Mixed-ANOVA & Multilevel Modeling

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Project

▶ The scientific question is to see whether web-based positive psychology interventions (PPIs) create greater increases in happiness and reductions in depression than a placebo control group.

▶ In other words, can these PPIs make subjects (: more than a control group?

Why Did I Study This?

- I will be going to graduate school this fall for a masters in sports psych.
- I wanted to be able to understand the statistical methods used in psych studies.
- Multi-level modeling and mixed-ANOVA methods are commonly used in psych.

Basics of the Study

▶ 4 PPIs: gratitude visit, 3 good things in life, using signiature strengths and early memories(placebo).

▶ Subjects complete the depression inventory, CES-D, and the hapiness inventory, AHI, on 6 occasions

▶ pretest < 1 week PPI (not an occasion) < postest < 1-week follow-up < 1-month follow-up < 3 month follow-up < 6 month follow-up

▶ 295 subjects with significant attrition occured. Only 74 subjects completed the requirements for all 6 occassions. This plays a role into how the analysis is conducted.

Mixed-Design ANOVA

- ANOVA doesn't handle missing data well thus only the 74 subjects who completed all measures are used.
- Within-subjects is when multiple measures of the same variable from the same subjects are taken over multiple time periods.
- Between-subjects is when each subject experiences only one of the interventions.
- Mixed ANOVA is the blend of within and between subjects design.
- "It tests for mean differences between two or more indepedent groups while subjecting subjects to repeated measures."
- 4 x 6 (Intervention x Occasion) mixed-ANOVA design is used.

Visulation by Boxplot

Happiness Scores Over Time

Continued

Depression Scores Over Time
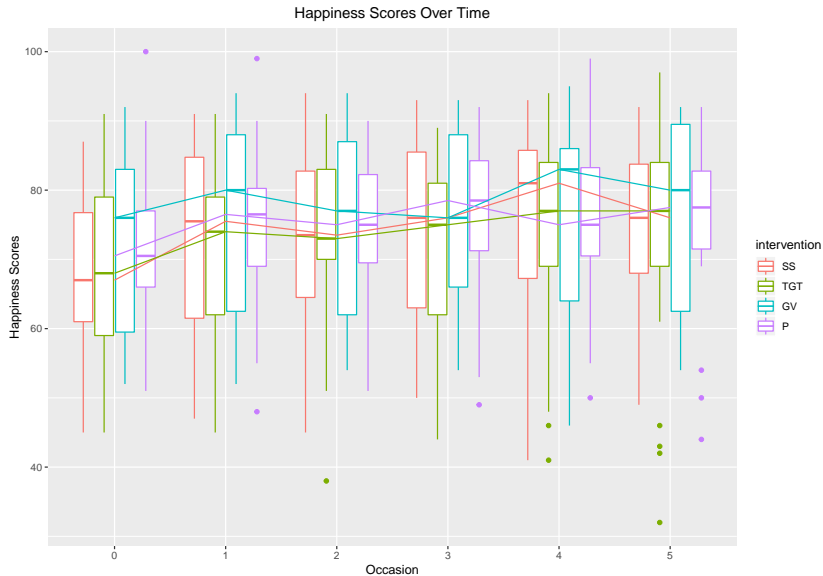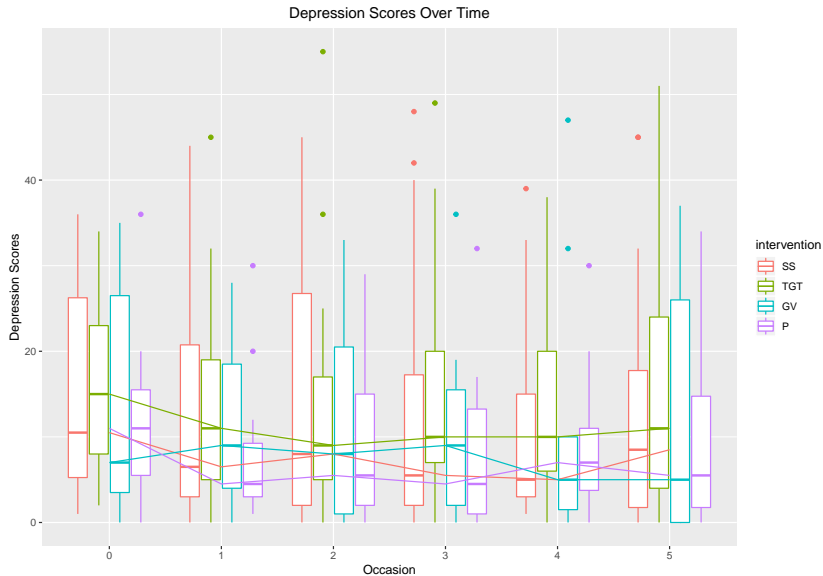
Check Assumptions for Both Depression & Happiness scores

- ▶ Check for outliers
- ▶ Normality assessed by Shapiro-Wilks test
- ▶ Visual by QQ-plots
- ▶ Homogneity of variance assumption
- ▶ Homogeneity of covariances assumption
- ▶ Sphericity

Computation

```
## ANOVA Table (type III tests)
##
##                     Effect DFn    DFd         SSn      SSd        F
## 1              (Intercept) 1.00  70.00 2185215.229 63992.38 2390.364
## 2             intervention 3.00  70.00     715.034 63992.38    0.261
## 3                 occasion 3.75 262.53     909.655 13162.35    4.838
## 4 intervention:occasion 11.25 262.53     277.994 13162.35    0.493
##          p p<.05   ges
## 1 7.54e-56     * 0.966
## 2 8.53e-01       0.009
## 3 1.00e-03     * 0.012
## 4 9.10e-01       0.004
```

▶ This computation comes from the lme4 package and the main functions used are anova_test and get_anova_table.

▶ We see that only occasion (time) is significant while the intervention and the interaction term are not significant.

Multilevel Modeling

Benefits
- ▶ Has advantages over mixed-ANOVA
- ▶ Can handle missing data points
- ▶ Treats time as a continuous variable as days elapsed

Model Composition

- ▶ From the boxplots we see that both depression and happy scores do not follow a linear trajectory over the entirety of the study.
- ▶ They are linear from the pretest to the 1-week follow-up and from the 1 month to 6 month follow-up. Thus there are two separate time periods being used.
- ▶ Fitted linear splines with random intercepts and random slopes and using a spline knot between the 1-week and 1-month follow-up.
- ▶ T1 is overal time that elapsed from pretest to each subsequent measure.
- ▶ T2 is time between the spline knot and a subject completing each later measure.

Continued

- This is a two level model
- Below is level one

$$Y_{i,j} = \pi_{0,i} + \pi_{1,i} T1_{i,j} + \pi_{2,i} T2_{i,j} + \epsilon_{i,j}$$

- Below is level two

$$\pi_{0,i} = \gamma_{0,0} + \gamma_{0,1} Intervention_i + \epsilon_{0,i}$$

$$\pi_{1,i} = \gamma_{1,0} + \gamma_{1,1} Intervention_i + \epsilon_{1,i}$$

$$\pi_{2,i} = \gamma_{2,0} + \gamma_{2,1} Intervention_i + \epsilon_{2,i}$$

Happy Score Computation

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: ahiTotal ~ (T1 + T2) * intervention + (T1 + T2 | id)
##    Data: ahi_cesd_lme
##
## REML criterion at convergence: 7222.4
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.3763 -0.3492  0.0112  0.3597  4.2449
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  id       (Intercept) 188.05552 13.7133
##           T1            0.09068  0.3011  -0.09
##           T2            0.10589  0.3254   0.06 -0.98
##  Residual              25.00987  5.0010
## Number of obs: 992, groups: id, 295
##
## Fixed effects:
##                     Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)         68.61666    1.70899  213.82720  40.150  < 2e-16 ***
## T1                   0.21785    0.06747  192.38991   3.229  0.00146 **
## T2                  -0.20197    0.07423  187.90362  -2.721  0.00712 **
## interventionTGT      0.50665    2.38217  212.81561   0.213  0.83178
## interventionGV       1.77433    2.40236  214.55807   0.739  0.46097
## interventionP        3.20057    2.40632  212.98020   1.330  0.18492
## T1:interventionTGT  -0.04528    0.08955  187.72087  -0.506  0.61366
## T1:interventionGV   -0.05727    0.09662  199.06057  -0.593  0.55403
## T1:interventionP    -0.03173    0.09202  194.40888  -0.345  0.73057
## T2:interventionTGT   0.03386    0.09827  183.89367   0.345  0.73079
## T2:interventionGV    0.04108    0.10657  195.86715   0.386  0.70028
## T2:interventionP     0.02406    0.10098  190.09837   0.238  0.81193
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

Sad Score Computation

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: cesdTotal ~ (T1 + T2) * intervention + (T1 + T2 | id)
##    Data: ahi_cesd_lme
##
## REML criterion at convergence: 7054.5
##
## Scaled residuals:
##    Min     1Q  Median     3Q     Max
## -3.0167 -0.3942 -0.0889  0.3065  4.7278
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  id       (Intercept) 108.67598 10.4248
##           T1            0.04762  0.2182  -0.20
##           T2            0.06127  0.2475   0.16 -0.98
##  Residual              28.42234  5.3313
## Number of obs: 992, groups: id, 295
##
## Fixed effects:
##                     Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)        15.085692   1.363321 242.159751  11.065   <2e-16 ***
## T1                 -0.141279   0.060816 187.323026  -2.323   0.0212 *
## T2                  0.142858   0.068176 182.102944   2.095   0.0375 *
## interventionTGT     1.046639   1.898700 240.212510   0.551   0.5820
## interventionGV      0.901638   1.917747 243.716590   0.470   0.6387
## interventionP      -2.534105   1.918079 240.468041  -1.321   0.1877
## T1:interventionTGT -0.047291   0.080752 181.950876  -0.586   0.5588
## T1:interventionGV   0.005566   0.087282 197.273619   0.064   0.9492
## T1:interventionP   -0.026539   0.083214 189.055515  -0.319   0.7501
## T2:interventionTGT  0.068034   0.090297 177.720380   0.753   0.4522
## T2:interventionGV  -0.008355   0.098044 192.882543  -0.085   0.9322
## T2:interventionP    0.034390   0.093032 184.048462   0.370   0.7121
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

Reference

Woodworth, R., O'Brien-Malone, A., Diamond, M., Schuz, B. (2017). Web-based positive psychology interventions: a reexamination of effectiveness. *Journal of Clinical Psychology*, 73(3), 218-232.