Bolger, N., & Laurenceau, J.-P. (2013). Intensive Longitudinal Methods: An Introduction to Diary and Experience Sampling Research. New York: Guilford.

In summary, the major hypothesis to be tested is whether females in the treatment group showed greater increases in intimacy over time than did females in the control group.

METHOD

Participants

Fifty opposite-sex couples were randomized to treatment (*n* = 25) and control (*n* = 25) conditions. The mean age of male partners was 32.4 years (*SD* = 4.6). The mean age of female partners was 30.8 years (*SD* = 3.4). All couples were homogeneous in terms of race. The racial breakdown in order of size was white (*n* = 32, 64%), Asian (*n* = 8, 16%), Hispanic (*n* = 6, 12%), and black (*n* = 4, 8%). Although couples were recruited into the study, in this paper we focus on the data for the female partners only.

Measures

Intimacy (female). The six-item Reis and Shaver Intimacy Scale was used (Reis & Shaver, 1988). Raw scores were rescaled to a 0–10 interval, such that 0 was the lowest possible score and 10 was the highest possible score. Summary statistics for wives' intimacy over couples and time were: *M* = 3.5, *SD* = 1.6, range = 0–10.

Time. The 16 weeks of 1-hour therapy sessions were scaled such that 0 was the value for week 1 and 1 was the value for week 16, with the intervening 14 weeks spaced equally across the 0 to 1 interval. This scaling of time implies that a linear slope for time estimates the total change in intimacy over the complete therapeutic period.

Procedure

Heterosexual couples were recruited from a marital therapy clinic in a large Midwestern city. The standard therapy for distressed couples was a 1-hour session each week for 16 consecutive weeks. Couples seeking treatment were randomly assigned to a treatment group that received therapy immediately, or to a control group that remained on a waiting list over the same 16-week period. All couples completed web-based questionnaires once per week. In the case of the treatment group, the reports were obtained on the evening prior to the day of each therapy session. Analyses were conducted on data from wives only.

RESULTS

Descriptive Statistics

The analysis dataset consisted of 50 (couples) * 16 (weeks) = 800 observations. Inspection of person-by-person scatterplots indicated that the within-person change in intimacy over time was approximately linear. The plots did not reveal any outliers, and there were no missing data.

Multilevel Model of Intimacy Change

We specified and estimated a linear growth model for intimacy that allowed each wife to have her own initial level of intimacy and rate of change in intimacy. Because couples were randomized to treatment and control conditions, we hypothesized no group differences in average initial levels of intimacy. We predicted that both groups would show an increase in intimacy over the course of the study. Our key hypothesis was that wives in the treatment group would show a steeper rate of change in intimacy compared to those in the control group.

The results are presented in Table 1 and in Figures 1 and 2. Table

Table 1. Parameter Estimates for Linear Growth Model of Female Intimacy as a Function of Intervention Group

Fixed effects (intercept, slopes)	Estimate (*SE*)	$t(48)$	p^a	CI_{95} Lower	CI_{95} Upper
Intercept (level at week 1)	2.90 (0.21)	14.00	<.001	2.48	3.32
Time[b]	0.74 (0.35)	2.12	.039	0.04	1.43
Group[c]	–0.06 (0.29)	–0.19	.848	–0.65	0.53
Group by time	0.92 (0.49)	1.88	.067	–0.07	1.91
Random effects ([co-]variances)	**Estimate (*SE*)**	z	p	CI_{95}^d Lower	CI_{95}^d Upper
Level 2 (between-person)					
Intercept	0.69 (0.22)	3.10	.001	0.40	1.46
Time	1.89 (0.62)	3.04	.001	1.09	4.09
Intercept and time	–0.52 (0.31)	–1.69	.092	–1.12	0.08
Level 1 (within-person)					
Residual	1.69 (0.09)	18.37	<.001	1.53	1.89
Autocorrelation	0.00 (0.04)	0.00	.999	–0.08	0.08

Note. $N = 50$.

[a]All p-values are two-tailed except in the case of variances, where one-tailed p-values are used (because variances are constrained to be non-negative).

[b]Time is coded 0 = week 1, 1 = week 16, with equal intervals for the intervening weeks.

[c]Group is coded 0 for the control group and 1 for the treatment group.

[d]Confidence intervals for variances were computed using the Satterthwaite method (see Littell, Milliken, Stroup, Wolfinger, and Schabenberger, 2006).

1 has two sets of parameter estimates. The first set, the fixed effects, can be thought of as the results for typical persons in the control and treatment groups, respectively. These fixed effects are represented by the heavy dark lines in Figure 1. The second set of effect estimates in Table 1 are the random effects. These describe variability at two levels of analysis: At the upper level they are the extent to which people vary from their group averages, and at the lower level they are the extent to which individual data points vary from the values predicted by the model. The upper-level random effects are represented in Figure 1 by the variability in individual regression lines from the group averages. The lower-level random effects are shown in Figure 2, which consists

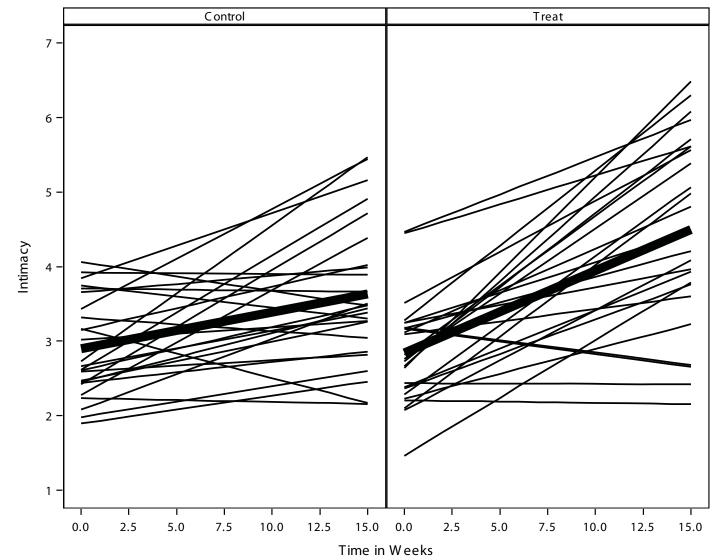

Figure 1. Spaghetti plot of average (thick) and subject-specific (thin) time courses for control (left) and treatment (right) groups.

of the raw data and fitted lines for a selection of five individuals from each group (about which, more details are to come).

The heavy black lines in Figure 1 show the central findings of the study, that the typical wife in the treatment group, who had similar levels of intimacy to the typical wife in the control group in week 1, showed a steeper rate of change and had a markedly higher level of intimacy by the end of the study at week 16. Of course, these graphical patterns do not necessarily imply that the results are statistically significant using standard criteria. We now turn to tests of significance on these fixed effects, listed in Table 1.

Recall that the control group was coded 0 and the treatment group, 1, and that time was coded 0 for week 1 and 1 for week 16, with equal intervals for the intervening weeks. Therefore, the model parameter

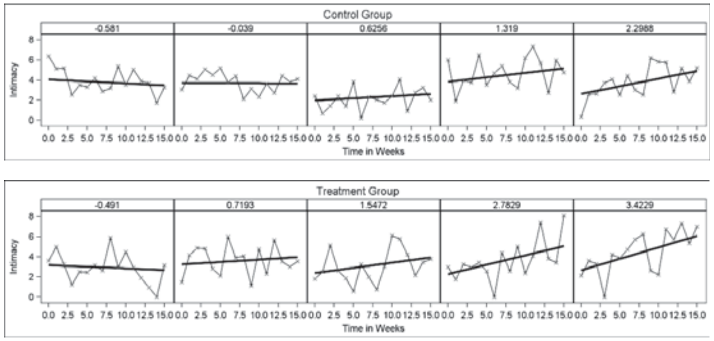

Figure 2. Raw and fitted time course for participants at the 5th, 25th, 50th, 75th, and 95th slope percentiles for the control (upper panel) and treatment (lower panel) groups.

estimates in Table 1 have the following interpretation: (1) the intercept is the level of intimacy at week 1 for the control group, (2) the group estimate is the intimacy difference (treatment minus control) at week 1, (3) the time estimate is the change in intimacy in the control group over the 16 weeks of the study, and (4) the time-by-group interaction is the difference in intimacy change between the treatment and control groups.

As we expected, and consistent with successful random assignment, there was no group difference in initial intimacy: Both groups showed an initial level of approximately 2.9 units on a 0–10 scale (control = 2.9; treatment = 2.90 + (–0.06) = 2.8). Over the 16 weeks of data collection, the control group showed a 0.7 unit increase in intimacy, whereas the treatment group showed a 0.74 + 0.92 = 1.6 unit increase in intimacy. The 0.9 unit slope difference due to group had a marginal *p*-value of .067. Its 95% confidence interval ranged from –0.1 to 1.9. Thus, although the best estimate of typical change in the treatment group change is that it is more than twice that of the control group, the uncertainty in the estimate does not allow us to rule out the possibility that the true difference is zero.

One reason for the uncertainty about differences in these typical patterns is that the between-persons random effects are substantial. The variability of the thin dark lines around their respective thick dark lines in Figure 1 is one way of illustrating this variability. These are model-based estimates of true growth patterns for the 50 individuals in the sample. The lower panel of Table 1 shows numerical values of the random effect parameters for the population. We can see that the variances for both intercept and rate of change are large relative to their standard errors, indicating that within the treatment and control groups there is substantial between-persons heterogeneity. The intercept variance, 0.69, corresponds to an *SD* of $\sqrt{0.69} = 0.8$, which indicates that 95% of the population vary between ±1.6 units of the typical intercept for their group. The predictions for the sample shown in Figure 1 broadly show this pattern. The slope variance is 1.89, which corresponds to an *SD* of $\sqrt{1.89} = 1.4$, which indicates that 95% of the population vary between ±2.8 units of the typical slope for its group. Again, the between-persons variability in the sample-predicted slopes in Figure 1 is consistent with these numbers.

To better understand the size of this heterogeneity for rates of change, it is useful to calculate how much overlap in the population it implies between distributions of the control and treatment groups (Cohen, 1988). With mean rates of change of 0.7 and 1.6 units, respectively, and a common *SD* of $\sqrt{1.89} = 1.4$ units, there is a 60% overlap between the distributions of the control and treatment groups. At the same time, there is appreciable between-groups separation: The patterns of means and standard deviations imply that 75% of persons in the treatment group had rates of change greater than the average for the control group (see Cohen, 1988, p. 22, for a table of these overlap values).

The second major reason for the uncertainty in the estimates of typical patterns is that the level-1 random effects (i.e., residuals from the level-1 fitted values) are large. Figure 2 shows examples of the fitted values and residuals at level 1 for five selected individuals in each group. Our choices were intended to show the range of slope estimates within and between each group. To do this, we first ordered the persons in each group by their slope magnitude and then chose persons corresponding approximately to the 5th, 25th, 50th, 75th, and 95th percentiles in each group. Notice that although there is a lot of variability in intimacy from week to week, a linear pattern of change is a reasonable summary of the data. Table 1 reports the population variance of the residuals from the fitted line as 1.69, which corresponds to an *SD* of $\sqrt{1.69} = 1.3$ units, and this, assuming that the residuals are normally distributed, implies that 95% of observed residuals should lie between ±2.6 units of their fitted values. The observed residuals in the selected participants are broadly consistent with this summary estimate. Finally, we note from the estimate reported at the bottom of Table 1 that there is no evidence of autocorrelation in the level-1 residuals.

4.4 CHAPTER SUMMARY

This completes the first and most basic empirical chapter of the book. Using as an example an intervention study with weekly diary assessments, we have illustrated how the time course of intensive longitudinal data can be displayed and analyzed. We believe an initial focus on the time course, with graphical displays for each subject, is desirable, whether or not the goal of the design is to model time trends. As we will see in the next chapter, even when time is not a focus, it remains an essential feature of the analysis model.