

MIXED EFFECT MODEL ANALYSIS USING SLEEPSTUDY DATASET

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Abstract

The independence of observation is one of the most important assumptions that must be upheld when fitting a regression model, but sometimes an experiment may require repeated measures from participants, which violates this assumption. The sleepstudy dataset is a case scenario where multiple measurements were taken for ten days from 18 participants; the assumption that participant observations should be independent of each other was not fulfilled; hence, the mixed effects model was used for the prediction analysis. The descriptive analysis shows that the participants have different reaction time thresholds, but the cumulative average reaction time per day is increasing progressively over the ten days from 257 (ms) to 351 (ms). From the model, the baseline effect of sleep deprivation was observed to be 247.70 ms for the reference level (Day 3), while every additional day of sleep deprivation, there is an increase in reaction time approximately to be 11.063 ms. The study established that chronic sleep deprivation has an effect over psychomotor performance based on reaction time, provided all other variables were kept constant.

Introduction

It is well established that chronic sleep deprivation is habitual among people and endemic within modern society. The long-term impact of sleep deprivation affects health predominantly and decreases the productivity of an individual. The majority of research that examines the behavioral effects of sleep deprivation often uses acute total sleep deprivation (TSD) as the experimental manipulation, which is difficult to generalize for chronic sleep deprivation. Belenky *et al.* 2003 then proceed to perform an experiment that aims at collating data for chronic sleep deprivation; the dataset is an in-built within the lme4 library in R. And it contains the data of 18 subjects, which are the most sleep-deprived group (three hours sleep over ten days) among the sixty-six participants. The experiment occurs for 10 days, and the average reaction time after waking up for each day was recorded, with an aggregate of 180 observations.

Methods

The sleepstudy dataset was loaded by using the data(sleepstudy) function after loading the lme4 library. The tidyverse library was used for data exploration and descriptive analysis to understand the dataset at the subject/population level and chronic sleep deprivation pattern over different days. A regression model was fit to the dataset using mixed effect model analysis to understand what is happening at the population and individual level while accounting for the repeated measures over the ten-day period.

Result

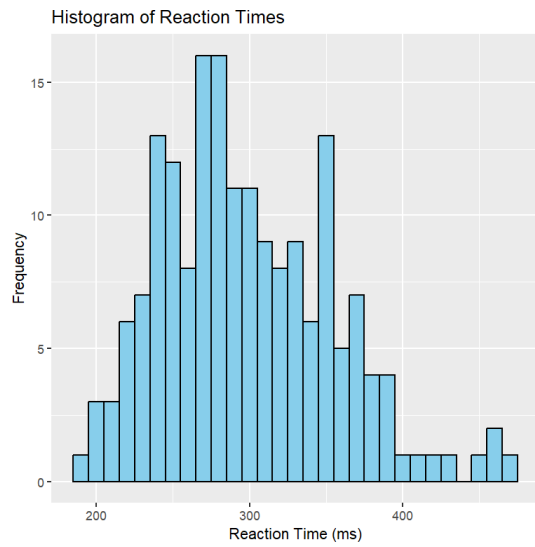


Figure 1: Histogram of reaction times.

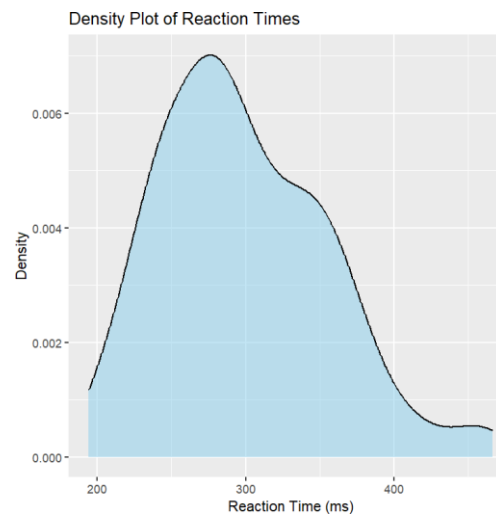


Figure 2: Density plot of reaction time.

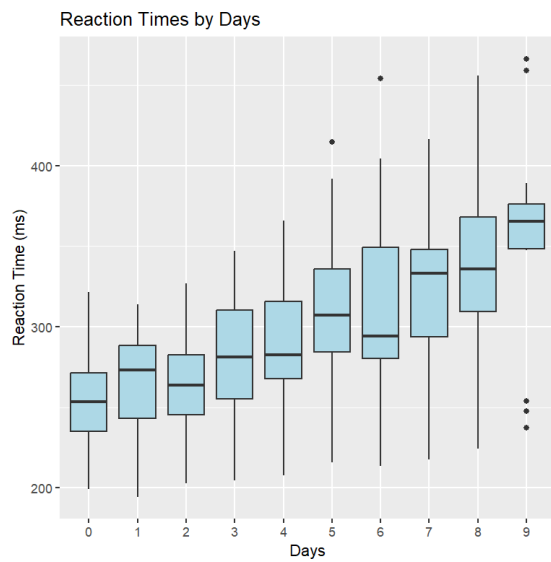


Figure 3: Boxplot of reaction over the ten days of sleep deprivation

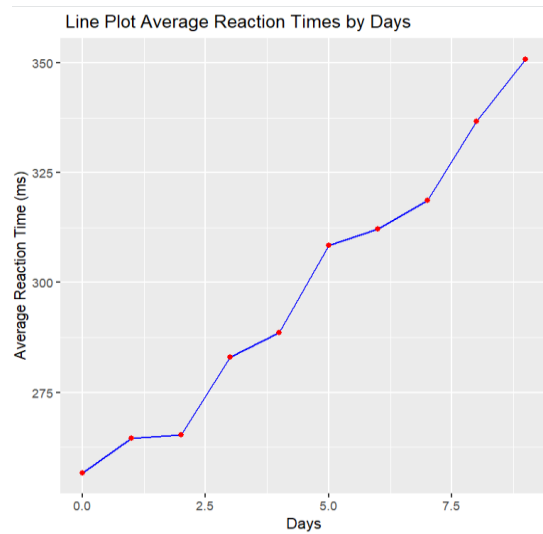


Figure 4: Average reaction per day for all subject.

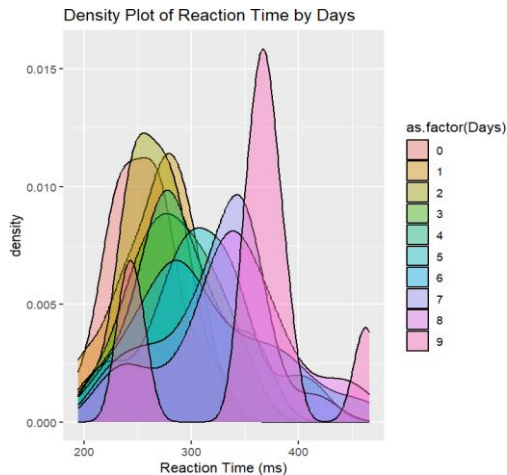


Figure5: Density plot of reaction across days of sleep deprivation

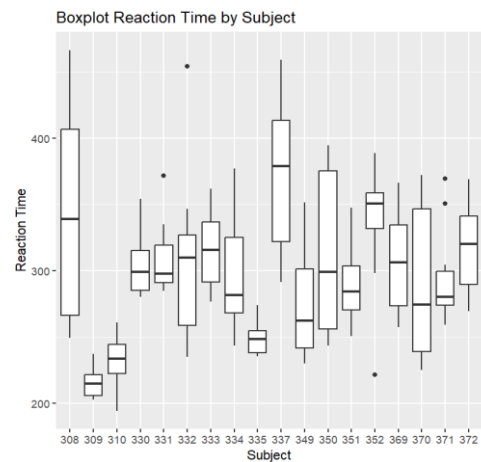


Figure6: Boxplot of reaction time of each participants

Discussion

The independence of observation, homoscedasticity, linear relationship between the independent (predictors) and dependent (outcomes), and normality of the data are assumptions for building most statistical model, but sometimes one or two of the assumptions is violated based on the characteristics of the data. The sleepstudy dataset violated the assumption of independence of observation at the individual level. The most suitable model to analyze this type of data is the mixed effect model.

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	247.702	13.538	18.297
Days	11.063	1.319	8.391

The linear mixed model was applied to the filtered_sleepstudy dataset after removing the first three days as seen in the R link code below, because information from the dataset shows that day 0 and 1 were adaptation and training day, while day 2 is the baseline day; actual sleep deprivation commenced from day 2. The comprehensive analysis reveals significant insights into the relationship between reaction times and days of sleep deprivation. The fixed effects indicate that for each additional day of sleep deprivation, reaction time increases by averagely 11.063 milliseconds. Both fixed effects are statistically significant, with t-values of 18.297 for the intercept and 8.391 for days. The model indicates that sleep deprivation substantially affects reaction times while considering individual variations.

Conclusion

The study found that prolonged sleep deprivation has an effect on psychomotor vigilance based on response time, assuming all other factors are constant.

Link to R script: Check out our project on GitHub: <https://github.com/Toheeb27/Mixed-Effect-Model-Analysis>