PSYP14-HT21 Sub-course 1 Home Assignment

Assignment 1

Introduction:

The following study was conducted to understand the underlying variables that influence pain post operation to improve the process of pain management. Previous research has shown that age and sex are good predictors of pain. These two established predictors as well as psychological and hormonal variables, such as, State Trait Anxiety Inventory (STAI trait), pain catastrophizing, mindfulness, cortisol serum and cortisol saliva were used to conduct a hierarchical regression to figure out the most influential variables in causing pain.

Results

Before regression analyses were conducted, the descriptives of the data were checked. The summary of the data showed two odd data points: pain was rated as 55 by participant ID 88 which is measured on a scale between 0 and 10, and anxiety was rated as 4.2 by participant ID 34 in the State Trait Anxiety Inventory which is measured on a scale between 20-80. Both participant ID ratings were recoded (pain 55 into 5, and STAI\_trait 4.2 into 42). The first multiple regression model containing predictors of age and sex was significantly better than the null model, explaining 8.36% of the variance in predicting pain (*F* (2, 157) = 7.18, *p* < .001, Adj. = 0.08, AIC = 579.55). Further statistics such as coefficients and beta values can be seen in Table 1.

The second regression model was built containing the pain as the outcome and age, sex, STAI\_trait, pain catastrophizing, mindfulness, and both cortisol measures as the predictors. Before the regression analyses, assumptions of linear regression, normality, linearity, and homogeneity were checked, and no violations were found. However, multicollinearity was found to be present in both cortisol predictors, as they had VIF over 3: cortisol serum (*VIF* = 4.73) and cortisol saliva (VIF = 5.03). To overcome this, cortisol saliva was excluded from the final regression model, because cortisol serum has been regarded as more reliable in medical research. The assumptions were checked again, and no violations were found. The final multiple regression model including six predictors: age, sex, STAI\_trait, pain catastrophizing, mindfulness, and cortisol serum was significantly better than the null model, explaining 52.26% of the variance in predicting pain (*F* (6, 153) = 27.92, *p* < .001, Adj. = 0.52, AIC = 483.25). Further statistics such as coefficients and beta values can be seen in Table 2. The final model can be calculated using the following equation: Pain = 1.41 – 0.04\*age + 0.16\*sex – 0.01\*STAI\_trait + 0.11\*pain catastrophising + 0.57\*cortisol serum – 0.28\*mindfulness.

Model 1 and model 2 final were compared to check how much variance they explain of the variability in pain using the Akaike report. A significant difference was found due the difference being above 2 (*AIC* model 1 = 579.55 *AIC* model 2 = 483.25). A final comparison was conducted using an ANOVA, which further confirms the significant difference between both models (*F* (4, 153) = 35.16, *p* < .001.

Discussion

The results show that model 2 final is much better at explaining postoperative pain than model 1. This implies that the inclusion of more variables allowed for a deeper understanding of pain, which could in turn help improve pain management after an operation.

Assignment 2

Introduction

Assignment 2 was conducted to check whether a stepwise backward model or a theory-based model is better at predicting postoperative pain. Further testing was done by introducing new data, which was then compared to the two models to check which model is the best at explaining actual pain ratings.

Results

The multiple regression model that was created after executing a stepwise backward regression was significantly better than the null model, explaining 51.92% of the variance in predicting pain (*F* (4, 155) = 41.84, *p* < .001, Adj. = 0.52, AIC = 480.41. Further statistics such as coefficients and beta values can be seen in Table 3. The backwards model can be calculated using the following equation: Pain = 1.16 – 0.04\*age – 0.26\*mindfulness + 0.54\*cortisol serum + 0.11\*pain catastrophising.

The initial model that was run through the stepwise backward model had nine predictors: age, sex, STAI\_trait, pain catastrophizing, cortisol serum, mindfulness, weight, IQ and household income. The *AIC* of the initial model was 487.92. The backwards model kept only four predictors: age, mindfulness, cortisol serum and pain catastrophising. The *AIC* for this final model was 480.41.

Next, an ANOVA was run to compare the backward model and the theory-based model from assignment 1. No significant difference was found (*F* (-5, 155) = 0.47, *p* < .798). The Akaike report was also run on both backward model and theory-based model. The *AIC* shows a significant effect, as the difference between the two is above 2 (*AIC* backwards model = 480.41 and *AIC* theory-based model = 483.25). Due to the models being nested within each other, the ANOVA cannot be used.

Lastly, predicted pain was calculated using a new data set to calculate whether predicted values or actual pain ratings can better predict pain ratings in the new data. Once the data was imported, descriptive statistics were run to see if there were any outliers. None were found thus keeping all 160 participants. To calculate the prediction performance, the sum of squared differences (RSS) was calculated for both predicted and actual pain ratings. The backward model showed higher error with an *RSS* of 249.68 compared to the theory-based *RSS* of 243.75.

Discussion

In the first section where the backward regression and theory-based regression were compared, backwards regression was found to be more robust and a better model in explaining pain post operation due a smaller *AIC.* In the second section, models were once again compared, and it was found that the theory-based model was better at predicting pain in a new data set compared to the backward model. In conclusion, the theory-based model is better at predicting pain in a clinical setting as the *RSS* was smaller than the backward model meaning that the data is more generalisable.

Assignment 3

Introduction

Following the success of the original study, more funding was granted to replicate the original study at twenty different hospital sites to increase the generalisability of the findings. Assignment 3 focuses on assessing the model coefficients as well as predictive efficiency of the predictors using linear mixed model.

Results

Before building a linear mixed model, data was checked for possible outliers. There was a negative household income, which was kept in the data. According to Winter non-applicable data in mixed linear models does not lead to problems in mixed linear model analyses, thus an executive decision was made that this negative household income would also not lead to any problems. In the variable sex, one participant had written woman, which was changed to female for the sake of continuation. First a random intercept model was built focusing on the same predictors as the theory-based model including a random intercept of hospital-ID. Table 4 shows a comparison of results between the random intercept model and theory-based model. The effect of predicting pain post operation in data file 3 showed a marginal *R2*of 0.39 and a conditional *R2* of 0.46. Using findings from data file 3, predictions were also done on data file 4, which found an *R2* of 0.38, explaining 38% of the variance.

Figure 1 displays a random slope model with fitted regression line for each hospital using the most influential predictor cortisol serum predicting pain.

Discussion

The direct comparison of the random intercept model and theory-based model in Table 4 show that the same predictors are significant in both models. However, in the random intercept model, the intercept is significant whereas in the theory-based model it is not. This suggests that the original findings from assignment 1 are generalisable since the outcome of pain within the random intercept model is predicted by predictors without the influence and interaction of the hospital. However, the intercept is significant in the random intercept model suggesting that the clustering of variables overall is more significant in explaining pain post operation. The *R2* of 0.38 obtained in data file 4 was much closer to the marginal *R2* (0.39) in data file 3 than the conditional *R2* (0.46). This implies that the variance is explained by fixed effects without considering random effects in both data files 3 and 4. Marginal *R*2 is much closer, as *R*2 obtained for data file 4 was calculated using the formula 1-(RSS/TSS), which does not include the random effect of the hospital. Comparing plots, the regression lines for random intercept model and random slope model showed a slight improvement in model fit in the random slope model, which was supported by the random slope having less error. However, focusing only on *RSS* when comparing prediction efficiency is not enough. Thus, comparison on model fit was done using the ANOVA and cAIC functions. The likelihood ratio test produced a non-significant result (*X2* = 2.66, df = 2, p = .265) meaning that the choice between these two models was done based on the cAIC (cAIC intercept = 664.54, cAIC slope = 664.54). However, this shows that the there was no difference in which model is a better fit for predicting pain, as cortisol serum explained 22% of the variance of pain experienced post operation (*R2* = 0.22 [95% CI = 0.13, 0.32]).”

Tables and Figures

**Table 1.**

*Hierarchical Regression Model: age and sex predicting pain.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Predictors | Estimates | *std. Beta* | 95 % *CI* | | *standardized CI* | | *p* |
|  |  |  | *LL* | *UL* | *LL* | *UL* |  |
| (Intercept) | 8.15 | -0.09 | 6.30 | 10.00 | -0.30 | 0.11 | **<0.001** |
| age | -0.09 | -0.28 | -0.13 | -0.04 | -0.43 | -0.13 | **<0.001** |
| sex [male] | 0.30 | 0.20 | -0.16 | 0.76 | -0.11 | 0.50 | 0.200 |

*Note*. Observations = 160, *R2 / R2* adjusted = 0.084 / 0.072. *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit.

**Table 2.**

*Hierarchical Regression Model: age, sex, STAI trait, pain cat, cortisol serum and mindfulness predicting pain.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Predictors | Estimates | *std. Beta* | 95 % *CI* | | *standardized CI* | | *p* |
|  |  |  | *LL* | *UL* | *LL* | *UL* |  |
| (Intercept) | 1.41 | -0.05 | -1.28 | 4.09 | -0.20 | 0.11 | 0.302 |
| age | -0.04 | -0.13 | -0.08 | -0.00 | -0.25 | -0.01 | **0.038** |
| sex [male] | 0.16 | 0.11 | -0.19 | 0.52 | -0.13 | 0.34 | 0.374 |
| STAI trait | -0.01 | -0.03 | -0.06 | 0.04 | -0.17 | 0.11 | 0.665 |
| pain cat | 0.11 | 0.38 | 0.07 | 0.16 | 0.23 | 0.53 | **<0.001** |
| cortisol serum | 0.57 | 0.35 | 0.36 | 0.78 | 0.22 | 0.47 | **<0.001** |
| mindfulness | -0.28 | -0.18 | -0.48 | -0.07 | -0.31 | -0.05 | **0.009** |

*Note*. Observations = 160, *R2 / R2* adjusted = 0.523/ 0.504. *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit.

**Table 3.**

*Backwards Hierarchical Regression Model: age, mindfulness, cortisol serum and pain cat predicting pain.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Predictors | Estimates | *std. Beta* | 95 % *CI* | | *standardized CI* | | *p* |
|  |  |  | *LL* | *UL* | *LL* | *UL* |  |
| (Intercept) | 1.16 | -0.00 | -1.14 | 3.74 | -0.11 | 0.11 | 0.372 |
| age | -0.04 | -0.13 | -0.07 | -0.00 | -0.25 | -0.01 | **0.027** |
| mindfulness | -0.26 | -0.17 | -0.47 | -0.06 | -0.30 | -0.04 | **0.011** |
| cortisol serum | 0.54 | 0.32 | 0.34 | 0.73 | 0.21 | 0.44 | **<0.001** |
| pain cat | 0.11 | 0.39 | 0.07 | 0.15 | 0.25 | 0.53 | **<0.001** |

*Note*. Observations = 160, *R2 / R2* adjusted = 0.519/ 0.507. *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit.

**Table 4.**

*Hierarchical Regression Model. Comparing Theory-based model and Random Intercept model.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Effect | Estimates | *std. Beta* | 95 % *CI* | | *standardized CI* | | *p* |
|  |  |  | *LL* | *UL* | *LL* | *UL* |  |
|  |  | Theory-based Model | | |  |  |  |
| (Intercept) | 1.41 | -0.05 | -1.28 | 4.09 | -0.20 | 0.11 | 0.302 |
| age | -0.04 | -0.13 | -0.08 | -0.00 | -0.25 | -0.01 | **0.038** |
| sex [male] | 0.16 | 0.11 | -0.19 | 0.52 | -0.13 | 0.34 | 0.374 |
| STAI trait | 0.11 | 0.38 | 0.07 | 0.16 | 0.23 | 0.53 | **<0.001** |
| pain cat | -0.01 | -0.03 | -0.06 | 0.04 | -0.17 | 0.11 | 0.665 |
| cortisol serum | -0.28 | -0.18 | -0.48 | -0.07 | -0.31 | -0.05 | **0.009** |
| mindfulness | 0.57 | 0.35 | 0.36 | 0.78 | 0.22 | 0.47 | **<0.001** |
|  |  |  |  |  |  |  |  |
|  |  | Random intercept model | | |  |  |  |
| (Intercept) | 3.85 | -0.08 | 1.10 | 6.59 | -0.31 | 0.15 | **0.006** |
| age | -0.06 | -0.19 | -010 | 0.02 | -0.31 | -0.07 | **0.002** |
| sex [male] | 0.23 | 0.15 | -0.09 | 0.55 | -0.06 | 0.37 | 0.158 |
| Pain cat | 0.08 | 0.26 | 0.04 | 0.13 | 0.12 | 0.41 | **<0.001** |
| STAI trait | -0.02 | -0.08 | -0.06 | 0.02 | -0.21 | 0.06 | 0.256 |
| mindfulness | -0.23 | -0.14 | -0.43 | -0.02 | -0.26 | -0.01 | **0.032** |
| cortisol serum | 0.51 | 0.34 | 0.33 | 0.69 | 0.22 | 0.46 | **<0.001** |

*Note*. Observations = 200, *R2 / R2* adjusted = 0.385/ 0.463. *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit. *Hospital* was used as a random effect term in the Random Intercept Model.

**Figure 1.**

*Linear Mixed Models: Random Slope Model showing the effect of cortisol serum on pain in each hospital.*

Diagram

Description automatically generated