**1**

An experiment was carried out to investigate the effect of incubation temperature and concentration of bacterial inoculum on measurement of log(m-prime) which is the log-concentration of an antibiotic at which the edge of a zone of inhibition of the bacteria on an agar plate occurs. The recommended method uses a temperature of 30°C and an initial inoculum of bacteria of $10^5$ c.f.u/ml.

The experiment used three temperatures and four inoculum levels and was replicated three times. For MINITAB, temperatures are coded 1,2 & 3 and the initial inocula are coded 1,2,3 & 4.
The calculated values of log ('m-prime') and an ANOVA using Minitab were as follows:

| | Temperature °C | | |
|---|---|---|---|
| Inoculum | 25 | 30 | 35 |
| $0.5 \times 10^5$ | 2.18 2.42 2.37 | 1.40 1.65 1.36 | 1.90 2.00 2.20 |
| $1.0 \times 10^5$ | 1.45 1.50 1.55 | 1.20 1.20 2.00 | 1.50 1.80 1.70 |
| $2.0 \times 10^5$ | 1.55 1.65 1.60 | 1.60 1.55 1.45 | 1.00 1.60 1.30 |
| $4.0 \times 10^5$ | 1.40 1.40 1.50 | 1.55 1.65 1.70 | 1.40 1.30 1.60 |

Analysis of Variance (Balanced Designs) **with some values replaced by #**

Analysis of Variance for log(mprime)

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| temp | # | 0.21391 | 0.10695 | 2.96 | 0.071 |
| dosage | # | 1.29692 | 0.43231 | 11.95 | 0.000 |
| temp*dosage | # | 1.21349 | 0.20225 | 5.59 | # |
| Error | # | 0.86813 | 0.03617 | | |
| Total | # | 3.59246 | | | |

**Table of means**

Means

| temp | N | log(mprime) |
|---|---|---|
| 1 | 12 | 1.7142 |
| 2 | 12 | 1.5258 |
| 3 | 12 | 1.6083 |

| innoc | N | log(mprime) |
|---|---|---|
| 1 | 9 | 1.9422 |
| 2 | 9 | 1.5444 |
| 3 | 9 | 1.4778 |
| 4 | 9 | 1.5000 |

pto…

| temp | innoc | N | log(mprime) |
|---|---|---|---|
| 1 | 1 | 3 | 2.3233 |
| 1 | 2 | 3 | 1.5000 |
| 1 | 3 | 3 | 1.6000 |
| 1 | 4 | 3 | 1.4333 |
| 2 | 1 | 3 | 1.4700 |
| 2 | 2 | 3 | 1.4667 |
| 2 | 3 | 3 | 1.5333 |
| 2 | 4 | 3 | 1.6333 |
| 3 | 1 | 3 | 2.0333 |
| 3 | 2 | 3 | 1.6667 |
| 3 | 3 | 3 | 1.3000 |
| 3 | 4 | 3 | 1.4333 |

(i) Using the analysis of variance table write out a table listing the sources as given above and completing the **column labelled DF** in the printout above.
(Do not write out all the other figures!)

(ii) The p-value for the interaction 'temp*dosage' has been removed. Test using statistical tables whether or not there is an interaction between temperature and inoculum level.

(iii) Re-write the table of means, properly labelled in a manner suitable for publication in a scientific journal.

(iv) Sketch a suitable response plot.

(v) Calculate the Least Significant Difference for comparing the means in your response plot and use it to explain the apparent pattern of response to temperature changes for each dosage.

## 2

An experiment was carried out to investigate the retention of ascorbic acid in a particular type of beans under storage conditions. Three storage temperatures $-10^{o}$C, $-20^{o}$C and $-30^{o}$C and four storage times 2, 4, 6 and 8 weeks were compared. A three by four factorial design was used with each treatment replicated 3 times.
The following ANOVA table was obtained from MINITAB with its associated tables of means. Some figures in the ANOVA have been replaced by asterisks.

```
ANOVA

Factor      Type  Levels     Values
Temp        fixed   3        1     2     3
Storage     fixed   4        1     2     3     4

ANOVA for ascorbic acid
Source           df         SS         MS         F          p
Temp             *       334.389    167.19     236.04      0.000
Storage          *        40.258     13.51      19.08      0.000
Interaction      *        34.056      ***        ***
Error            *        17.000      0.708
Total            *       425.927


Means for temp
1     15.325
2     13.825
3      8.225
ALL   12.458

Means for Storage
1     13.767
2     13.100
3     12.000
4     10.967
ALL   12.458

Means for interaction
      Temp  Storage    Mean
            1     1     15.000
            1     2     15.700
            1     3     15.300
            1     4     15.300
            2     1     15.000
            2     2     14.300
            2     3     13.700
            2     4     12.300
            3     1     11.300
            3     2      9.300
            3     3      7.000
            3     4      5.300
```

(i) Complete the columns in the ANOVA table for the degrees of freedom, mean squares and F-values.

(ii) Test whether there is any evidence of interaction between the temperature and the duration of storage.

(iii) Use the computer output from above to complete the following table giving the figures correct to 1 d.p.

| | Temperature | | | |
|---|---|---|---|---|
| Storage | $-10^{o}$C | $-20^{o}$C | $-30^{o}$C | Mean |

2 weeks

4 weeks

6 weeks

8 weeks

Mean

(iv) Draw a response plot to illustrate the possible interaction.

(v) Calculate a suitable Least Significant Difference for comparing the appropriate means and use it to explain what conclusions can be drawn from the table.

**3**

Nitrogen dioxide is an air pollutant caused in part by traffic. A study of its effect on lung function tested serum fluorescence in mice exposed to 0.5ppm $NO_2$ for 10, 12 and 14 days compared with control mice whose serum fluorescence was also measured at 10, 12 and 14 days. Thirty-six mice were used, each being tested once. High values indicate greater lung damage.

| | Serum fluorescence | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **10 days** | | | **12 days** | | | **14 days** | | |
| **Control group** | 143 | 169 | 95 | 179 | 160 | 87 | 76 | 40 | 119 |
| | 111 | 132 | 150 | 115 | 171 | 146 | 72 | 163 | 78 |
| **Exposed to $NO_2$** | 152 | 83 | 91 | 141 | 132 | 201 | 149 | 104 | 125 |
| | 86 | 150 | 108 | 242 | 209 | 114 | 147 | 200 | 178 |

An analysis of variance is given below:

**Analysis of Variance for serum-fluorescence**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Exposure | 1 | 4579 | 4579 | 3.17 | 0.085 |
| Time | 2 | 10600 | 5300 | 3.67 | 0.037 |
| Exposure*time | 2 | 10062 | 5031 | 3.48 | 0.044 |
| Error | 30 | 43312 | 1444 | | |
| Total | 35 | 8553 | | | |

(a) The above is a factorial experiment. What are the two factors and how many levels has each? How many replicates are there?

(b) Calculate the mean for each of the six treatments and draw a response plot. Does this suggest that there is interaction between the two factors?

(c) Using the analysis of variance, carry out a significance test to determine whether there is evidence of interaction.

(d) Calculate a suitable Least Significant Difference (LSD) to test for differences among the six treatment means calculated for (b) and explain which differences are significant.

(e) The above data are genuine. There appears to be something radically wrong. What is it?

**4**

A biologist carried out an experiment to explore the strength of different lures in attracting spruce moths in relation to the position of the lures on the tree. He placed traps at four different positions in the tree: ground, lower branches, middle branches and top branches with three types of lure: chemical, scent and sugar. He counted the number of spruce moths found in each trap after 48 hours. The results from the experiment are given below.

Rows: Location     Columns: Lure

| | **Chemical** | **Scent** | **Sugar** |
|---|---|---|---|
| **Ground** | 22 25 14 16 19 | 17 12 13 19 14 | 18 27 15 29 16 |
| **Lower** | 35 39 41 31 34 | 44 21 38 32 9 | 22 17 21 29 27 |
| **Middle** | 37 40 18 28 36 | 39 12 42 25 21 | 16 28 14 17 12 |
| **Top** | 32 29 16 18 20 | 28 19 32 15 13 | 35 22 33 21 17 |

The data were analysed using analysis of variance. The computer output of this analysis is below. Some of the numbers have been replaced by asterisks.

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Location | * | 1169.4 | 389.8 | 7.27 | 0.000 |
| Lure | * | 327.0 | 163.5 | 3.05 | 0.057 |
| Interaction | * | 809.0 | 134.8 | * | * |
| Error | * | 2573.6 | 53.6 | | |
| Total | 59 | 4879.0 | | | |

Treatment means

| | Chemical | Scent | Sugar | All |
|---|---|---|---|---|
| Ground | 20.0 | 15.5 | 22.6 | 19.8 |
| Lower | 36.4 | 34.7 | 24.0 | 32.6 |
| Middle | 33.8 | 32.3 | 19.2 | 30.0 |
| Top | 24.8 | 24.0 | 27.6 | 25.5 |
| All | 30.3 | 28.7 | 23.8 | 27.8 |

a) What is the name for the experimental design used in the above study? What are the two factors? What is the number of levels for each factor? How many different treatments are there? What is the number of replicates for each treatment? What is the total number of observations?

b) Replace the asterisks in the columns with the appropriate values for the degrees of freedom, mean square and F-value in the Minitab ANOVA output above.

c) Draw a response plot with the 12 treatment means in the last table above. Does the response plot suggest that there is an interaction between Location and Lure?

d) Using the ANOVA output in the first table above, carry out a significance test to determine whether there is any evidence of interaction between Location and Lure.

e) Calculate a suitable Least Significant Difference (LSD) to test for differences among the 12 treatment means in the last table above. Explain which differences are significant and what conclusions could be drawn from the experiment.

**5**

The car company Ectel has developed a new car filter that reduces pollution from exhaust gases. However, it is very important that such filters do not increase noise pollution by reducing gas pollution. Therefore, the noise level (decibels) for the new Ectel filter was compared with a standard filter for three different sizes of vehicle (small, medium and large). The data are presented in the table below.

Noise level reading (decibels) according to type of silencer and vehicle size

| | | Vehicle size | | |
|---|---|---|---|---|
| | | **Small** | **Medium** | **Large** |
| **Type of silencer** | **Standard** | 810 820 820<br>835 835 835 | 840 840 845<br>845 855 850 | 785 790 785<br>760 760 770 |
| | **Ectel filter** | 820 820 820<br>825 825 825 | 820 820 825<br>815 825 825 | 775 775 775<br>770 760 765 |

a) The data in the above table are based on a factorial design with two factors. State the response variable, the factors, the levels for each factor, the number of replications for each treatment combination and the total number of observations.

b) Replace the asterisks in the table below with the appropriate values for the degrees of freedom and the F-value for interaction.

Analysis of variance for Noise level reading (decibels)

```
Source             DF        SS        MS        F        P
Vehicle size        *   26051.4   13025.7   199.12    0.000
Type of silencer    *    1056.3    1056.3    16.15    0.000
Interaction         *     804.2     402.1        *        *
Error               *    1962.5      65.4
Total              35   29874.3
```

c) Draw a response plot with the appropriate means in the table below. Does it suggest that there is interaction between Vehicle size and Type of silencer?

Table of means

| | | Vehicle size | | | All |
|---|---|---|---|---|---|
| | | **Small** | **Medium** | **Large** | |
| **Type of silencer** | **Standard** | 825.83 | 845.83 | 775.00 | 815.55 |
| | **Ectel filter** | 822.50 | 821.67 | 770.00 | 804.72 |
| **All** | | 824.17 | 833.75 | 772.50 | 810.14 |

d) Using the F-value for interaction you calculated in b) above for the second table, carry out a significance test to determine whether there is any evidence of interaction between Vehicle size and Type of silencer.

e) Calculate a suitable Least Significant Difference to compare the means for interaction in the table of means above. Explain which differences are significant and draw appropriate conclusions.

**6**

Bird feathers could serve as indicators of environmental pollution. Birds could be exposed to contaminants by direct contact or via ingestion of water or food. Raptors (birds of prey) are particularly good bioindicators because they feed at the top of the food chain and could accumulate contaminants to a level that is easily detectable. Table 10.1 below contains the concentration of cadmium (Cd), lead (Pb) and mercury (Hg) in falcon feathers (ppm dry weight) in three different regions of the country. The feathers of four different birds were used to measure metal concentrations for each region.

**Metal concentrations (ppm dry weight) in feathers of falcons collected in three different regions of the country; Cd – cadmium, Pb – lead, Hg - mercury**

| | | **Region** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1** | | **2** | | **3** | |
| **Heavy metal** | **Cd** | 0.62 | 0.58 | 0.58 | 0.61 | 0.61 | 0.60 |
| | | 0.61 | 0.59 | 0.60 | 0.59 | 0.72 | 0.73 |
| | **Hg** | 0.62 | 0.58 | 1.53 | 1.71 | 3.16 | 2.96 |
| | | 0.61 | 0.59 | 1.48 | 1.77 | 3.14 | 3.18 |
| | **Pb** | 1.18 | 1.21 | 2.76 | 2.45 | 0.93 | 0.87 |
| | | 1.19 | 1.23 | 2.63 | 2.68 | 1.10 | 0.94 |

a) The data in the table above are based on a factorial design with two factors. State the response variable, the factors, the levels for each factor, the number of replications for each treatment combination and the total number of observations.

b) Use the MINITAB output in the table below to test for any evidence of:
   i) an interaction between the factors;
   ii) a main effect of either factor.

**ANOVA for metal concentrations (ppm dry weight) in falcon feathers**

```
Source               DF        SS         MS        F       P
Heavy metal           2   20.1604    10.0802   993.22   0.000
Region                2    0.1277     0.0638     6.29   0.006
Heavy metal*Region    4   10.9989     2.7497   270.93   0.000
Error                27    0.2740     0.0101
Total                 35  31.5610
```

c) Draw a response plot with the appropriate means from the table below. Does it suggest that there is interaction between Region and Heavy metal? [Tip: Put Heavy metal on the x-axis.]

**Table of means**

| | | **Region** | | | **Overall Mean** |
|---|---|---|---|---|---|
| | | **1** | **2** | **3** | |
| **Heavy metal** | **Cd** | 0.600 | 0.595 | 0.665 | 0.620 |
| | **Hg** | 2.622 | 1.623 | 3.110 | 2.452 |
| | **Pb** | 1.202 | 2.630 | 0.960 | 1.597 |
| | **Overall Mean** | 1.475 | 1.616 | 1.578 | 1.556 |

d) On the basis of your answers to (b) above calculate the LSD where appropriate and explain clearly what is shown by the study about the pollution by the three metals (Cd, Hg and Pb) in the three different regions of the country.

**7**

A nutritionist studied the inactivation of vitamin A in rancid fat (Sokal, RR & Rohlf FJ 1995. Biometry. New York: WH Freeman and Co.). As part of the study, the consumption of food by rats when it contained fresh or rancid fat was investigated. The experiment was carried out on 6 male and 6 female rats. Three randomly selected individuals from each sex were fed with food containing fresh fat and the other three individuals from each sex were fed food with rancid fat. Food consumption in grams was recorded. The data are presented in the table below.

**Data on consumption of food (g) containing fresh or rancid fat by male and female rats**

| Rows: Sex | Columns: Type of Fat | |
|---|---|---|
| | **Fresh** | **Rancid** |
| **Male** | 709 679 699 | 592 538 476 |
| **Female** | 657 594 677 | 508 505 539 |

The data were analysed using analysis of variance. The computer output of this analysis is in the tables below. Some of the numbers have been replaced by asterisks.

**Analysis of Variance for food consumption (g) by rats**

| Source | DF | Seq SS | Adj SS | Adj MS | F | P |
|---|---|---|---|---|---|---|
| Type of Fat | * | 61204 | 61204 | 61204 | * | * |
| Sex | * | 3781 | 3781 | 3781 | * | * |
| Type of Fat*Sex | * | 919 | 919 | 919 | 0.63 | 0.450 |
| Error | * | 11667 | 11667 | 1458 | | |
| Total | 11 | 77570 | | | | |

**Treatment means for food consumption (g)**

| Rows: Sex Columns: Type of Fat | Fresh | Rancid | All |
|---|---|---|---|
| Female | 642.7 | * | * |
| Male | * | 535.3 | 615.5 |
| All | 669.2 | * | 597.8 |

a) Give the name of the experimental design used in the above study? What are the two factors? What is the number of levels for each factor? How many are the treatment combinations? What is the number of replicates for each treatment? What is the total number of observations?

b) In Analysis of Variance table above replace the asterisks in the columns with the appropriate values for the degrees of freedom and the appropriate F-values.

c) Calculate the missing means in the Treatment Means table above and draw a response plot. What does the response plot suggest?

d) Using the ANOVA output in the Analysis of Variance table above, including the missing F-values calculated in b) above, carry out significance tests to determine whether there is any effect of Fat Type, Sex or the interaction between the two on the amount of food consumed by a rat. Use the p-value if it is available and critical values otherwise.

e) Is it appropriate to calculate a Least Significant Difference (LSD) for any of the sources of variation to test for differences among the respective treatment means in Table 10.3 above? Justify your answer.

**8**

In his paper (Quinn GP (1988) Ecology of the intertidal pulmonate limpet *Siphonaria diemenensis* Quoy et Garmard. II Reproductive patterns and energetics. *Journal of Experimental Marine Biology and Ecology* 117:137-156), the author investigated the effects of adult density and season on egg mass production by intertidal limpets. Quinn manipulated adult density by making enclosures with 6, 12 or 24 individuals. Studies were carried out during two seasons: spring and summer along the lower shoreline. The data are presented in the table below.

**Data on limpet egg mass (g) by season and adult density**

Rows: **SEASON** Columns: **DENSITY**

| | **6** | **12** | **24** |
|---|---|---|---|
| **spring** | 1.167 | 1.500 | 0.667 |
| | 0.500 | 0.833 | 0.667 |
| | 1.667 | 1.000 | 0.750 |
| **summer** | 4.000 | 3.330 | 2.540 |
| | 3.830 | 2.580 | 1.830 |
| | 3.830 | 2.750 | 1.630 |

The data were analysed using analysis of variance. The computer output of this analysis is in the table below. Some of the numbers have been replaced by asterisks.

a) What is the name of the experimental design used by Quinn in the above study? What are the two factors? What is the number of levels for each factor? How many are the treatment combinations? What is the number of replicates for each treatment combination? What is the total number of observations?

b) In the ANOVA table below replace the asterisks in the columns with the appropriate values for the degrees of freedom (DF), the mean square (MS) and the F-statistic, using the same precision as for the available values in the respective column.

**Analysis of variance for limpet egg mass (g)**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| DENSITY | 2 | 4.0019 | * | 13.98 | * |
| SEASON | * | 17.1483 | 17.1483 | 119.85 | 0.000 |
| DENSITY*SEASON | * | 1.6907 | 0.8454 | * | 0.016 |
| Error | * | 1.7170 | 0.1431 | | |
| Total | 17 | 24.5580 | | | |

**Treatment Means for limpet egg mass (g)**

Rows: SEASON Columns: DENSITY

| | 6 | 12 | 24 | All |
|---|---|---|---|---|
| spring | 1.111 | 1.111 | 0.695 | 0.972 |
| summer | 3.887 | 2.887 | 2.000 | 2.924 |
| All | 2.499 | 1.999 | 1.347 | 1.948 |

c) Use the means in Treatment Means table above to draw a response plot. What evidence for interaction between season and density does the response plot provide?

d) Using the output in the ANOVA table above, including the missing F-statistic calculated in b) above, carry out hypotheses tests for any effect of Density, Season or the interaction between the two on limpet egg mass. Use the p-value if it is available and critical values for F otherwise.

e) Calculate any appropriate Least Significant Difference (LSD) to test for differences among the appropriate means in the Treatment Means table above. Summarise your results in a couple of sentences.

**9**

A sociology student interested in our TV watching habits carried out a survey for his final year project. His data on the duration of TV watching per week (h) in relation to age group and gender is presented in the table below.

**Duration of TV watching per week (h) by age group and gender; F: female, M: male; age group intervals are given in years**

Rows: **Gender** Columns: **Age Group**

| | **20-25** | **26-55** | **56+** |
|---|---|---|---|
| **F** | 25 | 32 | 44 |
| | 21 | 26 | 45 |
| | 27 | 33 | 50 |
| | 26 | 33 | 43 |
| | 31 | 28 | 51 |
| **M** | 20 | 23 | 33 |
| | 27 | 21 | 34 |
| | 20 | 24 | 38 |
| | 22 | 28 | 33 |
| | 28 | 26 | 37 |

a) Use the table above to answer the following questions. What experimental design did the student use in his study? What are the two factors involved? How many levels does each factor have? What is the number of treatment combinations? How many replicates did the student use for each treatment combination? What is the total number of observations he collected?

The data were analysed using analysis of variance. The computer output of this analysis is in the table immediately below. One p-value has been replaced by an asterisk.

**Analysis of variance (ANOVA) for TV watching per week (h)**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Age Group | 2 | 1486.87 | 743.43 | 69.48 | 0.000 |
| Gender | 1 | 340.03 | 340.03 | 31.78 | 0.000 |
| Age Group*Gender | 2 | 103.27 | 51.63 | 4.83 | * |
| Error | 24 | 256.80 | 10.70 | | |
| Total | 29 | 2186.97 | | | |

**Treatment Means for duration of TV watching per week (h)**

Rows: **Gender** Columns: **Age Group**

| | **20-25** | **26-55** | **56+** | All |
|---|---|---|---|---|
| **F** | 26.00 | 30.40 | 46.60 | 34.33 |
| **M** | 23.40 | 24.40 | 35.00 | 27.60 |
| All | 24.70 | 27.40 | 40.80 | 30.97 |

b) Use the means in the Treatment Means table above to draw a response plot. What evidence for interaction between Gender and Age Group does the response plot provide?

c) Using the output in the ANOVA table above, draw conclusions from hypothesis tests for any effect of Age Group, Gender, and the interaction between the two on the duration of TV watching per week (h). Use the p-value if it is available and critical values for F otherwise.

d) Calculate any appropriate Least Significant Difference (LSD) to test for differences among the appropriate means in the Treatment Means table above. Summarize your results in a couple of sentences.

**10**

Headache sufferers are frequently sensitive to noise even when not suffering headache. One hypothesis put forward was that learning to relax might make a subject able to tolerate louder noise but that this might not be effective for all types of headache sufferer. Two groups of 22 subjects were chosen. One group comprised people suffering from migraine headaches (MH). The other group comprised people suffering from tension headaches (TH). Half of each group (11 subjects) were picked at random and were given relaxation training (RT). The other half received no treatment (NT). Each subject then listened to a tone gradually increasing in volume. The level of volume at which the subject found the tone unpleasant was recorded as score.

**Raw data on score in relation to type of headache and type of treatment**

```
Rows: headache   Columns: treatment

       RT    NT

MH   5.70  2.80
     5.63  2.20
     4.83  1.20
     3.40  1.20
     7.20  0.43
     1.40  1.78
     4.03  3.50
     6.94  0.64
     6.88  0.95
     2.00  0.58
     1.56  0.83

TH   2.70  2.10
     4.65  1.42
     5.25  4.98
     3.78  3.36
     3.13  2.44
     3.27  3.20
     5.54  1.71
     5.12  1.24
     2.31  1.24
     1.36  2.00
     1.11  4.01

Cell Contents: score
```

a) Describe the experimental design.

b) Use the MINITAB output in the ANOVA table below to test whether there is evidence of interaction between headache type and treatment.

c) Use the MINITAB output in the ANOVA table to complete the table of means below.

**Table of means for score**

| | | Treatment type | | |
|---|---|---|---|---|
| | | RT | NT | Overall Mean |
| Headache type | MH | | | |
| | TH | | | |
| | Overall Mean | | | |

d) Draw the response plot for the interaction between headache type and treatment.

e) Calculate the appropriate LSD for comparing the means for interaction.

f) Explain what conclusions could be drawn about the hypothesis put forward on the basis of the results from the study.

**Analysis of variance (ANOVA) for score**

```
MTB > ANOVA 'score' = 'headache' 'treatment' 'headache'*'treatment';
SUBC> Means 'headache' 'treatment' 'headache'*'treatment'.

Analysis of Variance for score

Source               DF        SS        MS       F       P
headache              1     0.001     0.001    0.00   0.982
treatment             1    43.960    43.960   18.24   0.000
headache*treatment    1    11.960    11.960    4.96   0.032
Error                40    96.390     2.410
Total                43   152.312

Means

headache      N     score
MH           22    2.9855
TH           22    2.9964

treatment     N     score
RT           22    3.9905
NT           22    1.9914

headache treatment     N     score
MH        RT          11    4.5064
MH        NR          11    1.4645
TH        RT          11    3.4745
TH        NT          11    2.5182
```