Examining Lagged Effects of Stress in Predicting Psoriasis Severity

These data come from a study of weekly fluctuation in psoriasis severity, as also featured in Example 4. The goal of these analyses is to examine how weekly fluctuations in psoriasis severity may be predicted by weekly fluctuation in stress, and at what time lag these effects might be observed.

SAS Data Setup for Lags:

```
* Location for original SPSS portable multivariate file for these models;
LIBNAME import SPSS "F:\Example Data\p2mult.por";
DATA work.p2stack; SET import.p2mult;
      * Calculating person mean for time-varying predictor;
      pmStress = MEAN(of lesneg1-lesneg8); LABEL pmStress = "Person-Mean Stress";
      * Stacking data;
            Week=1; severity=sapasi1; stress=lesneg1; OUTPUT;
            Week=2; severity=sapasi2; stress=lesneg2; OUTPUT;
            Week=3; severity=sapasi3; stress=lesneg3; OUTPUT;
            Week=4; severity=sapasi4; stress=lesneg4; OUTPUT;
            Week=5; severity=sapasi5; stress=lesneg5; OUTPUT;
            Week=6; severity=sapasi6; stress=lesneg6; OUTPUT;
            Week=7; severity=sapasi7; stress=lesneg7; OUTPUT;
            Week=8; severity=sapasi8; stress=lesneg8; OUTPUT;
      LABEL    week = "Week of Study"  severity = "Psoriasis Severity"
            stress = "Weekly Stress"; RUN; %LET datafile=p2stack;

* Creating predictors for analysis;
DATA p2stack; SET p2stack; WHERE NMISS(severity, stress)=0; * Selecting complete cases;
* Creating person mean(between-person) indicator for LES;
      PMstress2 = pmStress - 2; LABEL PMstress2 = "Between-Person Stress (0=2)";
* Person-centering stress to be a level 1 predictor;
      WPstress = stress - pmStress; LABEL WPstress = "Within-Person Stress (0=person mean)";
* Nothing new needed for lag=0;
      WPstressLag0 = WPstress; LABEL WPstressLag0= "Within-Person Stress Lag=0";
* New values for each lag get transferred only if the row is for the same subid;
      IDlag1 = lag1(subid); WPstressLag1 = lag1(WPstress);
            IF subid=IDlag1 THEN WPstressLag1 = WPstressLag1; ELSE WPstressLag1= .;
            LABEL WPstresslag1= "Within-Person Stress Lag=1";
      IDlag2 = lag2(subid); WPstressLag2 = lag2(WPstress);
            IF subid=IDlag2 THEN WPstressLag2 = WPstressLag2; ELSE WPstressLag2= .;
            LABEL WPstressLag2= "Within-Person Stress Lag=2"; run;
```

Example of Data File after Lagging:

subid	Week	severity	pmStress	PMstress2	stress	WPstress	WPstressLag0	IDlag1	WPstressLag1	IDlag2	WPstressLag2
100	1	1.93	0.60	-1.40	0.00	-0.60	-0.60	.	.	.	.
100	2	2.00	0.60	-1.40	0.00	-0.60	-0.60	100	-0.60	.	.
100	3	1.85	0.60	-1.40	1.10	0.50	0.50	100	-0.60	100	-0.60
100	4	1.68	0.60	-1.40	0.69	0.09	0.09	100	0.50	100	-0.60
100	5	1.82	0.60	-1.40	0.00	-0.60	-0.60	100	0.09	100	0.50
100	6	0.00	0.60	-1.40	1.39	0.79	0.79	100	-0.60	100	0.09
100	7	1.47	0.60	-1.40	1.61	1.01	1.01	100	0.79	100	-0.60
100	8	0.66	0.60	-1.40	0.00	-0.60	-0.60	**100**	1.01	100	0.79
101	1	2.10	0.45	-1.55	0.69	0.24	0.24	**100**	.	**100**	.
101	2	1.70	0.45	-1.55	1.10	0.64	0.64	101	0.24	**100**	.
101	3	1.50	0.45	-1.55	0.00	-0.45	-0.45	101	0.64	101	0.24
101	4	2.00	0.45	-1.55	0.00	-0.45	-0.45	101	-0.45	101	0.64
101	5	1.42	0.45	-1.55	0.00	-0.45	-0.45	101	-0.45	101	-0.45
101	6	1.26	0.45	-1.55	0.00	-0.45	-0.45	101	-0.45	101	-0.45
101	7	0.98	0.45	-1.55	1.39	0.93	0.93	101	-0.45	101	-0.45
101	8	.	0.45	-1.55	.	.	.	101	0.93	101	-0.45

1a) Empty Means, Random Intercept Model for Severity (DV)

```
TITLE 'Empty Means, Random Intercept Model for Severity Outcome';
PROC MIXED DATA=&datafile. COVTEST NOCLPRINT NAMELEN=100 METHOD=REML;
      CLASS subid week;
      MODEL severity = / SOLUTION DDFM=Satterthwaite;
      RANDOM INTERCEPT / VCORR TYPE=UN SUBJECT=subid;
      REPEATED week / TYPE=VC SUBJECT=subid; RUN;
```

Level 1: $\text{Severity}_{ti} = \beta_{0i} + e_i$
Level 2: $\beta_{0i} = \gamma_{00} + U_{0i}$

```
                  Covariance Parameter Estimates
                              Standard      Z
Cov Parm    Subject   Estimate    Error    Value      Pr Z
UN(1,1)     SUBID      0.6667    0.08782     7.59     <.0001
week        SUBID      0.1318    0.006780   19.44     <.0001
```

ICC for Severity:
$.6667 / (.6667 + .1318) = .83$
Houston, we may have a problem

1b) Empty Model for Stress (Time-Varying Predictor)

```
TITLE 'Empty Means, Random Intercept Model for Stress TV Predictor';
PROC MIXED DATA=&datafile. COVTEST NOCLPRINT NAMELEN=100 METHOD=REML;
      CLASS subid week;
      MODEL stress = / SOLUTION DDFM=Satterthwaite;
      RANDOM INTERCEPT / VCORR TYPE=UN SUBJECT=subid;
      REPEATED week / TYPE=VC SUBJECT=subid; RUN;
```

Level 1: $\text{Stress}_{ti} = \beta_{0i} + e_i$
Level 2: $\beta_{0i} = \gamma_{00} + U_{0i}$

```
                  Covariance Parameter Estimates
                              Standard      Z
Cov Parm    Subject   Estimate    Error    Value      Pr Z
UN(1,1)     SUBID      0.3562    0.05102     6.98     <.0001
week        SUBID      0.2519    0.01298    19.41     <.0001
```

ICC for Stress:
$.3562 / (.3562 + .2519) = .56$
At least stress is time-varying!

Our best-fitting unconditional model for time (as found in Example 4) included a random intercept variance in the **G** matrix and a lag-3 correlation with heterogeneous residual variances in the **R** matrix. We now add fixed effects of predictors to that model.

Level 1: $\text{Severity}_{ti} = \beta_{0i} + e_{ti}$
Level 2: $\beta_{0i} = \gamma_{00} + \gamma_{01}\left(\overline{\text{Stress}_i} - 2\right) + U_{0i}$

2) Predicting Severity from Between-Person Effect of Stress

```
TITLE "SAS: BP Effect of Stress";
PROC MIXED DATA=&datafile. COVTEST NOCLPRINT NAMELEN=100 METHOD=REML;
      CLASS subid week;
      MODEL severity = PMstress2 / SOLUTION DDFM=Satterthwaite;
      RANDOM INTERCEPT / TYPE=UN SUBJECT=subid;
      REPEATED week / TYPE=TOEPH(4) SUBJECT=subid; RUN;
```

```
         Dimensions
Subjects                    124
Max Obs Per Subject           8

        Number of Observations
Number of Observations Read          880
Number of Observations Used          880
Number of Observations Not Used        0
```

Interpret each fixed effect:

```
              Solution for Fixed Effects
                    Standard
Effect      Estimate    Error     DF    t Value    Pr > |t|
Intercept    1.9464    0.1272    123     15.31      <.0001
PMstress2    0.4572    0.1097    123      4.17      <.0001
```

3a) Predicting Severity from Between- and Within-Person (Simultaneous) Effects of Stress

$$\text{Level 1: Severity}_{ti} = \beta_{0i} + \beta_{1i}\left(\text{Lag0Stress}_{ti} - \overline{\text{Stress}_i}\right) + e_{ti}$$

$$\text{Level 2: Intercept: } \beta_{0i} = \gamma_{00} + \gamma_{01}\left(\overline{\text{Stress}_i} - 2\right) + U_{0i}$$

$$\text{Lag-0 WP Stress: } \beta_{1i} = \gamma_{10}$$

```
TITLE "Add WP Effect of Stress at 0-Week Lag";
PROC MIXED DATA=&datafile. COVTEST NOCLPRINT NAMELEN=100 METHOD=REML;
     CLASS subid week;
     MODEL severity = PMstress2 WPstressLag0 / SOLUTION DDFM=Satterthwaite;
     RANDOM INTERCEPT / TYPE=UN SUBJECT=subid;
     REPEATED week / TYPE=TOEPH(4) SUBJECT=subid; RUN;
```

```
          Dimensions
Subjects                    124
Max Obs Per Subject           8
```

Note: 8 observations per person are used here.

```
        Number of Observations
Number of Observations Used          880
Number of Observations Not Used        0
```

Interpret the effect of WPstressLag0:

```
               Solution for Fixed Effects
                    Standard
Effect        Estimate      Error     DF   t Value   Pr > |t|
Intercept       1.9463     0.1272    123     15.30    <.0001
PMstress2       0.4572     0.1097    123      4.17    <.0001
WPstressLag0   -0.00720    0.02348   680     -0.31    0.7591
```

3b) Predicting Severity from Between- and Within-Person (+1-Week Lag) Effects of Stress

$$\text{Level 1: Severity}_{ti} = \beta_{0i} + \beta_{1i}\left(\text{Lag0Stress}_{ti} - \overline{\text{Stress}_i}\right) + \beta_{2i}\left(\text{Lag1Stress}_{ti} - \overline{\text{Stress}_i}\right) + e_{ti}$$

$$\text{Level 2: Intercept: } \beta_{0i} = \gamma_{00} + \gamma_{01}\left(\overline{\text{Stress}_i} - 2\right) + U_{0i}$$

$$\text{Lag-0 WP Stress: } \beta_{1i} = \gamma_{10}$$

$$\text{Lag-1 WP Stress: } \beta_{2i} = \gamma_{20}$$

```
TITLE "Add WP Effect of Stress at 1-Week Lag";
PROC MIXED DATA=&datafile. COVTEST NOCLPRINT NAMELEN=100 METHOD=REML;
     CLASS subid week;
     MODEL severity = PMstress2 WPstressLag0 WPstressLag1
               / SOLUTION DDFM=Satterthwaite;
     RANDOM INTERCEPT / TYPE=UN SUBJECT=subid;
     REPEATED week / TYPE=TOEPH(4) SUBJECT=subid; RUN;
```

```
          Dimensions
Subjects                    122
Max Obs Per Subject           7
```

Note the change in number of observations used: only 7 occasions per person in adding a 1-week lag within-person predictor. Estimating models on different samples means we cannot compare variance components (e.g., compute pseudo-R^2) or do any kind of LRT for change in model fit.

```
        Number of Observations
Number of Observations Used          756
Number of Observations Not Used      124
```

```
                  Solution for Fixed Effects
                        Standard
Effect          Estimate      Error      DF    t Value    Pr > |t|
Intercept         1.9649     0.1307     121      15.04      <.0001
PMstress2         0.4833     0.1132     121       4.27      <.0001
WPstressLag0      0.01976    0.02662    557       0.74      0.4582
WPstressLag1      0.05919    0.02509    545       2.36      0.0187
```

Interpret the effect of WPstressLag1:

Calculated predicted values in excel worksheet to plot these effects:

Predicted Psoriasis Severity By Stress Level
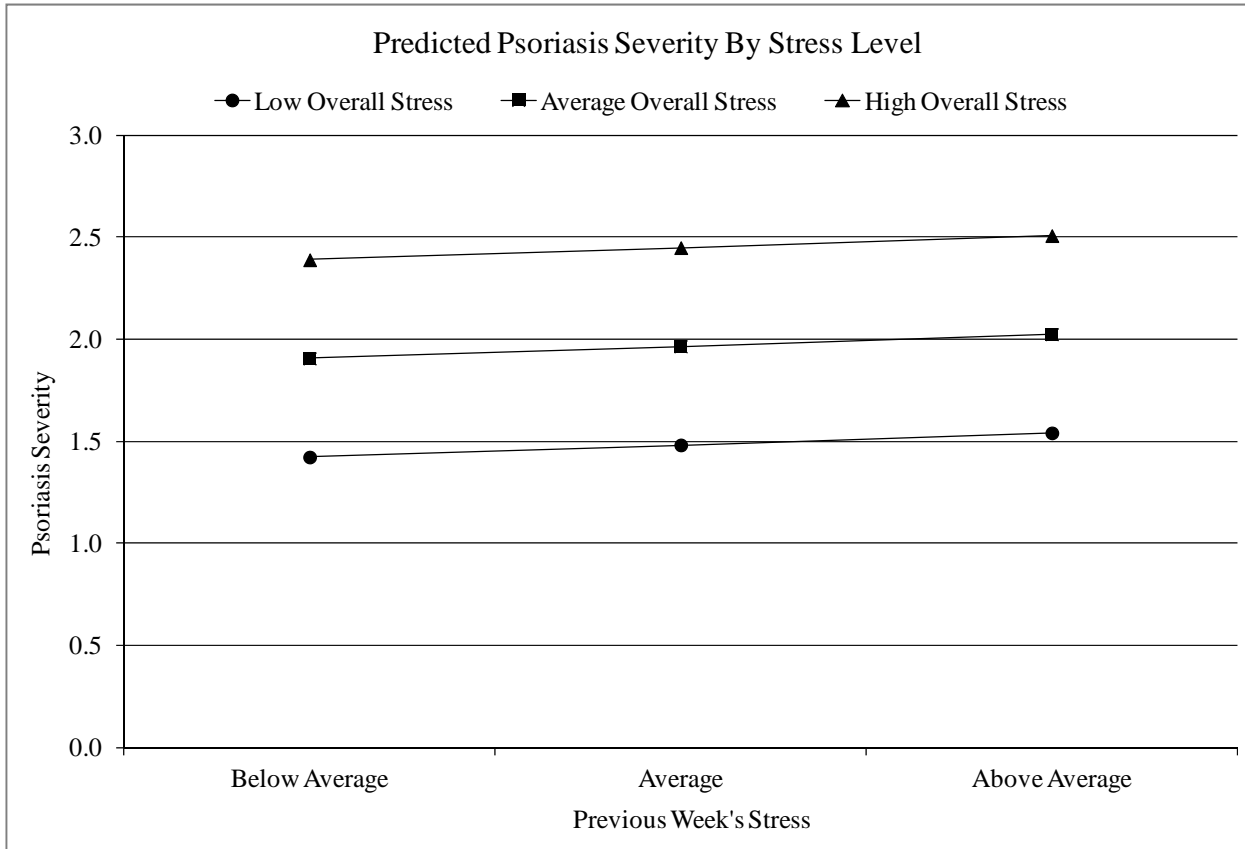
3b) Predicting Severity from Between- and Within-Person (+2-Week Lag) Effects of Stress

$$\text{Level 1: Severity}_{ti} = \beta_{0i} + \beta_{1i}\left(\text{Lag0Stress}_{ti} - \overline{\text{Stress}_i}\right) + \beta_{2i}\left(\text{Lag1Stress}_{ti} - \overline{\text{Stress}_i}\right)$$
$$+ \beta_{3i}\left(\text{Lag2Stress}_{ti} - \overline{\text{Stress}_i}\right) + e_{ti}$$

$$\text{Level 2: Intercept: } \beta_{0i} = \gamma_{00} + \gamma_{01}\left(\overline{\text{Stress}_i} - 2\right) + U_{0i}$$

$$\text{Lag-0 WP Stress: } \beta_{1i} = \gamma_{10}$$
$$\text{Lag-1 WP Stress: } \beta_{2i} = \gamma_{20}$$
$$\text{Lag-2 WP Stress: } \beta_{3i} = \gamma_{30}$$

```
TITLE "Add WP Effect of Stress at 2-Week Lag";
PROC MIXED DATA=&datafile. COVTEST NOCLPRINT NAMELEN=100 METHOD=REML;
     CLASS subid week;
     MODEL severity = PMstress2 WPstressLag0 WPstressLag1 WPstressLag2
               / SOLUTION DDFM=Satterthwaite;
     RANDOM INTERCEPT / TYPE=UN SUBJECT=subid;
     REPEATED week / TYPE=TOEPH(4) SUBJECT=subid; RUN;
```

```
        Dimensions
Subjects                    119
Max Obs Per Subject           6

        Number of Observations
Number of Observations Used          634
Number of Observations Not Used      246
```

Note the change in number of observations used: only 6 occasions per person in adding a 2-week lag within-person predictor.

```
              Solution for Fixed Effects
                    Standard
Effect        Estimate    Error     DF   t Value   Pr > |t|
Intercept       1.9295    0.1397    116    13.81     <.0001
PMstress2       0.4771    0.1199    117     3.98     0.0001
WPstressLag0   0.01772    0.03117   475     0.57     0.5699
WPstressLag1   0.08317    0.02946   380     2.82     0.0050
WPstressLag2   0.04163    0.03089   489     1.35     0.1785
```

4) Examining Fixed Effects under Alternative Models for the Variances (Listed in Order of Fit)

Unstructured R:

```
Fit Statistics
-2 Res Log Likelihood    875.6
AIC (smaller is better)  931.6
AICC (smaller is better) 933.8
BIC (smaller is better)  010.1
```

```
                Solution for Fixed Effects
                        Standard
Effect        Estimate    Error     DF    t Value   Pr > |t|
Intercept       1.9860    0.1274    120     15.59    <.0001
PMstress2       0.4723    0.1107    122      4.27    <.0001
WPstressLag0   0.02335    0.02603   529      0.90    0.3701
WPstressLag1   0.06751    0.02418   494      2.79    0.0054
```

Random Intercept + 3-Lag Heterogeneous Toeplitz R:

```
Fit Statistics
-2 Res Log Likelihood    895.6
AIC (smaller is better)  917.6
AICC (smaller is better) 918.0
BIC (smaller is better)  948.5
```

```
                Solution for Fixed Effects
                        Standard
Effect        Estimate    Error     DF    t Value   Pr > |t|
Intercept       1.9649    0.1307    121     15.04    <.0001
PMstress2       0.4833    0.1132    121      4.27    <.0001
WPstressLag0   0.01976    0.02662   557      0.74    0.4582
WPstressLag1   0.05919    0.02509   545      2.36    0.0187
```

AR(1) in R only:

```
Fit Statistics
-2 Res Log Likelihood    970.9
AIC (smaller is better)  974.9
AICC (smaller is better) 975.0
BIC (smaller is better)  980.6
```

```
                Solution for Fixed Effects
                        Standard
Effect        Estimate    Error     DF    t Value   Pr > |t|
Intercept       1.9868    0.1218    131     16.31    <.0001
PMstress2       0.4828    0.1055    132      4.57    <.0001
WPstressLag0   0.03198    0.02866   613      1.12    0.2650
WPstressLag1   0.05776    0.02726   614      2.12    0.0345
```

Random Intercept Only (CS):

```
Fit Statistics
-2 Res Log Likelihood    1028.2
AIC (smaller is better)  1032.2
AICC (smaller is better) 1032.2
BIC (smaller is better)  1037.8
```

```
                Solution for Fixed Effects
                        Standard
Effect        Estimate    Error     DF    t Value   Pr > |t|
Intercept       1.9522    0.1307    122     14.94    <.0001
PMstress2       0.4872    0.1131    122      4.31    <.0001
WPstressLag0   0.04558    0.02926   633      1.56    0.1199
WPstressLag1   0.05712    0.02831   632      2.02    0.0440
```

Residual Variance Only (VC):

```
Fit Statistics
-2 Res Log Likelihood    1883.4
AIC (smaller is better)  1885.4
AICC (smaller is better) 1885.4
BIC (smaller is better)  1888.2
```

```
                Solution for Fixed Effects
                        Standard
Effect        Estimate    Error     DF    t Value   Pr > |t|
Intercept       1.9259    0.05754   752     33.47    <.0001
BPstress2       0.4842    0.04999   752      9.69    <.0001
WPstressLag0   0.006840   0.06633   752      0.10    0.9179
WPstressLag1   0.06815    0.06450   752      1.06    0.2911
```