**Confident Interval**

1. An analysis was made of peat soils from a number of sites which had similar vegetation. The total phosphate in the soil was as follows:

(mg/100g dry weight)

39.3 46.6 51.7 46.0 68.3 58.0

Calculate the mean and s.d. of the sample and hence find a 95% confidence interval for the mean phosphate content of the soil.

2. Using specimens from 10 children, determination of the %calcium content of sound teeth gave the following:

36.39 36.19 34.20 35.15 35.47

35.22 36.11 35.63 36.63 35.59

(i)Find 95% and 99% confidence intervals for the mean %calcium of the teeth.

3. The mean indirect bilirubin level of 16 four-day old infants was found to be 5.98 mg/100cc. The s.d. was calculated to be 3.5 mg/100cc.

Find 90%, 95% and 99% confidence intervals for the mean bilirubin level of the population.

4. A sample of 100 apparently normal adult males, aged 25, had a mean systolic blood pressure Assuming that the s.d. of the sample is 15 find

(i) a 90% C.I. for the population mean

(ii) a 95% C.I. for the population mean.of 125.

**Paired and Unpaired T-test**

1. Employees working in a factory were tested for fatigue after working in hot and cold conditions. Eight men and eight women were tested in both environments. (A high fatigue score is high fatigue.)

Men Women

160C 250C 160C 250C

1 34 42 1 51 56

2 37 39 2 53 59

3 43 46 3 41 45

4 25 25 4 59 57

5 51 50 5 37 37

6 37 41 6 42 46

7 21 26 7 61 45

8 28 30 8 52 50

(i) Is there any evidence that there was a difference in mean fatigue for the men due to the temperature?

(ii) Is there any evidence that there was a difference in mean fatigue for the women due to the temperature?

(iii) Is there any evidence that men differ from women in respect of fatigue when working at 16 (iv) Is there any evidence that men differ from women in respect of fatigue when working at 25

2. A test of reaction times after the consumption of alcohol measured the reaction time of each subject then gave them a small quantity of 90% proof alcohol and then measured their reaction time 15 minutes later.

Reaction time (secs)

Subject 1 2 3 4 5 6 7

Before 0.64 0.80 0.47 0.75 0.83 0.82 0.73

After 0.71 0.82 0.63 0.80 0.81 0.86 0.91

Did the alcohol slow the mean reaction time?

3. Urinary fluoride concentration (ppm) in sheep grazing on land exposed to fluoride pollution was measured and similar measurements were made on a group of the same type of sheep grazing on unpolluted but otherwise similar grass. The results were as follows:

Polluted land 24.2 18.7 23.0 16.1 16.8 20.9 19.7

Unpolluted land 14.2 18.3 17.2 18.4 18.0 16.3 14.7

Does the data suggest that urinary fluoride differs between the two groups?

4. Surface soil pH and subsoil pH were measured at eight locations.

Location 1 2 3 4 5 6 7 8

Surface 6.55 5.98 5.59 6.17 5.92 6.18 6.43 5.68

Subsoil 6.78 6.14 5.80 5.91 6.10 6.01 6.58 5.88

Does the data suggest that the mean pH differs for surface and subsoil?

5. An article on 'A Study of Wood Stove Particulate Em

ission' reported the following on burn time (hours) for samples of oak and pine.(The samples were all blocks of the same size.)

Burn Time (hours)

Oak 1.72 0.67 1.55 1.56 1.42 1.23 1.77

Pine 0.98 1.40 1.33 1.52 0.73 1.20 1.10

Is there any evidence that the mean burn time differs for the two woods?

**Two-sample tests for a population proportions.**

1. Of a random sample of 250 male smokers 85 said they were trying to give up smoking. In a sample of 200 female smokers 110 said that they were trying to give up smoking.

Test whether there is any significant difference in the percentages of males and females trying to give up smoking.

2. A standard treatment for asthma resulted in a major improvement in 32 out of 50 patients on a clinical trial. A new treatment gave a major improvement in 37 out of 49 patients. Can we conclude statistically that the new treatment is better?

3. In an examination 23 out of 37 male students passed at the first attempt. For the women students the numbers were 35 out of 40. Does this suggest a difference in the pass rates for men and women?

**One-way ANOVA**

2. A study on the effects of exercise on physiological and psychological variables comprised four groups of male subjects.

The test group (T) consisted of 10 participants in an exercise programme.

A control group (C) comprised 5 subjects who volunteered to take part but were unable to take part in the exercise for various reasons.

Subjects in the other two groups comprised 11 joggers (J) and 10 sedentary people (S) similar in age etc to the other two groups.

At the end of the exercise program each subject was tested and given a physical fitness score.

(This data comes from a genuine study which I do not think was very well designed. The 'control' group seems to be irrelevant.)

(i) How many treatments?

(ii) How many replicates? How many observations in total?

The ANOVA table is as follows:

Source d.f. S.S. M.S. F

--------------------------------------------------------------

Groups 3 104855.87

Error 70500.59

--------------------------------------------------------------

Total 35

(iii) Complete the above table.

(iv) Specify the hypotheses which are tested by the above.

(v) Carry out the F test and hence decide whether there is any evidence of differences between the mean fitness score for the groups.

3. The same study looked at a depression score. High values of this indicate more depression.

The means depression scores are

Group Mean n

---------------------------------

(T) 51.90 10

(C) 57.40 5

(J) 49.73 11

(S) 58.20 10

The ANOVA is

Source d.f. S.S. M.S. F.

Groups 476.87

Error

---------------------------------------------------

Total 2486.75

Complete the table and test whether mean depression scores differ

between the groups.( i.e. repeat tasks (iv) (v) (vi) as in 2 above)

1\*\*. An individual's critical flicker frequency (in cycles/sec) is the frequency at which the flicker in a flickering light source can be detected. At frequencies above the critical frequency the light source appears to be continuous even though it is actually flickering. An investigation carried out to see if true average critical frequency depends on iris colour gave the following data. (Genuine data.)

Iris colour Critical frequency (cycles/sec)

Brown 26.8 27.9 23.7 25.0 26.3 24.8 25.7 24.5

Green 26.4 24.2 28.0 26.9 29.1

Blue 25.7 27.2 29.9 28.5 29.4 28.3

Does the data support the theory that iris colour affects the critical flicker frequency?

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2\*\*. The presence of harmful insects in farm fields is detected by erecting boards which are covered with a sticky material and then examining the insects trapped on the board. To investigate which colours are most attractive to cereal leaf beetles researchers placed six boards of each of four colours in a field of oats in July. The table below gives the numbers of cereal leaf beetles trapped.  Colour Insect trapped | | | | | | | |  |
| Lemon yellow | 45 | 59 | 48 | 46 | 38 | 47 |
| White | 21 | 12 | 14 | 17 | 13 | 17 |
| Green | 37 | 32 | 15 | 25 | 39 | 41 |
| Blue | 16 | 11 | 20 | 21 | 14 | 7 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 3\*\*. The table below gives the yields of 6 wheat varieties, each being sown on five plots (with random allocation of the varieties to the plots). Examine the significance of the differences observed between the varieties.  Wheat variety | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 11 | 16 | 12 | 14 | 12 | 12 |
| 9 | 10 | 14 | 8 | 8 | 8 |
| 11 | 13 | 11 | 10 | 9 | 10 |
| 12 | 16 | 13 | 15 | 15 | 6 |
| 10 | 12 | 8 | 10 | 11 | 7 |

4\*\*. A study to determine whether the use of concentrated milk protein affected cheese production looked at the bacteria count for each of four concentrations of the protein. Five replicates were used for each concentration. The counts were as follows:

Concentration Bacteria Count

1% 39 21 48 58 63

1.16% 24 19 34 28 50

1.48% 22 12 54 16 59

1.79% 29 13 36 30 63

Does the data suggest that the bacteria count is affected by the concentration of protein?

5\*\*. An entomologist is studying the vertical distribution of a fly species in a deciduous forest and obtains four collections of the flies from three different vegetation layers; herb, shrub, and tree. Test the hypothesis that the abundance of flies is the same in all three vegetation layers.

Number of flies/m3 of foliage

Herbs 14.0 12.1 9.6 8.2

Shrubs 8.4 5.1 7.3 6.6

Trees 6.9 5.3 5.8 4.1

6\*\*. It is thought that the concentration (micro-g/cc) of a particular antigen in supernatant fluid may be related to the onset of meningitis in infants. Three groups of infants were examined and their antigen concentration determined.

Asymptomatic infants 1.56 1.06 0.87 1.39 0.71 0.87 0.95 1.51

Infants with late-onset sepsis 1.51 1.78 1.45 1.13 1.87 1.89 1.07 1.72

Infants with late-onset meningitis 1.21 1.34 1.95 2.00 2.27 0.88 1.67 2.57

Carry out a one-way analysis of variance and determine which groups differing antigen concentration (if any).

**2-way ANOVA**

1. The amount of the active ingredient of a drug which can be produced from 500g of the original compound seems to be dependent on the temperature used and on the source of a plant derivative used as in the drug. To determine the optimum mixture of conditions three temperatures (15C, 18C, 21C) and three sources of the plant derivative A B and C were tested with 3 replicates of each combination being used. The yields were as follows:

Plant source Temp Yield(g)

A 15 23 20 21

A 18 22 19 20

A 21 19 18 21

B 15 22 20 19

B 18 24 25 22

B 21 20 19 22

C 15 18 18 16

C 18 21 23 20

C 21 20 22 24

Carry out the required F-tests.

2. ANALYSIS OF VARIANCE for **fresh weight of leaves**

SOURCE DF SS

Date 3 11260.6

Solution 3 10.7

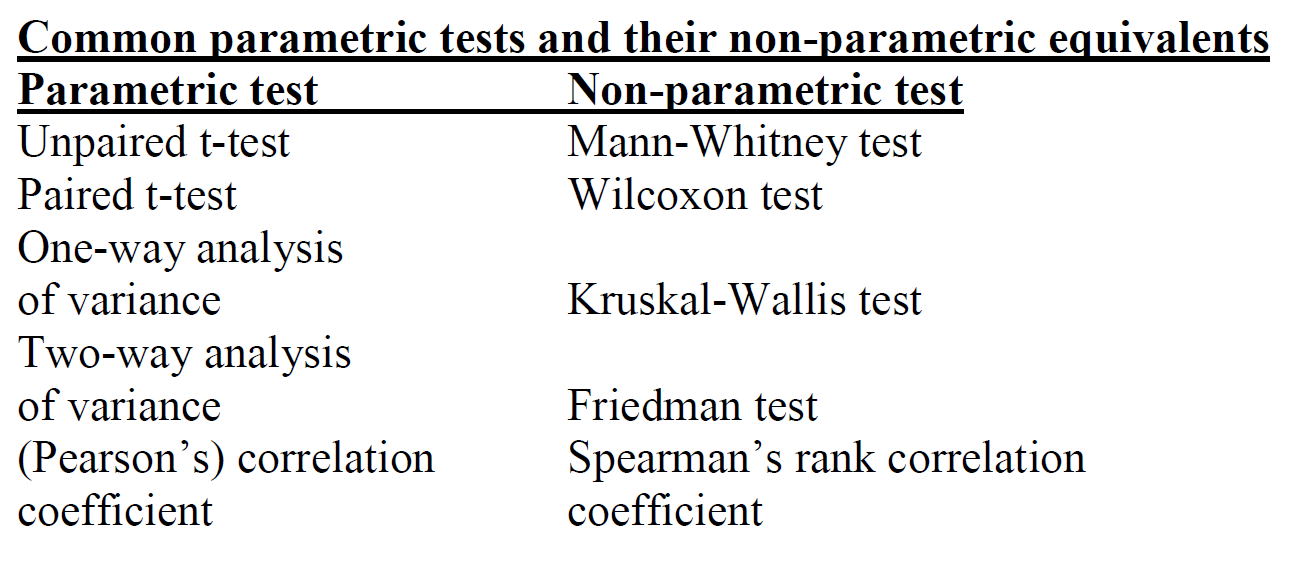
INTERACTION 9 1015.9

TOTAL 79 16236.3

a. Calculate the F-ratios.

b. Test which effects are significant.

**NON-PARAMETRIC TEST**



**Tutorial questions 1: Mann-Whitney and Wilcoxon tests**

Before starting any calculations please **read** through each example and decide whether it is a **paired test** or an **unpaired test**. One reason for doing this topic at this point is to revise the ideas of paired and unpaired designs for experiments as you could be designing your own experiments soon in the next set of lab work. It is very important that you do this exercise of deciding whether a paired or unpaired test is needed yourself. If you cannot recognise the requirements for paired or unpaired you will waste your time doing unsuitable analyses (and will lose half the marks for a question on these in the exam!)

1. Nine patients each tried two analgesic drugs A & B. The hours of pain relief were recorded:-

Patient 1 2 3 4 5 6 7 8 9

Drug A 3.2 1.6 5.7 3.6 5.5 1.2 6.1 3.4 12.9

Drug B 3.8 1.6 10.4 2.8 5.0 3.5 7.3 3.4 14.8

Is there any evidence of difference between the duration of pain relief using A & B?

2. A large corporation is suspected of sex discrimination in the salaries of the employees. From employees with similar responsibilities and work experience, 12 male and 12 female employees were randomly selected. Their salaries in thousands of pounds were:

Females

11.3 9.9 10.3 12.8 11.6 9.6 9.4 10.5 10.8 11.8 10.4 11.8

Males

11.0 10.8 11.2 12.0 12.1 11.7 10.6 12.0 10.3 32.3 11.2 11.8

Does the data give any support to the suspicions?

3. A new treatment has been tried for a particularly intractable cancer. Eight patients have been given the new treatment and eight have been given the standard treatment. The survival times in months have been recorded for the patient.

(i) Test whether the new treatment is better then the standard treatment.

|  |  |  |  |
| --- | --- | --- | --- |
| New  treatment | | Standard treatment | |
| 1 | 9 | | 7 |
| 2 | 5 | | 7 |
| 3 | 16 | | 12 |
| 4 | 13 | | 11 |
| 5 | 20 | | 16 |
| 6 | >24 | | 10 |
| 7 | 8 | | 4 |
| 8 | 22 | | 16 |

4. In a survey of water pollution the strontium level was measured in various lakes. Six replicate measurements were made at each lake. The results for Blinking Tarn and Marrick Water (names not genuine!) in mg/l were as follows:

Blinking Tarn 39.6 40.8 37.9 37.1 43.6 42.4

Marrick Water 46.3 42.1 43.5 48.8 43.7 40.1

Use a non-parametric test to ascertain whether the average level of strontium differs between the lakes.

6. Hypertension is difficult to cure but can be controlled. Drugs are generally effective but a team of researchers investigated a biofeedback relaxation technique which when combined with drugs gave very promising results. The results below show the reduction in systolic blood pressure for two independent groups. Test whether the biofeedback + drugs technique is more effective than drugs alone in reducing blood pressure.

Drugs + biofeedback Drugs only

----------------------------------------

16 15

18 12

25 20

30 18

20 30

50 35

47 40

36 22

46 38

7. A slimming program was tested by 12 people for a period of 8 weeks. Their weights at the start and finish of the test were as follows:

Weight Before (lb.) Weight After (lb.)

132.2 123.7 It is claimed that the program will

121.6 111.9 reduce weight by at least 10 lb.

156.4 141.1 Does the data support the claim?

167.9 151.4 Hint: You are trying to see if the

141.7 124.6 (weight before) - 10 = weight after

183.5 163.8

137.0 126.2

153.1 145.1

138.4 121.9

145.4 123.9

161.0 156.1

150.8 137.9

8. Eleven seedlings in pots were divided into two groups of size 5 & 6. The first group was grown in normal light, the second in restricted light. After four months the heights were measured and were as follows:

Normal Height (cm) Restricted Height (cm) Is there any evidence that light affected

46 39 the average height of the plant?

39 28 Are there any assumptions which have to

41 37 be made (which are not stated here)

36 41 before doing a t-test?

34