**Assignment 3:** **Linear Mixed Effects Modeling**

Samuel Obeng Nkrumah

Department of Psychiatry, Dalhousie University

PSYR 6003: Fundamentals of Applied Statistics

Dr. Sandra M. Meier

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**Linear Mixed Effects Modeling**

**Results**

The dataset contains a sample of 263 people with 4252 observations that were measured with daily questionnaire once a day for up to 20 days.

**Data analysis strategy**

The raw dataset was initially explored, and preliminary descriptive analyses are presented in Appendix A. All statistical analyses were conducted using R programming language. Descriptive statistics, including the mean, standard deviation (SD), and a bivariate correlation matrix, were computed to summarize the characteristics of the study variables. To identify the most appropriate model for the data structure, linear mixed-effects modelling (LMM) was employed, accounting for the nested and repeated measures design, with observations nested within individual participants and across days. Restricted Maximum Likelihood Estimation (REML) was utilized for model estimation, given its advantage in providing less biased estimates of variance components in mixed models. However, to facilitate nested model comparisons and model selection procedures, models were subsequently refitted using the Maximum Likelihood (ML) estimation method. All statistical inferences were conducted at the 95% confidence level. A series of linear mixed-effects models with increasing complexity were developed to examine the hypothesized relationships between the outcome variable, Satisfaction with Life (SWL), and the predictors, Extraversion and Neuroticism. The modelling process began with a baseline model that included only the outcome variable, SWL, and random intercepts for both individual participants (id) and day. The intraclass correlation coefficient (ICC) was calculated based on the baseline model to estimate the proportion of total variance attributable to the random effects. To address the main hypotheses, separate models were constructed to assess the individual effects of Extraversion and Neuroticism on life satisfaction. Nested model comparisons were conducted to determine the optimal random effect’s structure. Initially, a model with random intercepts only was compared to a model with random slope. The final, best-fitting model included random slopes for both Extraversion and Neuroticism at the level of individual participants (id), capturing both between-person and within-person variability in the predictors' effects on life satisfaction.

Final selected best fitting model expressed in an equation form below:

swlij​=β0​+β1​tipm.Eij​+β2​tipm.Nij​+b0j​+b1j​tipm.Eij​+b2j​tipm.Nij​+ϵij​

where:

swl=satisfaction with life

timp.E=extraversion

timp.N=neuroticism

i = observation (for a given person)

j = person (ID)

β0​ = fixed intercept (overall average swl when predictors are 0)

β1​ = fixed effect of extraversion (on average, how extraversion relates to swl)

β2​ = fixed effect of neuroticism (on average, how neuroticism relates to swl)

b0j​ = random intercept for person j (individual-specific deviation from the overall intercept)

b1j​ = random slope for extraversion for person j

b2j​ = random slope for neuroticism for person j

ϵij​ = residual error (within-person variability)

To determine the best-fitting model, the final two models were compared using nested model comparison procedures. Specifically, a model including both Extraversion and Neuroticism as predictors with random slope for both variables at the identifier for each individual participant (id) and “day” was compared against a model including both predictors with random slope at the identifier for each individual participant (id) only. The model incorporating random slopes for both Extraversion and Neuroticism at the identifier for each individual participant (id) only demonstrated superior fit, as indicated by lower Akaike Information Criterion (AIC = 10364.47) and Bayesian Information Criterion (BIC = 10428.02) values compared to the alternative model (AIC = 10373.57; BIC = 10475.24). Furthermore, the Bayes Factor (BF = 17956660151) provided overwhelming evidence in favor of the model with random slope at id only (**see Table 1**). This also indicates that random effect at day was not that important. The two models produce very similar predictions most of the time. In fact, for half of the cases, the predicted difference is less than 0.01, and even the largest difference is only about 0.12. This suggests that the models are producing very similar predictions, and the practical impact of switching from one model to another may be small.

**Table 1**

**Comparing final two models to selected best fit model**

|  |  |  |  |
| --- | --- | --- | --- |
| Model | AIC | BIC | Bayes Factor |
| Model 6 (random slope at “id” only) | 10364.47 | 10428.02 | 17956660151 |
| Model 7 (random slope at both “id” and “day”) | 10373.57 | 10475.24 | 0 |

**Observation of the results of the Univariate and bivariate distribution**

The distribution of Satisfaction with Life (SWL) scores exhibits a mild left skew, characterized by a concentration of lower scores near the range of 1 to 2. The majority of responses are clustered between 4 and 6, with a pronounced peak around 6, reflecting generally high levels of life satisfaction within the sample. No extreme outliers are observed. The distribution of Extraversion appears approximately symmetric and centered around a value of 4, which corresponds to the midpoint of the scale, suggesting a balanced distribution of Extraversion traits. In contrast, the distribution of Neuroticism is right-skewed, with a greater density of responses at the lower end of the scale. Most values fall between 2 and 4, with the highest frequency observed near 2. As scores increase, the frequency of responses decreases gradually, indicating fewer individuals with elevated Neuroticism scores. Although the upper end of the distribution is characterized by relatively low counts, no extreme outliers are evident. **Figure 1** (**Appendix A**) presents the univariate distributions for each variable.

Bivariate relationships among the variables were examined using scatterplots with fitted regression lines. The associations between satisfaction with life and the personality traits of Extraversion and Neuroticism appeared approximately linear. Specifically, Extraversion demonstrated a positive association with satisfaction with life, whereas Neuroticism exhibited a negative association. Additionally, Extraversion and Neuroticism appeared to be negatively correlated with each other. The bivariate distributions of these variables are presented in **Figure 2** (**Appendix B**).

**Assessing Assumptions**

Evaluation of model assumptions suggests that the assumptions of normality, linearity, homoskedasticity, and independence are largely upheld (**Figure 3, Appendix C**). The histogram of residuals demonstrates a symmetric, bell-shaped distribution centered around zero, indicating that the normality assumption is reasonably satisfied, with only minor deviations unlikely to materially affect model inference. In the Residual Dependence Plot, residuals are predominantly scattered randomly around zero, although a slight pattern characterized by minor funneling and banding is observed, suggesting a modest deviation from perfect linearity; however, this is not deemed a serious violation. The S-L Plot reveals a slight increase in the spread of the absolute residuals with increasing fitted values, indicative of mild heteroscedasticity. Nonetheless, this departure from homoskedasticity appears minimal. Furthermore, no discernible patterns were observed that would suggest strong dependence among residuals, supporting the conclusion that the independence assumption is reasonably met. assumption is reasonably met. To check for Multicollinearity, the Variance Inflation Factor (VIF) was calculated for the predictors (VIF=1.02), indicating no concerns for multicollinearity. Overall, the model assumptions are sufficiently satisfied, and the linear mixed-effects model is appropriate for interpretation.

**Descriptive Statistics**

**Table 2** presents the descriptive statistics for the study variables, including Satisfaction with Life, Neuroticism, and Extraversion. The mean score for Satisfaction with Life (SWL) was 4.43 (SD = 1.61), with observed scores ranging from 1 to 7, suggesting that participants generally reported moderate to high levels of life satisfaction. Neuroticism had a mean score of 3.49 (SD = 1.54), with values also ranging from 1 to 7, indicating considerable variability in participants' emotional stability and tendency toward negative affect. Extraversion demonstrated a mean score of 4.18 (SD = 1.52), similarly spanning a range from 1 to 7, reflecting a broad distribution of extraverted traits within the sample. Overall, the descriptive statistics suggest that the participants exhibited moderate levels of life satisfaction and Extraversion, while Neuroticism levels were somewhat lower but still displayed substantial individual differences.

**Table 2**

*Descriptive statistics of study variables.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Mean | Standard Deviation | Minimum range of values | Maximum range of values |
| Satisfaction with Life | 4.43 | 1.61 | 1 | 7 |
| Neuroticism | 3.49 | 1.54 | 1 | 7 |
| Extraversion | 4.18 | 1.52 | 1 | 7 |

**Table 3** presents the bivariate correlations among Satisfaction with Life, Extraversion, and Neuroticism. Satisfaction with Life was positively correlated with Extraversion (r = 0.38) and negatively correlated with Neuroticism (r = -0.45). These findings suggest that higher levels of Extraversion are associated with greater life satisfaction, whereas higher levels of Neuroticism are associated with lower life satisfaction. Furthermore, Extraversion and Neuroticism were negatively correlated (r = -0.33), indicating that individuals who scored higher in Extraversion tended to report lower levels of Neuroticism. All correlations were in the expected directions, consistent with prior literature linking personality traits to subjective well-being outcomes.

**Table 3**

*Bivariate correlation among study variables*

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | Satisfaction with Life | Extraversion | Neuroticism |
| Satisfaction with Life | 1.00 | 0.38 | -0.45 |
| Extraversion | 0.38 | 1.00 | -0.33 |
| Neuroticism | -0.45 | -0.33 | 1.00 |

**Table 4** shows the estimates (B), standard errors (SE), 95% CIs, ICC, and Pseudo R2 for the final selected model. The intraclass correlation coefficient (ICC) was 0.74, suggesting that a substantial proportion (74%) of the variance in Satisfaction with Life could be attributed to differences between individuals. This indicates that running this as a mixed model (as opposed to a regular linear regression) is important. The table also presents the fixed effects estimates and model fit statistics for the linear mixed-effects model predicting Satisfaction with Life based on Extraversion and Neuroticism. The intercept was statistically significant (B = 4.51, SE = 0.12, 95% CI [4.27, 4.74], p < .001), indicating the estimated mean level of Satisfaction with Life when Extraversion and Neuroticism were at zero. Extraversion was positively associated with Satisfaction with Life (B = 0.16, SE = 0.02, 95% CI [0.13, 0.19], p < .001), suggesting that higher levels of Extraversion were significantly related to greater life satisfaction. Conversely, Neuroticism was negatively associated with Satisfaction with Life (B = -0.21, SE = 0.02, 95% CI [-0.24, -0.18], p < .001), indicating that higher levels of Neuroticism were significantly associated with lower life satisfaction. The model fit indices indicated a conditional R² of 0.788, reflecting the proportion of variance explained by both fixed and random effects, and a marginal R² of 0.094, indicating that the fixed effects alone accounted for approximately 9.4% of the variance in Satisfaction with Life. Overall, these results suggest that personality traits significantly predict life satisfaction, although much of the variability is explained by random effects at the participant level.

**Table 4**

*Estimates from final selected mixed effects model*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameters** | **Estimates (B)** | **Standard Error (SE)** | **95% Confidence Interval** | | ***p*-values** |
| **Lower Bound** | **Upper Bound** |
| Intercept | 4.51 | 0.12 | 4.27 | 4.74 | < .001 |
| Extraversion | 0.16 | 0.02 | 0.13 | 0.19 | < .001 |
| Neuroticism | -0.21 | 0.02 | -0.24 | -0.18 | < .001 |
|  |  |  |  |  |  |
| ICC | *0.74* |  |  |  |  |
| Conditional R2: | *0.788* |  |  |  |  |
| Marginal R2: | *0.094* |  |  |  |  |

**Interpretation of Results in lay terms.**

**Hypothesis 1 (H1):** People who are more outgoing and sociable (higher in Extraversion) would be more satisfied with their lives.

This idea was supported by the results. In simple terms, the more outgoing someone was, the more likely they were to feel happy and satisfied with their life. This matches what other research has found — that being energetic, friendly, and outgoing is linked to feeling better about life.

**Hypothesis 2 (H2):** People who are more anxious and prone to negative emotions (higher in Neuroticism) would be less satisfied with their lives.

This idea was also supported. People who tended to worry more, feel anxious, or experience a lot of negative emotions reported being less happy with their lives. Again, this fits well with other research showing that emotional instability is often linked to lower life satisfaction.

**Hypothesis 3 (H3)** suggested that the way Extraversion and Neuroticism relate to life satisfaction would be similar both over time within the same person and between different people.

The results partially supported this idea. The model we used allowed the strength of the relationship to vary from person to person. This means that although being more extraverted generally led to higher life satisfaction (and being more neurotic led to lower satisfaction), the size of these effects was not exactly the same for everyone. Some people might have had a stronger or weaker connection between their personality and their life satisfaction compared to others. Most of the differences in life satisfaction came from differences between people (not within the same person over time), which was shown by a high ICC value (0.74). The overall patterns were consistent, but there was some individual variation, so the hypothesis was only partly confirmed.

**Discussion**

This study investigated the relationship between personality traits and life satisfaction using linear mixed-effects modeling. Extraversion was positively associated with greater satisfaction with life, while Neuroticism was negatively associated, supporting the initial hypotheses. Model comparison analyses revealed that allowing both Extraversion and Neuroticism to vary across participants significantly improved model fit, as indicated by lower AIC and BIC values and an extremely large Bayes Factor. The high intraclass correlation coefficient suggests that much of the variance in life satisfaction is attributable to stable differences between individuals. These findings highlight the importance of both personality traits in shaping subjective well-being. The results also emphasize the value of modeling random slopes in capturing individual variability in psychological research.

**Conclusion**

In this study, we found that personality traits are closely linked to how satisfied people feel with their lives. People who were more outgoing (higher in Extraversion) tended to report greater life satisfaction, while those who were more anxious and emotionally sensitive (higher in Neuroticism) reported lower satisfaction. By using a detailed statistical approach, we showed that allowing both traits to vary across individuals gave us a much better understanding of these patterns. Most of the differences in life satisfaction were explained by differences between people, rather than daily changes within a person. These results highlight how important personality is for overall well-being and suggest that understanding individual differences can help us better support people's happiness in a meaningful way.

**Appendix A**

**Figure 1**

A graph of a graph

AI-generated content may be incorrect. A graph of a bar graph

AI-generated content may be incorrect.

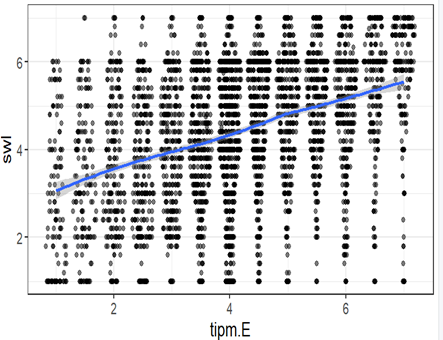
A graph with a number of columns

AI-generated content may be incorrect.

**Appendix B**

**Figure 2**

A graph with a line going up

AI-generated content may be incorrect. 

A graph with a line going up

AI-generated content may be incorrect.

**Appendix C**

**Figure 3**

A collage of graphs and diagrams

AI-generated content may be incorrect.