MAS programmes - Statistical Analysis (Autumn Term)

Exercises 7 - SOLUTIONS

1. Using the data frame `keyboard` [see solutions to Exercises 6]. Note: you may also need to refit the ANOVA object `keyboard.aov`.

(a)
```
> pairwise.t.test(score,method, p.adj="none")

        Pairwise comparisons using t tests with pooled SD

data:  score and method

  A       B       C
B 0.03671 -       -
C 0.01047 0.59845 -
D 0.09277 0.00041 8.5e-05

P value adjustment method: none

> keyboard.aov <- aov(score ~ method, data = keyboard)
> Tukey.keyboard<-TukeyHSD(keyboard.aov)
> Tukey.keyboard
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = score ~ method, data = keyboard)

$method
    diff        lwr         upr     p adj
B-A -4.9 -10.982495  1.18249453 0.1512083
C-A -6.1 -12.182495 -0.01750547 0.0491186
D-A  3.9  -2.182495  9.98249453 0.3250603
C-B -1.2  -7.282495  4.88249453 0.9508776
D-B  8.8   2.717505 14.88249453 0.0022085
D-C 10.0   3.917505 16.08249453 0.0004749
```

The Fisher approach shows that the effects of Methods A and D are both significantly better than the effects of both of Methods B and C. The effects of Methods A and D are not significantly different from each other. The effects of Methods B and C are not significantly different from each other.

The conclusions from the more conservative Tukey approach are essentially the same, except that the effects of Methods A and B do not differ significantly from each other.

(b)
```
> c1 <- c(3, -1, -1, -1)
> c2 <- c(0, 2, -1, -1)
> c3 <- c(0, 0, 1, -1)
>
> ctr <- matrix(c(c1, c2, c3), nrow = 4)
> contrasts(keyboard$method) <- ctr
>
> keyboard.aov <- aov(score ~ method, data = keyboard)
> summary(keyboard.aov, split = list(method = list("A v B,C,D" = 1, "B v C,D" = 2,
+                                                    "C v D,E" = 3)))
```

```
                  Df Sum Sq Mean Sq F value   Pr(>F)    
method             3  638.3   212.8   8.343 0.000243 ***
  method: A v B,C,D  1   42.0    42.0   1.647 0.207540    
  method: B v C,D    1   96.3    96.3   3.775 0.059884 .  
  method: C v D,E    1  500.0   500.0  19.606  8.5e-05 ***
Residuals         36  918.1    25.5                     
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1
```

According to this approach there is no significant difference between Method A and the others, nor between Method B and Methods C and D. There is a highly significant difference between Methods C and D. (The latter accounts for 78% of the sum of squares for method.)

2. You will need the data frame `tyres` [see solutions to Exercises 6].

```
> c1 <- c(1, 1, -1, -1)
> c2 <- c(1, -1, 1, -1)
> c3 <- c(1, -1, -1, 1)
> ctr <- matrix(c(c1, c2, c3), nrow = 4)
> contrasts(tyres$position) <- ctr
> tyres.aov <- aov(wear ~ position, data = tyres)
> summary(tyres.aov)
            Df Sum Sq Mean Sq F value   Pr(>F)
position     3 1189.0   396.3   13.74 6.28e-06 ***
Residuals   32  923.1    28.8
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

> summary(tyres.aov, split = list(position = list("front v rear" = 1, "offside v nearside" = 2,
                                                  "interaction" = 3)))
                                Df Sum Sq Mean Sq F value   Pr(>F)
position                         3 1189.0   396.3  13.739 6.28e-06 ***
  position: front v rear         1 1006.8  1006.8  34.901 1.42e-06 ***
  position: offside v nearside   1  180.9   180.9   6.272   0.0176 *
  position: interaction          1    1.3     1.3   0.045   0.8332
Residuals                       32  923.1    28.8
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1
```

There is very strong evidence of overall differences in wear among the four positions for the tyres.

The wear on the rear tyres is significantly greater than on the front tyres, the difference being very highly significant ($p = 0.0000014$). The wear on the offside tyres is significantly greater than on the nearside tyres ($p = 0.0176$). The sums of squares for the corresponding contrasts account for 99.9% of the total sum of squares for position. The third contrast, for interaction, is not significant.