Module 4: R Practice

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ALY 6010: Probability Theory and Introductory Statistics

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Introduction

In this practice assignment, we will explore MASS library in R and analyze "cats" data which is inbuilt in the library and perform two-sample hypothesis testing on the dataset. We will also perform hypothesis testing on a study related to meditation and its impact on sleep quality.

Part 1:

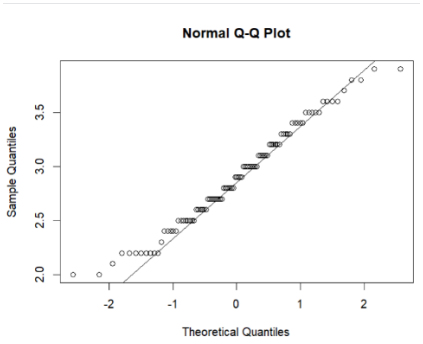
The cats dataset contains three columns: sex, body weight, and heart weight. First, we build a subset of data for male and female cats and use a Q-Q plot and the Shapiro test to see if the body weight column follows a normal distribution.

Figure 1: Determining that the males body weight is normal.

```
> shapiro.test(male$Bwt)

        Shapiro-Wilk normality test

data:  male$Bwt
W = 0.97883, p-value = 0.119
```



We can see from our Shapiro test that the p-value of 0.119 is bigger than the significance level of 0.05, hence there is insufficient evidence to reject the null hypothesis that male cat bodyweight does not deviate significantly from normal distribution. The graphic also shows that there is no substantial deviation of results from the theoretical line.

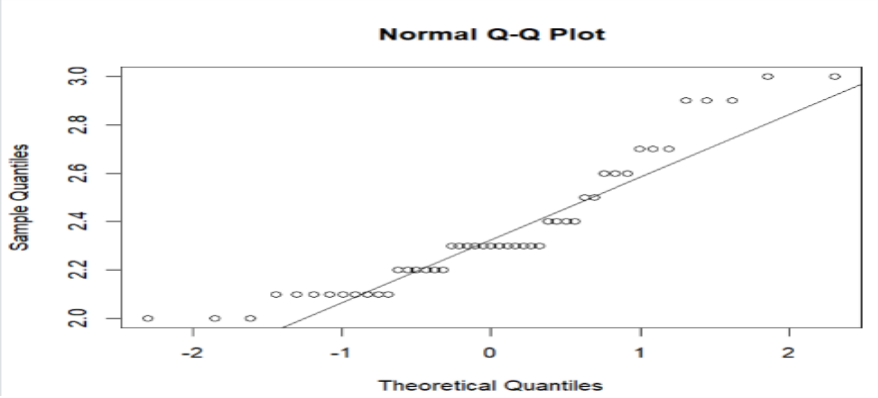
Similarly, for female body weight, we did the Shapiro test and generated the Q-Q plot. We can see that with a p-value of 0.0003754, which is less than the significance level of 0.05, we may declare that there is sufficient evidence to reject the null hypothesis, which is that the body weight of female cats deviates considerably from normal distribution. Furthermore, we can see there is significant deviation from theoretical line.

Figure 2: Determining that the females body weight is normal

```
> shapiro.test(female$Bwt)

        Shapiro-Wilk normality test

data:  female$Bwt
W = 0.89096, p-value = 0.0003754
```



On the cats' data, we do a two-sample hypothesis test to see if there is a significant difference in average body weight between male and female cats. The null hypothesis is that there is a statistically significant difference in average body weight between male and female cats, and the alternative hypothesis is that the average body weight of male and female cats is statistically similar.

Figure 3: Testing the hypothesis on cats' body weight

```
> #Two Sample Hypothesis testing to check there is no statistical difference between male and female body wei
ght
> t.test(male$Bwt, female$Bwt, alternative = "two.sided", var.equal = FALSE, conf.level = .95)

        Welch Two Sample t-test

data:  male$Bwt and female$Bwt
t = 8.7095, df = 136.84, p-value = 0.000000000000008831
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.4177242 0.6631268
sample estimates:
mean of x mean of y
 2.900000  2.359574
```

The extraordinarily low p-value shows strong evidence against the null hypothesis, demonstrating that the mean body weights of male and female cats differ significantly. The 95 percent confidence interval for the mean difference is (0.4177242, 0.6631268), showing that male cats have heavier body weights on average than female cats. In summary, the Welch Two Sample t-test results give statistical evidence to support the conclusion that male and female cats have significantly different mean body weights.

Part 2:

In this section, we examine data from ten students chosen for a meditation workshop in order to investigate the impact of meditation on individuals' sleep quality. Students' sleep scores were tested before and after the workshop, and the researchers claimed that meditation enhanced their sleep scores; we will conduct hypothesis tests to support or refute their claim. Initially, we do an F-test on the data to see if the variances are identical before and after the workshop.

Figure 4: F-test for variance equality

```
> #Loading test scores before workshop
> bft_wrkshp <- c(4.6, 7.8, 9.1, 5.6, 6.9, 8.5, 5.3, 7.1, 3.2, 4.4)
> #Loading test scores after workshop
> aftr_wrkshp <- c(6.6, 7.7, 9.0, 6.2, 7.8, 8.3, 5.9, 6.5, 5.8, 4.9)
>
> # F-test for equality of variances
> var.test(bft_wrkshp, aftr_wrkshp)

        F test to compare two variances

data:  bft_wrkshp and aftr_wrkshp
F = 2.2698, num df = 9, denom df = 9, p-value = 0.2379
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.5637943 9.1383331
sample estimates:
ratio of variances
          2.269833
```

The p-value of 0.2379 shows that there is insufficient evidence to reject the null hypothesis, which assumes that the two groups have equal variances. The variance ratio's 95 percent confidence interval contains one, indicating that the variances are not significantly different.

We will use a paired t-test in this instance because the data points being tested are from the same subjects before and after the session and have equal variances. The null hypothesis is that there is no significant difference in mean sleep scores before and after the meditation workshop, while the alternate hypothesis is that there is a significant difference in mean scores.

Figure 5: Sleep score hypothesis testing at the 95% significance level

```
> #Two Sample Hypothesis testing with significance level at 0.05
> t.test(bft_wrkshp, aftr_wrkshp, paired = TRUE, conf.level = .95)

        Paired t-test

data:  bft_wrkshp and aftr_wrkshp
t = -1.9481, df = 9, p-value = 0.08322
alternative hypothesis: true mean difference is not equal to 0
95 percent confidence interval:
 -1.33995222  0.09995222
sample estimates:
mean difference
          -0.62
```

The p-value of 0.08322 is higher than the standard level of significance of 0.05. This indicates that the evidence is insufficient to reject the null hypothesis. In other words, there is insufficient statistical evidence to infer that the mean difference differs significantly from zero. The mean difference has a 95% confidence interval of -1.33995222 to 0.09995222. The observed difference in mean between the two groups is -0.62. In conclusion, the results do not support rejecting the null hypothesis. There is no compelling evidence to imply that there is a substantial difference in means before and after the workshop. The negative mean difference implies that before-workshop scores are lower than after-workshop scores on average, but this difference is not statistically significant at the 0.05 significance level.

We perform the same test at 0.10 significance level.

Figure 5: Sleep score hypothesis testing at 90% significance level

```
> #Two Sample Hypothesis testing with significance level at 0.1
> t.test(bft_wrkshp, aftr_wrkshp, paired = TRUE, conf.level = .90)

        Paired t-test

data:  bft_wrkshp and aftr_wrkshp
t = -1.9481, df = 9, p-value = 0.08322
alternative hypothesis: true mean difference is not equal to 0
90 percent confidence interval:
 -1.20340497 -0.03659503
sample estimates:
mean difference
          -0.62
```

The p-value of 0.08322 is lower than the level of significance of 0.10. This indicates that the evidence is sufficient to reject the null hypothesis. In other words, there is statistical evidence to infer that the mean difference differs from zero. The mean difference has a 90% confidence interval of -1.20340497 to -0.03659503. The observed difference in mean between the two groups is -0.62. In conclusion, the results accept alternative hypothesis that is there is substantial difference in means before and after the workshop. The negative mean difference implies that before-workshop scores are lower than after-workshop scores on average, and this difference is statistically significant at the 0.10 significance level.

Conclusion

We were able to perform normality check, two-sample t-tests on cats data and also performed variance equality test with help of F-test and paired t-test on the meditation dataset. After hypothesis testing, we could conclude that male cats have statistically larger mean weights than female cats. We were also able to comprehend the significance of confidence intervals in our mediation workshop analysis, as well as how confidence intervals can influence the outcome of our hypothesis. Our research revealed that meditation had no significant influence on sleep scores at 95% confidence interval, although there was a significant difference in average mean scores at 90% confidence interval.

Citations

R Documentation, An introduction to R. Retrieved 5th December 2023 from https://cran.r-project.org/doc/manuals/r-release/R-intro.html#Related-software-and-documentation

Null hypothesis, Retrieved 5th December 2023 from https://byjus.com/maths/null-hypothesis/