

Problem 19.

Matlab commands: `x = data matrix, boxplot(x), anova1(x)`

Boxplots: 4 control groups of 5 mice each. Boxplots show non-normality. The largest difference is between the third and the fourth boxplots. (Question: why the third boxplot has no upper whisker?)

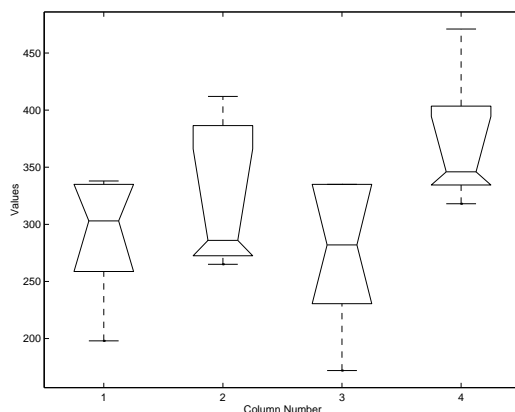


Figure 1: *Boxplots*

H_0 : no systematic differences between groups.

One way ANOVA: $I = 4$ independent samples of size $J = 5$

| Source | SS | df | MS | F |
|---------|-------|----|------|-------|
| Columns | 27230 | 3 | 9078 | 2.271 |
| Error | 63950 | 16 | 3997 | |
| Total | 91190 | 19 | | |

$P = 0.1195$. Accept H_0 at 10% significance level.

Kruskal-Wallis test. Pooled sample ranks

- group I: 2, 6, 9, 11, 14, $\bar{R}_{1.} = 8.4$
- group II: 4, 5, 8, 17, 19, $\bar{R}_{2.} = 10.6$
- group III: 1, 3, 7, 12.5, 12.5, $\bar{R}_{3.} = 7.2$
- group IV: 10, 15, 16, 18, 20, $\bar{R}_{4.} = 15.8$

$$K = \frac{12 \cdot 5}{20 \cdot 21} ((8.4 - 10.5)^2 + (10.6 - 10.5)^2 + (7.2 - 10.5)^2 + (15.8 - 10.5)^2) = 6.20$$

$\chi_3^2(0.1) = 6.25$. Accept H_0 at 10% significance level.

Problem 24.

$I = 3$ treatments on $J = 10$ subjects with $K = 1$ observations per cell.
 H_0 : no treatment effects.

Results of `anova2(x)`:

| Source | SS | df | MS | F |
|-------------------|-------|----|--------|--------|
| Columns (blocks) | 0.517 | 9 | 0.0574 | 0.4683 |
| Rows (treatments) | 1.081 | 2 | 0.5404 | 4.406 |
| Error | 2.208 | 18 | 0.1227 | |
| Total | 3.806 | 29 | | |

Two P-values: columns = 0.8772, rows = 0.0277. Reject H_0 at 5% significance level.

Friedman's test. Ranking within blocks:

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|-------------------|
| 1 | 2 | 3 | 2 | 1 | 2 | 1 | 3 | 1 | 3 | $\bar{R}_1 = 1.9$ |
| 2 | 1 | 1 | 3 | 2 | 1 | 3 | 1 | 2 | 2 | $\bar{R}_2 = 1.8$ |
| 3 | 3 | 2 | 1 | 3 | 3 | 2 | 2 | 3 | 1 | $\bar{R}_3 = 2.3$ |

$Q = \frac{12 \cdot 10}{3 \cdot 4} ((1.8 - 2)^2 + (1.9 - 2)^2 + (2.3 - 2)^2) = 1.4$
 $\chi^2_2(0.1) = 4.61$. Accept H_0 at 10% significance level.

Problem 26.

Boxplots: 3 types of stopwatches.

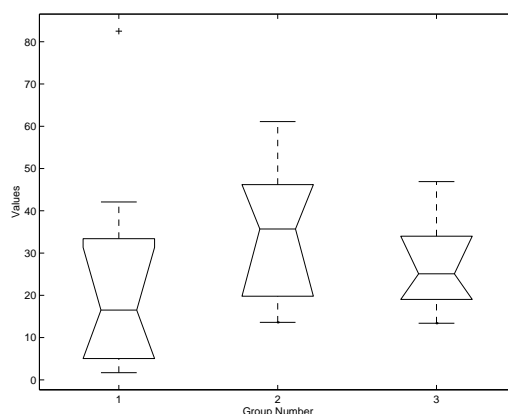


Figure 2: *Boxplots*

H_0 : no systematic differences between groups.

One way ANOVA table

| Source | SS | df | MS | F |
|---------|-------|----|-------|--------|
| Columns | 446.6 | 2 | 223.3 | 0.4974 |
| Error | 7632 | 17 | 449 | |
| Total | 8079 | 19 | | |

$P = 0.6167$. Accept H_0 at 10% significance level.

Kruskal-Wallis test. Pooled sample ranks

group I: 1, 2, 3, 4, 7, 10.5, 14, 15, 20, $\bar{R}_1 = 8.5$
 group II: 6, 8, 12, 16.5, 16.5, 19, $\bar{R}_2 = 13.0$
 group III: 5, 9, 10.5, 13, 18, $\bar{R}_3 = 11.1$

$K = \frac{12}{20 \cdot 21} (9 \cdot (8.5 - 10.5)^2 + 6 \cdot (13.0 - 10.5)^2 + 5 \cdot (11.1 - 10.5)^2) = 2.15$
 $\chi_2^2(0.1) = 4.61$. Accept H_0 at 10% significance level.

Problem 27.

$I = 3$ poisons and $J = 4$ treatments with $K = 4$ observations per cell.
 H_A : no poison effect, H_B : no treatment effect, H_{AB} : no interaction.

a) Survival in hours $x =$ data matrix 12×4 . Results of `anova2(x,4)`:

| Source | SS | df | MS | F |
|----------------------|-------|----|-------|-------|
| Columns (treatments) | 91.9 | 3 | 30.63 | 14.01 |
| Rows (poisons) | 103 | 2 | 51.52 | 23.57 |
| Intercation | 24.75 | 6 | 4.124 | 1.887 |
| Error | 78.69 | 36 | 2.186 | |
| Total | 298.4 | 47 | | |

Three P-values: columns = 0.0000, rows = 0.0000, interaction = 0.1100. Reject H_A and H_B at 1% significance level, accept H_{AB} at 10% significance level.

- 3 poisons act differently
- 4 treatments act differently
- some indication of interaction.

The normal probability plot of residuals reveals non-normality:

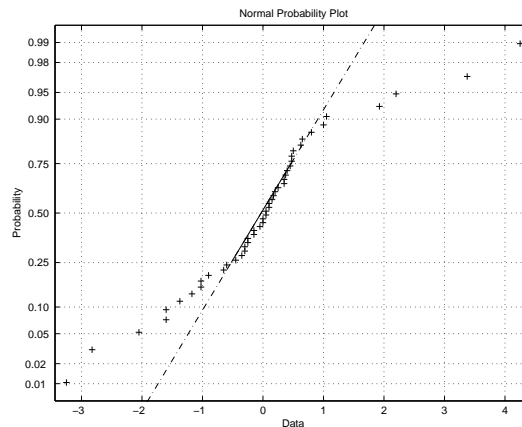


Figure 3: *Normplot a*

b) Transformed data: death rate = 1/survival time. Results of `anova2(x.^(-1),4)`:

| Source | SS | df | MS | F |
|----------------------|---------|----|--------|-------|
| Columns (treatments) | 0.204 | 3 | 0.068 | 28.41 |
| Rows (poisons) | 0.349 | 2 | 0.174 | 72.84 |
| Intercation | 0.01157 | 6 | 0.0026 | 1.091 |
| Error | 0.086 | 36 | 0.0024 | |
| Total | 0.6544 | 47 | | |

Three P-values: columns = 0.0000, rows = 0.0000, interaction = 0.3864. Reject H_A and H_B at 1% significance level, accept H_{AB} at 10% significance level.

- 3 poisons act differently
- 4 treatments act differently
- no indication of interaction.

The normal probability plot of residuals reveals a closer fit to normality assumption:

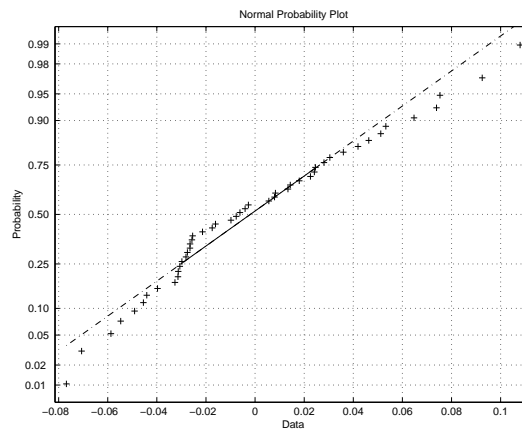


Figure 4: *Normplot b*