Statistics by Hand

An Introductory Course for Psychologists

Test selection

Version 3.0

Spearman's r

- If only ranks are available, the same equations can be applied. The test is then called Spearman's r or r_s
- Where $N > 9$ the critical value of r_s is numerically close to the values in a Pearson's r table.
- Even if actual data are available, we sometimes use just the ranks. The main advantage is that it avoids the assumption that X and Y are normally distributed.

Normality of distribution

Scores out of 60 (whole numbers) on a behavioural problems index
1,6,12,16,20,13,8,3,6,14,7,15,12,9,13

1-5	||
6-10	|||||
11-15	||||||
16-20	||

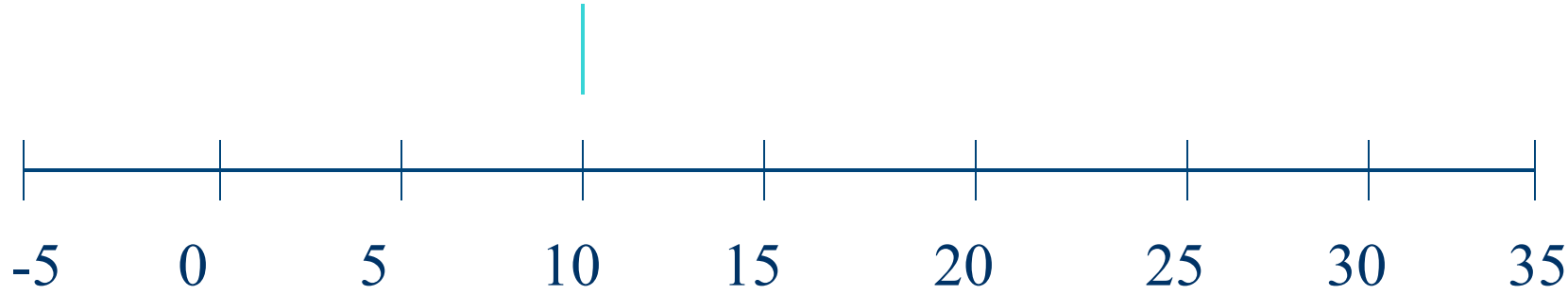
- Create roughly N/4 equal sized "bins"
- Make a mark for each number in the data set
- It'll never look great with small samples. This data set is roughly normal.

- Main things to look for: bimodality and asymmetry (skew)
- If N<10 then there's not really enough data to do this.

Outliers

- Data collection is not perfect:
  - Calculation and recording errors
  - Subject distracted by an outside event
  - Accidental inclusion of a subject from a different population (e.g. non-native English speaker in a language experiment).
- This “rogue” data can often ruin an experiment by making all effects n.s.

Outlier detection: Box plot

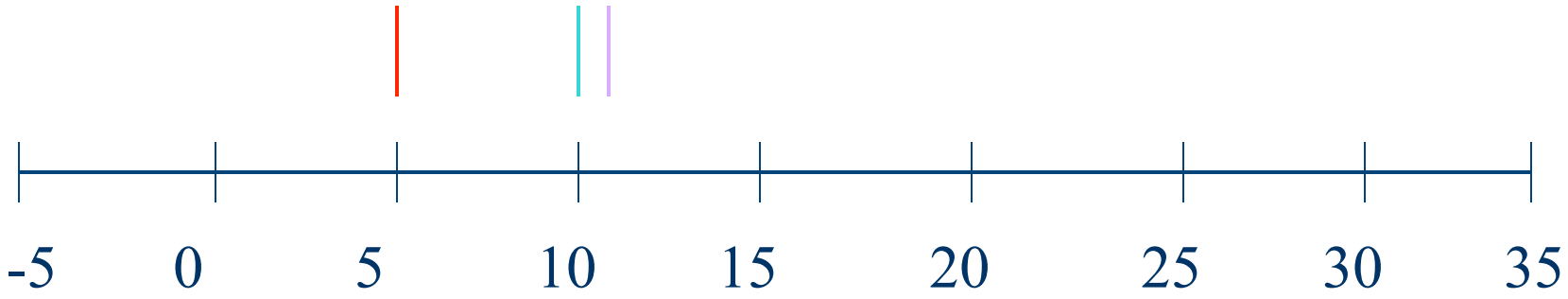


- Place data in rank order

  3, 5, 5, 7, 10, 10, 11, 11, 35

- Work out the *median* (middle value when data is placed in rank order)
  - Median = 10

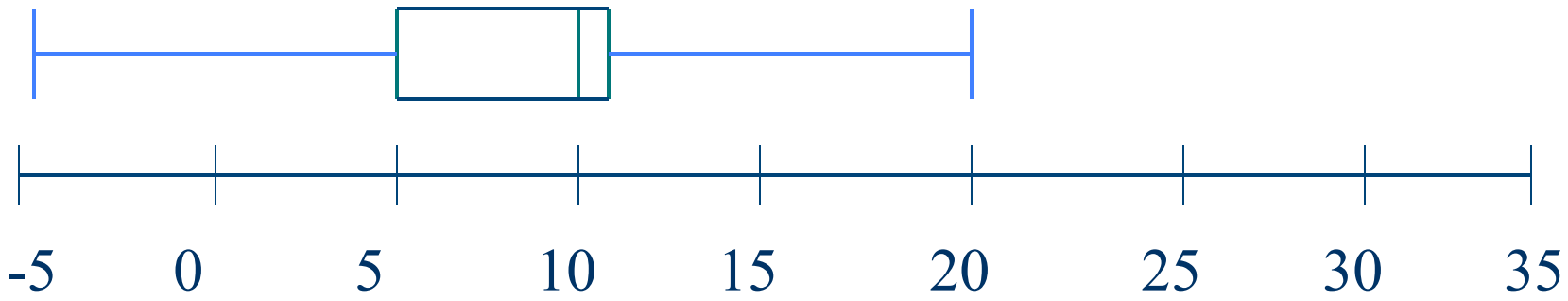
Outlier detection: Box plot



3, 5, 5, 7, 10, 10, 11, 11, 35

- Work out the *lower quartile* (half way between the median and the start)
- Work out the *upper quartile* (half way between the median and the end)

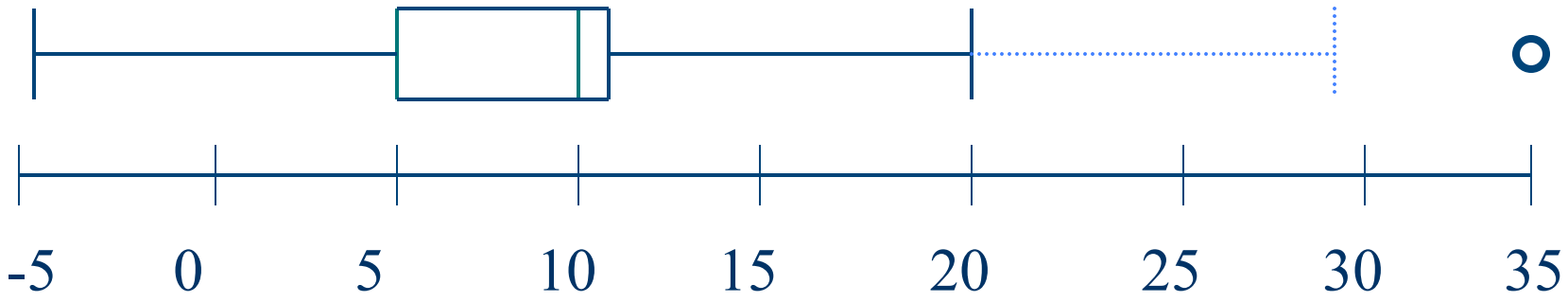
Outlier detection: Box plot



3, 5, 5, 7, 10, 10, 11, 11, 35

- Work out the inter-quartile range (11-5 = 6)
- Work out the length of the *whiskers* (1.5 x IQR) = 9

Outlier detection: Box plot



3, 5, 5, 7, 10, 10, 11, 11, 35

- Any point more than 2 whiskers beyond the nearest “hinge” is considered an outlier.

Detected: What now?

- Ideally - go back to lab notes and investigate whether there is any reason for the outlier. Exclude if a problem is discovered.
- Pragmatically - Sometimes not possible. Assume there was a problem and remove.

Where to look for outliers

- Between-subject tests
  - On each group of data separately
- Within-subject tests
  - On the differences between the two groups
- Tests not amenable to this procedure:
  - Chi-square
  - Correlation

Not in the handbook or handout.

Test selection

- All methods now covered (for this course).
- How do you select the correct test?
  - Classify tests for usage
  - 8 questions that will help your learning
  - This information not available in exam.

Classification of tests

- Group differences (means)
  - Between-subjects
    - Wilcoxon rank-sum test (Small N / non-normal / het. var.)
    - Unrelated samples t-test
  - Within-subjects
    - Wilcoxon matched-pairs test (Small N / non-normal)
    - Related samples t-test
- Group differences (variance)
    - Variance test

Classification of tests

- Relationships
  - Contingency chi-square (Categorical)
  - Pearson's correlation (Continuous & normal)
  - Spearman's correlation (Ranks, or continuous & non-normal)

Classification of tests

- Other situations
  - Z-test
    - Single data point
    - Normal population with known s.d.

Jargon

- To use the questions, you need some jargon:
  - Dependent variables
  - Independent variables
  - Categorical vs. quantitative
  - Sufficiently normal
  - Homogeneous variance

Outliers?

Example 1

A neuroscientist hypothesises that the *hippocampus* (a small brain region) is the site of the mammalian ability to learn the spatial location of objects. To test this hypothesis, he puts rats (one at a time) in a paddling pool full of milk with a submerged platform. Rats seek out the platform because they do not like swimming. He then removes the rats and places them in a holding cage for 30mins. He then times how long it takes them to find the platform a second time.

He gives the same task to a different group of rats who have had their hippocampi surgically removed. Times taken to find the platform (to the nearest second) are as follows:

Hippocampus intact	15, 30, 11, 30, 12, 47
Hippocampus removed	90, 120, 42, 382, 178, 87

Does the neuroscientist have any support for his hypothesis?

No->No->No->Quantitative ->One ->No (N/4 =1.5) -> *Wilcoxon*

(rank-sum test because it's between-subjects)

Example 2

An elderly stroke patient is referred to a clinical psychologist for testing. In order to develop a programme of rehabilitation, the psychologist needs to know where the patient's greatest difficulties lie. The psychologist decides to use significant deviation from normal performance as a "yard stick". One well-used test of fluent vocabulary is to ask the patient to name as many things beginning with the letter "C" as they can in 30 seconds. Strokes frequently reduce performance on this task. They have never been known to improve it.

The test has been administered to thousands of members of the general public (of a similar age), and it is known that scores are normally distributed, with a mean of 15.3 and a standard deviation of 6.6. The patient scores 4. Is the patient significantly impaired on the vocabulary fluency task?

No->No->Yes -> *Z-test*

Outlier test not needed

Example 4

A cognitive psychologist believes that when people have to decide whether two objects are identical they can "mentally rotate" one of them until it is the same orientation as the other. He also believes that this is basically analogous to rotation in the real world, in that it takes more time to rotate something through a large number of degrees than a small number of degrees. To this end, he tests 10 different groups of people on tasks where they have to say whether two objects are identical and the required degree of rotation differs. Here are his mean data:

Degrees	0, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200
RT (s)	1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.4, 2.9, 3.2

Are reaction time and degree of rotation significantly correlated?

No->No->No->Quantitative->Yes -> No ->

Spearman correlation

Outlier test not appropriate

Practice session

- Attempt problems F-1, F-2, F-3 and F-4 (apart from the final sentence)
  - These are exam-level questions
  - Don’t forget about outliers
  - Don’t forget about checking for normality
  - Don’t forget to homogeneity of variances where appropriate

Problems

- *CLR-1 – Assume it is a Pearson's.*
- *CLR-2 – Use histograms to determine whether it is a Pearson's or a Spearman's.* ***Do not attempt last sentence.***