

## 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 of CLDP 944. 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 "C:\Dropbox\Archive\Example Data\Psoiriasis\p2stress.por";
DATA work.p2stack; SET import.p2stress;
  * 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;

* Creating BP/WP predictors for analysis;
DATA work.p2stack; SET work.p2stack;
* Selecting complete cases;
  WHERE NMISS(severity, stress)=0;
* Creating between-person indicator for LES;
  BPstress2 = pmStress - 2; LABEL BPstress2 = "Between-Person Stress (0=2)";
* Person-centering stress to be a level 1 predictor;
  WPstressLag0 = stress - pmStress; LABEL WPstressLag0 = "Within-Person Stress Lag=0";
RUN;
* Creating lagged variables;
PROC EXPAND DATA=work.p2stack OUT=work.p2lag;
  BY subid;
  ID week;          * Old = new name;
  CONVERT WPstressLag0=WPstressLag1 / METHOD=NONE TRANSFORMOUT=(LAG 1);
  CONVERT WPstressLag0=WPstressLag2 / METHOD=NONE TRANSFORMOUT=(LAG 2); RUN;
```

### Example of Data File after Lagging:

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

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

```
TITLE 'Empty Means, Random Intercept Model for Severity Outcome';
PROC MIXED DATA=work.p2lag 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;
```

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

#### Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z 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= work.p2lag 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;
```

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

#### Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z 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 of CLDP 944) 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.

### 2) Predicting Severity from Between-Person Effect of Stress

```
TITLE "SAS: BP Effect of Stress";
PROC MIXED DATA= work.p2lag 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;
```

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

#### 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

#### Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr >  t
Intercept	1.9464	0.1272	123	15.31	<.0001
PMstress2	0.4572	0.1097	123	4.17	<.0001

Interpret each fixed effect:

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

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

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

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

```
TITLE "Add WP Effect of Stress at 0-Week Lag";
PROC MIXED DATA= work.p2lag 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

Solution for Fixed Effects					
Effect	Estimate	Standard 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

Interpret the effect of WPstressLag0:

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

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

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

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

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

```
TITLE "Add WP Effect of Stress at 1-Week Lag";
PROC MIXED DATA= work.p2lag 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

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

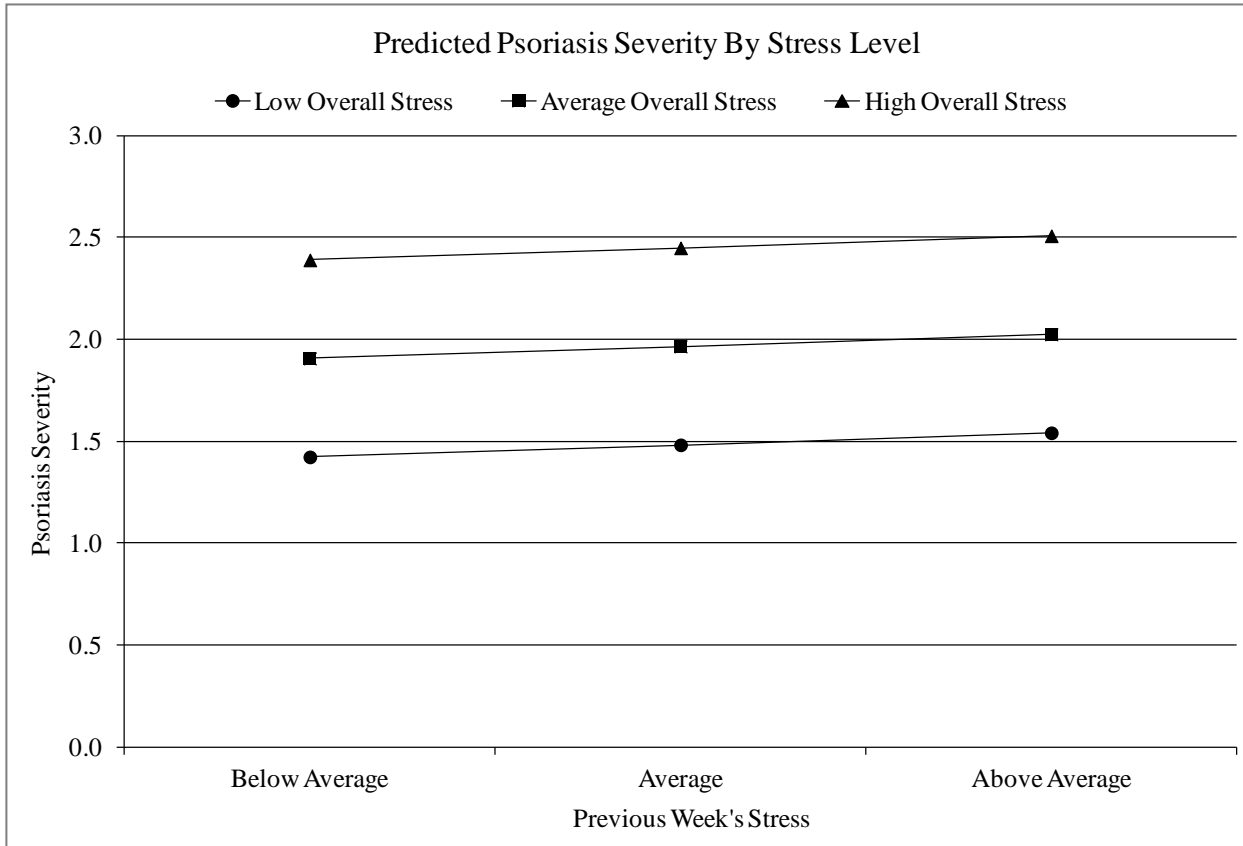
Note the change in number of observations used: only 7 occasions per person in adding a 1-week lag within-person predictor. Estimating models on different samples means we cannot compare variance components (e.g., compute pseudo-R<sup>2</sup>) or do any kind of LRT for change in model fit.

## Solution for Fixed Effects

Effect	Estimate	Standard 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
<b>WPstressLag1</b>	<b>0.05919</b>	<b>0.02509</b>	<b>545</b>	<b>2.36</b>	<b>0.0187</b>

Interpret the effect of WPstressLag1:

Calculated predicted values in excel worksheet to plot these effects:



### 3b) Predicting Severity from Between- and Within-Person (+2-Week Lag) Effects of Stress

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

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

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

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

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

```

TITLE "Add WP Effect of Stress at 2-Week Lag";
PROC MIXED DATA= work.p2lag 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

Effect	Estimate	Standard 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)

<b>Unstructured R:</b> 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 <table> <thead> <tr> <th>Effect</th> <th>Estimate</th> <th>Standard Error</th> <th>DF</th> <th>t Value</th> <th>Pr &gt;  t </th> </tr> </thead> <tbody> <tr> <td>Intercept</td> <td>1.9860</td> <td>0.1274</td> <td>120</td> <td>15.59</td> <td>&lt;.0001</td> </tr> <tr> <td>PMstress2</td> <td>0.4723</td> <td>0.1107</td> <td>122</td> <td>4.27</td> <td>&lt;.0001</td> </tr> <tr> <td>WPstressLag0</td> <td>0.02335</td> <td>0.02603</td> <td>529</td> <td>0.90</td> <td>0.3701</td> </tr> <tr> <td><b>WPstressLag1</b></td> <td><b>0.06751</b></td> <td><b>0.02418</b></td> <td><b>494</b></td> <td><b>2.79</b></td> <td><b>0.0054</b></td> </tr> </tbody> </table>	Effect	Estimate	Standard 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	<b>WPstressLag1</b>	<b>0.06751</b>	<b>0.02418</b>	<b>494</b>	<b>2.79</b>	<b>0.0054</b>
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<b>Residual Variance Only (VC):</b> 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 <table> <thead> <tr> <th>Effect</th> <th>Estimate</th> <th>Standard Error</th> <th>DF</th> <th>t Value</th> <th>Pr &gt;  t </th> </tr> </thead> <tbody> <tr> <td>Intercept</td> <td>1.9259</td> <td>0.05754</td> <td>752</td> <td>33.47</td> <td>&lt;.0001</td> </tr> <tr> <td>BPstress2</td> <td>0.4842</td> <td>0.04999</td> <td>752</td> <td>9.69</td> <td>&lt;.0001</td> </tr> <tr> <td>WPstressLag0</td> <td>0.006840</td> <td>0.06633</td> <td>752</td> <td>0.10</td> <td>0.9179</td> </tr> <tr> <td><b>WPstressLag1</b></td> <td><b>0.06815</b></td> <td><b>0.06450</b></td> <td><b>752</b></td> <td><b>1.06</b></td> <td><b>0.2911</b></td> </tr> </tbody> </table>	Effect	Estimate	Standard 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	<b>WPstressLag1</b>	<b>0.06815</b>	<b>0.06450</b>	<b>752</b>	<b>1.06</b>	<b>0.2911</b>
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