	128	3.11	0.0023
TVstress	0.08555	0.09690	403	0.88	0.3779

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|
Between Stress Effect	1.0298	0.2875	104	3.58	0.0005
Between Mood Effect	1.4774	0.3743	105	3.95	0.0001

Mplus Results: This is a fuller model of X→ M → Y…

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters	18
Loglikelihood	
H0 Value	-864.265
Information Criteria	
Akaike (AIC)	1764.530
Bayesian (BIC)	1840.714
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	1783.580

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
Residual Variances				
SYMPTOM	0.612	0.043	14.184	0.000
MOOD	0.089	0.006	14.146	0.000
Between Level				
MOOD ON				
FEMALE	0.009	0.054	0.158	0.874
AGE	0.014	0.008	1.628	0.104
AGEFEM	-0.006	0.009	-0.633	0.526
PMSTRES	0.124	0.079	1.564	0.118
SYMPTOM ON				
FEMALE	-0.531	0.209	-2.540	0.011
AGE	0.070	0.033	2.113	0.035
AGEFEM	-0.095	0.037	-2.588	0.010
PMSTRES	1.092	0.304	3.591	0.000
MOOD	1.853	0.606	3.059	0.002
Means				
WPXTOM	0.162	0.036	4.486	0.000
WPXTOY	0.085	0.097	0.872	0.383
WPMTOY	0.141	0.131	1.078	0.281
Intercepts				
SYMPTOM	-0.650	0.672	-0.967	0.334
MOOD	1.120	0.049	22.769	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				
SYMPTOM	0.679	0.122	5.546	0.000
MOOD	0.040	0.008	4.802	0.000
New/Additional Parameters				
BPXTOM	0.286	0.070	4.066	0.000
BPXTOY	1.176	0.289	4.069	0.000
BPMTOY	1.994	0.576	3.460	0.001
WPIND	0.023	0.022	1.048	0.294
CONIND	0.229	0.164	1.395	0.163
BPIND	0.570	0.217	2.631	0.009

Step 5: Fitting the Full BP and WP Stress (X) → Mood (M) → Symptoms (Y) Mediation Model with Mood*Sex Interactions → Symptoms

The full mediation model is not possible in SAS, but we can compare effects predicting symptoms (X, M → Y).

In SAS, partitioning stress and mood into level-1 WP vs. level-2 contextual effects by brute force (observed variables):

```
TITLE1 "Add Sex Interactions of GMC Mood";
PROC MIXED DATA=example COVTEST NOCLPRINT NOITPRINT NOINFO
IC NAMELEN=50 METHOD=ML;
      CLASS ID;
      MODEL symptom5 = female age80 female*age80
                       PMmood2 TVmood2 PMstress40 TVstress
                       female*PMmood2 female*TVmood2
                    / SOLUTION DDFM=SATTERTHWAITE NOTEST;
      RANDOM INTERCEPT / TYPE=UN SUBJECT=ID;
      REPEATED / TYPE=VC SUBJECT=ID;
ESTIMATE "BP Female*Mood" female*PMmood2 1 female*TVmood2 1;
RUN;
```

Mplus code, continued under %BETWEEN%:

```
 moodint ON female  (femtoM);   ! BP effect of female on moodint;
 moodint ON age     (agetoM);   ! BP effect of age on moodint;
 moodint ON agefem  (agefemM);  ! BP effect of age*female on moodint;
 symptom ON female  (femtoY);   ! BP effect of female on symptoms;
 symptom ON age     (agetoY);   ! BP effect of age on symptoms;
 symptom ON agefem  (agefemY);  ! BP effect of age*female on symptoms;
 moodint ON PMstres (conXtoM);  ! Context effect of stress on moodint;
 symptom ON PMstres (conXtoY);  ! Context effect of stress on symptoms;
 symptom ON moodint (conMtoY);  ! Context effect of moodint on symptoms;
 WPMtoY ON female   (WPfemmo);  ! Level-1 mood by sex on symptoms;

! Latent interaction of sex*context mood;
   femmood2 | female XWITH moodint;

! L2 effect of latent sex*mood on symptoms;
  symptom ON femmood2 (confemmo);

!!! Getting BP interaction;
MODEL CONSTRAINT:
NEW(BPfemmo);
  BPfemmo = WPfemmo + confemmo;  ! BP effect of female*mood on symptoms;
```

In Mplus, partitioning WP vs. contextual for stress by brute force, but for mood within the MODEL:

```
TITLE:  Full model of Stress --> Mood --> Symptoms with Mood by Sex;
DATA:    FILE = symptoms.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 symptom female age mood WPmood PMmood TVstres
              WPstres PMstres;
! List of ALL variables used in model (DEFINED variables at end);
    USEVARIABLES ARE symptom female age mood TVstres PMstres agefem;
! Missing data codes (here, -999);
    MISSING ARE ALL (-999);
! Identify person-level nesting;
    CLUSTER = PersonID;
! Predictor variables with variation ONLY within-persons at level 1;
    WITHIN = TVstres;
! Predictor variables with variation ONLY between-persons at level 2;
    BETWEEN = age female agefem PMstres;

DEFINE:     agefem = age*female;     ! Creating level-2 interaction;

ANALYSIS:   TYPE IS TWOLEVEL RANDOM; ! 2-level model with random slopes;
            ESTIMATOR IS ML;         ! Can use MLR for non-normality;
  ALGORITHM=INTEGRATION;   ! Numeric integration for latent interactions

MODEL:
!!!!! Stress --> Mood --> Symptoms Mediation Model;
! Level-1, time-level model;
%WITHIN%
   mood;                          ! Residual level-1 mood variance;
   symptom;                       ! Residual level-1 symptoms variance;
   WPXtoM | mood on TVstres;      ! Level-1 effect of stress on mood;
   WPXtoY | symptom ON TVstres;   ! Level-1 effect of stress on symptoms;
   WPMtoY | symptom ON mood;      ! Level-1 effect of mood on symptoms;

! Level-2, person-level model;
%BETWEEN%
   moodint BY mood@1;       ! Create latent variable for mood random int;
   mood@0;                  ! Random mood intercept variance shut off;
   symptom;                 ! Random symptoms intercept variance;
   [moodint mood@0];        ! Fixed intercept for moodint, not mood;
   [symptom];               ! Fixed intercept for symptoms;
   [WPXtoM] (WPXtoM);       ! WP effect of stress on mood;
   WPXtoM@0;                ! No random effect of stress on mood;
   [WPXtoY] (WPXtoY);       ! WP effect of stress on symptoms;
   WPXtoY@0;                ! No random effect of stress on symptoms;
   [WPMtoY] (WPMtoY);       ! WP effect of mood on symptoms;
   WPMtoY@0;                ! No random effect of mood on symptoms;
```

SAS Results:

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	ID	0.6973	0.1147	6.08	<.0001
Residual	ID	0.6098	0.04295	14.20	<.0001

Information Criteria

Neg2LogLike	Parms	AIC	AICC	HQIC	BIC	CAIC
1389.5	12	1413.5	1414.2	1426.4	1445.4	1457.4

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	3.6789	0.7037	109	5.23	<.0001
female	-1.5836	0.7555	107	-2.10	0.0384
age80	0.05343	0.03411	106	1.57	0.1202
female*age80	-0.07259	0.03803	106	-1.91	0.0590
PMmood2	2.7277	0.8927	126	3.06	0.0027
TVmood2	-0.1123	0.2713	407	-0.41	0.6792
PMstress40	0.9194	0.3010	129	3.05	0.0027
TVstress	0.08414	0.09678	404	0.87	0.3852
female*PMmood2	-1.6829	0.9650	129	-1.74	0.0836
female*TVmood2	0.3206	0.3066	406	1.05	0.2963

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|
Between Female by Mood	-1.3622	0.9204	107	-1.48	0.1418

Mplus Results:

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters	20
Loglikelihood	
H0 Value	-862.851
Information Criteria	
Akaike (AIC)	1765.703
Bayesian (BIC)	1850.351
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	1786.869

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
Residual Variances				
SYMPTOM	0.610	0.043	14.194	0.000
MOOD	0.089	0.006	14.121	0.000
Between Level				
MOODINT BY				
MOOD	1.000	0.000	999.000	999.000
MOODINT ON				
FEMALE	0.007	0.054	0.129	0.897
AGE	0.014	0.008	1.697	0.090
AGEFEM	-0.006	0.009	-0.689	0.491
PMSTRES	0.141	0.079	1.787	0.074
WPMTOY ON				
FEMALE	0.200	0.197	1.013	0.311
SYMPTOM ON				
MOODINT	3.809	1.463	2.604	0.009
FEMMOOD2	-2.238	1.499	-1.493	0.135
SYMPTOM ON				
FEMALE	1.759	1.688	1.042	0.297
AGE	0.044	0.041	1.073	0.283
AGEFEM	-0.067	0.044	-1.520	0.128
PMSTRES	1.001	0.310	3.233	0.001
Means				
WPXTOM	0.155	0.036	4.297	0.000
WPXTOY	0.084	0.097	0.870	0.384
Intercepts				
SYMPTOM	-2.672	1.641	-1.629	0.103
MOOD	0.000	0.000	999.000	999.000
MOODINT	1.123	0.049	22.896	0.000
WPMTOY	-0.016	0.201	-0.079	0.937
Variances				
WPXTOM	0.000	0.000	999.000	999.000
WPXTOY	0.000	0.000	999.000	999.000
Residual Variances				
SYMPTOM	0.631	0.123	5.119	0.000
MOOD	0.000	0.000	999.000	999.000
MOODINT	0.039	0.008	4.773	0.000
WPMTOY	0.000	0.000	999.000	999.000
New/Additional Parameters				
BPFEMMO	-2.038	1.476	-1.381	0.167

Example Results Section for Steps 1 to 4:

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 multilevel structural equation modeling within Mplus v. 7.11 (Muthén & Muthén, 1998-2012) under maximum likelihood (ML). 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 was used to partition the effect of dichotomous daily stressors 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 model-based instead 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.The MODEL CONSTRAINT command was used to obtain model-implied between-person effects and 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 a series of models to examine each of the relevant direct effects in isolation before evaluating their unique effects.

First, a multilevel model of stressors predicting negative mood (X → M) revealed a significant positive within-person effect, such that negative mood was higher on days in which a stressor was experienced (after controlling for proportion of stressor days). Although there was also a significant between-person effect, such that negative mood was higher on average for persons who experienced more stressor days than others, this effect became nonsignificant after controlling for daily stressors (e.g., a nonsignificant contextual effect). Second, a separate multilevel model of stressors predicting physical symptoms (X → Y) revealed a significant positive contextual and between-person effects but no significant within-person effect. Thus, 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. Third, a separate multilevel model of negative mood predicting physical symptoms (M → Y) revealed significant contextual and between-person effects but no significant within-person effect. Thus, 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 all three paths, (although the X → M path for the contextual effect was no longer significant after controlling for daily stressors), but significant direct effects were found within persons (at level 1) only for X → M.

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. Results are shown in Table 1. At level 2, the between-person effect of stressors on physical symptoms was significantly reduced 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; however, both between-person effects of stressors and negative mood on symptoms (and their contextual effects) were still 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 does not result solely from a concomitant difference in negative mood. 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, the within-person effect of stressors on physical symptoms was not significantly reduced (and 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 does not predict reporting more physical symptoms that day, although it does predict greater negative mood than usual that day.