Applied Analysis 3

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August 2024

Rodent Altruism Rats are like humans in that they dislike incarceration and physical restraint. They also dislike seeing a fellow rat in distress from physical restraint. Rats are altruistic to a certain extent: a free rat observing a restrained rat under stress may respond like the Good Samaritan and endeavour to free the restrained rat from his shackles even though there is no immediate or apparent reward in it for the free rat. Like humans, rats learn by training; on average, over time, they become more adept at restraint removal.

A study in the lab of Peggy Mason measured the response time—the time taken for the free rat to pick the lock—under a range of treatments. Each pair of rats was observed daily over a period of 12 days, which for present purposes may be taken as consecutive. Each day, one rat was restrained (the same one each day), and the other rat was free to explore in the vicinity. The observation is the time in minutes for the free rat to open the restraint. All times are truncated at 40 minutes. The first experiment consists of 96 pairs of male rats divided into six groups of 16 pairs. Each of the six treatment levels is a short-lasting drug given by injection to the free rat just before the commencement of the experiment each day. The treatment levels are: `uninjected, saline, highMDZ, lowMDZ, nadalol, propranolol`, the first two of which are control levels. The data for this experiment are available in the file `free_rat.csv`.

The data are in spreadsheet format with 96 rows, one column for treatment level, one for rat ID, and one for the response time on each of the 12 days. Although the days are presumed to be consecutive for each rat, the entire experiment was not performed in 12 days, so day 1 for rat 1 is not the same as day 1 for rat 96. Two values are missing; other values reported as 0 are not missing but are presumed to be less than 30 seconds.

Data Reading

```
#data reading
rat_data=read.csv("free_rat.csv")
head(rat_data)
```

```
##      TRT Ratid D1 D2 D3 D4 D5 D6 D7 D8 D9 D10 D11 D12
## 1 saline    R1 40 40 40 40 40 40 40 40 40  40  40  40
## 2 saline    R2 40 40 25 12  2  0  0  1  0   0   0   0
## 3 saline    R3 19 40 40 40 40  0  4  0  0   0   0   2
## 4 saline    R4 10 40 40 40 40 40 40 40 40  40  40  40
## 5 saline    R5  6 40 40 40 40 40 40 40  4  40  40   3
## 6 saline    R6 14 36 38  2  4  0  0  0  0   0   0   0
```

Possible Questions

Problem 1

Construct a plot of the data illustrating the temporal trends in mean truncated response times for each of the six treatment levels. Report any interesting observation, you see.

Problem 2

There are two control levels in the treatments. `(1) Uninjected and (2) Saline`. Does the plot above suggest that these two control levels effect the response time differently for rats? Why did the experimenter even chose to include these two control levels - what purpose does it solve?

Problem 3

We want to fit a linear Gaussian model for studying the mean response by day and treatment. Argue whether the linear gaussian model is suitable for this data? Additionally, what model assumptions do the plot from *Problem 2* suggest?

Problem 4

Fit the previously discussed model on the data and provide its interpretation. Report the estimates , their significance and also discuss how one should interpret them.

Problem 5

Observe that the same rat was observed on 12 consecutive days and it might be possible that the residual effect of drug in one day is carried forward to the next day measurements. Does your model above already take care of that issue? If not, how will you fix it?

Problem 6

The plots in *Problem 1* should have indicated that the effect of time is different on response time for different treatment. Can you do a statistical test to check whether the effect is actually different across different treatments. Clearly mention the models and test procedures you use.

Problem 7

In the conduct of this experiment, it appears that the rats must first become familiar with their handler. Otherwise they 'freak out' when injected by a stranger. Assume that one graduate student can become friendly with up to eight pairs of rats at once, and that it is feasible for one hard-working student to perform eight experiments per day. The student can repeat this performance once per month on different batches of rats over a three-month period. Accordingly, four graduate students are needed to perform the experiment on 96 rat pairs over a 3-month period. Handler information is not available in the data provided.

How would you allocate rats to students if you were in charge? Explain how this information would affect your analysis of the data if it were available. Discuss other factors that could influence the design of an experiment such as this, and also the analysis of data.

Problem 8

What do you think is the impact of the truncation of response times on the results you generated? Describe in detail a model that that you think would be best for analyzing these data. Report parameter estimates and their interpretation.