Week 10 Non-parametric methods

10.1 One-sample tests

ammonia

Catalytic converters have been installed in cars to reduce pollutants in exhaust emissions. However, these converters increase the level of ammonia in the air. In 2001, the journal *Environmental Science and Technology* published a study on ammonia levels near the exit of a San Fransisco road tunnel. The data represents the daily ammonia concentrations (ppm) recorded on eight randomly selected days during the evening rush-hour in the summer of 1999.

1. State the null and alternative hypotheses for the test.
2. Find the value of the sign test statistic and the observed significance level.
3. State your conclusions at significance level $\alpha = 0.05$.

guppy

In a study of the migratory behaviour of guppy fish, 30 adult female guppies were placed in the left compartment of an experimental aquarium tank which was divided in half by a glass plate. After the plate was removed, the number of fish passing through the slit from the left compartment to the right one, and vice versa, were recorded. The experiment was repeated 30 times and the numbers of fish situated in the left compartment after 5 minutes were recorded. Test the hypothesis $H_0 : \nu = 20$ against the alternative $\nu \neq 20$ using

1. a sign test,
2. a Wilcoxon signed rank test, and
3. a normal approximation to the Wilcoxon signed-rank test.

10.2 Paired samples tests

twins

Twelve pairs of identical twins are given psychological tests to determine whether the first-born of the twins tends to be more aggressive than the second-born. The file contains the test scores, where the higher score indicates a higher level of agression. Do the data provide sufficient evidence to indicate that the first-born of a pair of twins is more aggressive than the other?

hypogly

Hypoglycemia is a condition in which blood sugar is below normal limits. To compare the effectiveness of two treatments, A and B, for treating hypoglycemia, each treatment is applied to half the diaphragms of seven white mice. Blood glucose uptake (in milligrams per gram of tissue) is measured for each half. Do the data provide sufficient evidence to indicate that one of the treatments tends to produce higher blood sugar uptake readings than the other?

fonts

An experiment was conducted to compare two different fonts, A and B, to determine whether text printed using font A is easier to read. Ten subjects were randomly divided into two groups of five. Each subject was given the same material to read, one group receiving material printed using font A, the other receiving material printed using font B. The file contains the times necessary for each subject to read the material (in seconds). Do the data provide sufficient

evidence to indicate that font A is easier to read?

motorway

A motorway patrol was interested in knowing whether frequent patrolling of motorways substantially reduces the number of drivers breaking the speed limit. Two similar motorways were selected for the study, one heavily patrolled and the other only occasionally patrolled. After 1 month, random samples of 100 cars were chosen on each motorway, and the number of cars exceeding the speed limit was recorded. This process was repeated on another 4 randomly chosen days. Do the data provide sufficient evidence to indicate that the heavily-patrolled motorway tends to have fewer speeding drivers per 100 cars than the occasionally-patrolled motorway?

10.3 Two-sample tests

eyemove

In a study of visual acuity of deaf and hearing children, eye movement rates are taken on 10 deaf and 10 hearing children. A psychologist believes that deaf children have greater visual acuity than hearing children. Evaluate the psychologist's claim using a Mann-Whitney test, and then by a normal approximation to the Mann-Whitney test.

infosys

Organisations from the private sector and public sector were sampled at random, and each organisation asked what percentage of its total revenues it had spent on information systems over the previous financial year. Test whether the median amount spent by public sector organisations is greater than the amount spent by private sector firms.

exam

An educational psychologist claims that the order in which exam questions are asked affects a student's ability to answer correctly. To investigate this assertion, a class of 13 students is randomly divided into two groups, 7 in one group and 6 in the other. One set of exam questions is prepared, but are arranged in two different orders. On exam paper A, the questions are arranged in increasing difficulty (from easiest to most difficult), while on exam paper B the order is reversed. Do the data provide sufficient evidence to indicate that the order in which exam questions are asked affects a student's ability to answer correctly?

10.4 Kruskal-Wallis test

reading

Children at a primary school were taught reading by three different methods. Children were randomly assigned to three classes. One class used programmed instruction, a second used standard memorization techniques, and the third used an open classroom approach. The file records the increase in reading levels attained by five children randomly selected from each of the three classes. Do the data provide sufficient evidence to indicate that the probability distributions of increases in reading level differ for at least two of the three methods?

namegame

Psychologists at Lancaster University evaluated three methods of name retrieval in a controlled setting (*Journal of Experimental Psychology*, June 2000). A sample of 139 students was ran-

domly divided into three groups, and each group used a different method to learn the names of the other students in the group. Group 1 used the 'simple name game', where the first student states his/her full name, the second student states his/her name and the name of the first student, the third students statest his/her name and the names of the first two students, and so on. Group 2 used the 'elaborate name game', where students not only state their names but also their favourite activity (e.g. sports). Group 3 used 'pairwise introductions', where students are divided into pairs and each student must introduce the other member of the pair. One year later, all participants were sent pictures of the students in their group and asked to state the full name of each. For each respondent, the percentage of names recalled correctly was recorded.

1. Show that the conditions required for ANOVA are likely to be violated.
2. Use a Kruskal-Wallis test to compare the distributions of the percentage of names recalled correctly for the three name-retrieval methods.

`wordlist`

Three lists of words, representing three levels of abstraction, are randomly assigned to 21 subjects so that seven subjects receive each list. The subjects were asked to respond to each word on their list with as many associated words as possible within a given period of time. The file contains the total number of word associates for each subject. Do the data provide sufficient evidence to indicate a difference (shift in location) between at least two of the probability distributions of the number of word associates that subjects produce for the three lists?

10.5 Friedman test

`mosquito`

A species of Carribean mosquito is known to be resistant against certain insecticides. The effectiveness of five different insecticide (temephos, malathion, fenitrothion, fenthion and chlorpyrifos) in controlling this mosquito species was investigated. Mosquito larvae were collected from each of seven Carribean locations. In a laboratory, the larvae from each location were divided into five batches, and each batch exposed to one of the five insecticides. The dosage of insecticide required to kill 50% of the larvae was recorded, and divided by the known dosage for a susceptible mosquito species. The resulting value is called the *resistance ratio*. (The higher the ratio, the more resistant is the mosquito species to the insecticide compared to the susceptible mosquito species). The file contains the resistance ratios recorded for the study. Compare the resistance ratio distributions of the five insecticides. Are any of the insecticides more effective than any of the others?

`atlas`

Atlases are an important educational resource that are updated on a regular basis. One of the most critical aspects in the design of a new atlas design is its thematic content. In a survey of atlas users, a large sample of secondary school teachers ranked 12 thematic topics for usefulness, and the consensus rankings of the teachers, based on the percentage who responded that they would 'definitely use' the topic, was recorded. The survey was repeated four times: for a sample of teachers when they started their career, after 5 years, after 10 years, and after 15 years. The file contains the rankings of all four groups. Is there evidence that the teachers rank the importance of the topics in the same way at different stages of their career?

`boxing`

Eight amateur boxers participated in an experiment to investigate the effect of massage on

boxing performance. The punching power (measured in Newtons) was recorded in the round following each of four different interventions.

`M1`	An intervention during round 1 following a pre-bout sports massage.
`R1`	An intervention during round 1 following a pre-bout period of rest.
`M5`	An intervention during round 5 following a sports massage between rounds.
`R5`	An intervention during round 5 following a period of rest between rounds.

Test to compare the median punching power following the four interventions.

`prestige`

A sociologist performed an experiment to investigate the general public's perception of certain occupations. Each of a random sample of 15 people was asked to rank five leading professions (lawyer, politician, doctor, company director and university professor) in order of prestige. Do the data provide sufficient evidence to indicate a difference in the amount of prestige the public attaches to these five professions?

10.6 Spearman rank correlation

`defects`

A manufacturer suspects that the number of defective items produced by its employees tends to increase as the day progresses. Unknown to the employees, a complete inspection is made of every item that was produced on one day, and the hourly fraction of defective items is recorded. Do the data provide evidence that the fraction of defective items produced increases as the day progresses?

`blackbream`

A study was conducted to investigate the feeding behaviour of blackbream fish spawned in aquariums. Over a period of nine weeks, zoologists recorded the number of aggressive strikes between two blackbream fish feeding at the bottom of an aquarium during the 10-minute period following the addition of food. The file contains the number of strikes and the age of the fish (ranked from 1-9 because the exact age of the fish is unknown).

1. Find the Spearman rank correlation coefficient of the number of strikes and age of fish.
2. Are the number of strikes and age negatively correlated?