**Assignment 4: Linear Mixed Effects Modelling**

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PSYR-6003: Fundamentals of Applied Statistics and Research Design

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In the current study, a sample of *n*=334 people were asked to fill out a daily questionnaire over the course of 20 days, measuring several variables regarding personality ratings and satisfaction of life. Our study aims to examine the effects of extraversion and neuroticism on life satisfaction over the observation period. We predicted that 1) extraversion would be positively associated with satisfaction with life, 2) neuroticism would be negatively associated with satisfaction with life, 3) the effects will be similar both within participants and between participants (level 1 v. level 2). Data management and analyses were conducted via R version 4.3.2 (2023) using “tidyverse” (Wickham et al., 2019), “flexplot” (Fife, 2024), “haven” (Wickham et al., 2023), “lme4” (Bates et al., 2015), “lmerTest” (Kuznetsova et al., 2017), “performance” (Ludecke et al., 2021), and “apaTables” packages (Stanley, 2021).

**Data Analytic Plan**

To determine the effects of neuroticism and extraversion on overall life satisfaction, our research team constructed a linear mixed effects model under the principles of general linear model comparison to establish trends within participants across the span of several weeks. Models will be clustered by participant ID and denote changes by study objectives. A sensitivity analysis will be run to determine if our model violates assumptions of normality, linearity, and homoskedasticity; if assumptions are violated, our team will construct statistical corrections (i.e., robust errors model) to correct said violations.

Prior to constructing the linear mixed effects model, our team will create a base model and calculate the intraclass correlation (ICC) to determine the proportion of variability influenced by the clustering effects. Then, a nested model comparison methodology will be used for comparing the use of fixed or random slopes to our variables of extraversion and neuroticism. A model comparison test will be conducted via the model.comparison() function within R to produce a Bayes factor for determination of whether a fixed or random slope fits better according to the model. As we are using a nested model comparison method, we will be using maximum likelihood estimation, which allows for the comparison of random and fixed effects. After selecting random and fixed effects for both objective variables, estimates, standard deviations, and confidence intervals will be collected for each parameter within the model. Furthermore, the model’s *R2* values (conditional and marginal) will also be reported.

Our model equation is Satisfaction = *b0 + b1*(Extraversion | ID) *+ b2*(Neuroticism | ID) *+ error*. R syntax and code will be available to view via GitHub at the following repository: “PSYR6003-Assignment-4” for further information regarding construction of our model (<https://github.com/CoolbyPrice/PSYR6003-Assignment-4.git>).

**Descriptive Statistics and Bivariate Correlations**

Means, standard deviations, and correlation coefficients of satisfaction, extraversion, and neuroticism are described in Table 1. Satisfaction was an average of *M*=4.43 (*SD*=1.61). Mean scores of extraversion were higher than mean scores of neuroticism with scores being *M*=4.18 (*SD*=1.52) and *M*=3.49 (*SD*=1.54) respectively.

In running our correlation analysis, we denoted weak, but significant, interactions between all our measured variables. Interestingly, our analysis showed a significant positive relationship between extraversion and weekly satisfaction (*r*=0.38), meaning that higher extraversion scores are associated with greater satisfaction scores throughout the week. A weak negative relationship exists between neuroticism scores and life satisfaction (*r*=-0.45). Moreover, a similarly weak negative relationship exists between neuroticism and extraversion (*r*=-0.33). Thus, greater neuroticism scores are indicative of lower scores in both satisfaction and extraversion scores.

**Results**

In our base model, our research team denoted a high intraclass correlation coefficient of *ICC*=0.74, which means that our data is highly independent from one another with high variability, being influenced by the effects of clustering by participant. This provides our team with enough rationale to continue with the nested model comparison and construct an equation using linear mixed effects modeling.

Both the variables of extraversion and neuroticism were fitted and compared for random and fixed slopes; consequently, random slopes were determined to be the best fit in our model comparison. In comparing the models for fixed and random fit for extraversion, there was a significantly higher Baye’s factor (*BF*=2.54x1014). Similarly, the Bayes factor for neuroticism random slopes was significantly higher in our model comparison (*BF*=5.80x1024). Therefore, our model used random slopes to best explain extraversion and neuroticism’s interactions with overall life satisfaction. After visualizing trends in data, we ran a sensitivity analysis and checked for any violations in linearity, normality, and homoskedasticity, to which none were violated. This is supported by the residual distribution, dependence, and SL plots, being normally distributed and largely linear.

In the case of our model and clustering by participant, for every one-point increase in extraversion within our model, satisfaction with life would increase by *b*=0.16; furthermore, a point increase in neuroticism would decrease satisfaction with life by *b*=.21. These findings support our first and second hypotheses of a positive relationship between extraversion and life satisfaction and a negative relationship between neuroticism and life satisfaction. However, our third hypothesis, of similar findings both between-participants and within-participants was not supported. According to our *R*2 values, our conditional is much higher (*R2Conditional*=0.79) than our marginal *R2* values (*R2­Marginal=*.10), meaning that our fixed effects model (within-participants) is not a great fit to explaining our model. In comparison, the conditional*R2*, or between-participant model, explains the variance in our data much better. These values are not at all similar, which supports rejecting our third hypothesis.

**References**

Douglas Bates, Martin Maechler, Ben Bolker, Steve Walker (2015). Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67(1), 1-48. doi:10.18637/jss.v067.i01.

Fife D (2024). \_flexplot: Graphically Based Data Analysis Using 'flexplot'\_. R package version 0.20.3.

Gosling, S. D., Rentfrow, P. J., & Swann, W. B., Jr. (2003). A Very Brief Measure of the Big Five Personality Domains. Journal of Research in Personality, 37, 504-528.

Kuznetsova A, Brockhoff PB, Christensen RHB (2017). “lmerTest Package: Tests in Linear Mixed Effects Models.” \_Journal of Statistical Software\_, \*82\*(13), 1-26. doi:10.18637/jss.v082.i13

<https://doi.org/10.18637/jss.v082.i13>.

Lüdecke et al., (2021). performance: An R Package for Assessment, Comparison and Testing of Statistical Models. Journal of Open Source Software, 6(60), 3139. https://doi.org/10.21105/joss.03139

R Core Team (2023). \_R: A Language and Environment for Statistical Computing\_. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>.

Stanley D (2021). \_apaTables: Create American Psychological Association (APA) Style Tables\_. R package version 2.0.8, <https://CRAN.R-project.org/package=apaTables>.

Wickham H, Averick M, Bryan J, Chang W, McGowan LD, François R, Grolemund G, Hayes A, Henry L, Hester J, Kuhn M, Pedersen TL, Miller E, Bache SM, Müller K, Ooms J, Robinson D, Seidel DP, Spinu V, Takahashi K, Vaughan D, Wilke C, Woo K, Yutani H (2019). “Welcome to the tidyverse.” \_Journal of Open Source Software\_, \*4\*(43), 1686. doi:10.21105/joss.01686 <https://doi.org/10.21105/joss.01686>

Wickham H, Miller E, Smith D (2023). \_haven: Import and Export 'SPSS', 'Stata' and 'SAS' Files\_. R package version 2.5.4, <https://CRAN.R-project.org/package=haven>.

**Table 1**

*Descriptive statistics and correlations of satisfaction, extraversion, and neuroticism scores*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *M* (*SD*) | Satisfaction | Extraversion | Neuroticism |
| Satisfaction | 4.43 (1.61) | --- |  |  |
| Extraversion | 4.18 (1.52) | .38  (0.35, 0.41) | --- |  |
| Neuroticism | 3.49 (1.54) | -0.45  (-0.47, -0.43) | -0.33  (-0.36, -0.31) | --- |

**Table 2**

*Linear mixed effects model estimates, standard error, 95% confidence intervals, and R2*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *E* (*SE*) | 95% Confidence Interval | *R2* | |
| Intercept | 4.51 (0.12) | (4.27, 4.73) | --- |  | |
| Extraversion | 0.16 (0.02) | (0.13, 0.19) | --- |  | |
| Neuroticism | -0.21 (0.02) | (-0.24, -0.18) | --- |  | |
| --- | --- | --- | Conditional: 0.79  Marginal: 0.09 |  | |