Statistics by Hand
Practice problems

Wilcoxon problems

Problem W-1

The head of Eton wishes to demonstrate that people with a public school education and people with a state school education have different IQs. He asks a psychologist to administer a standard IQ test, and she tests 6 randomly selected school-leavers from Eton and 8 randomly selected school-leavers from the local comprehensive school. The scores collected are as follows:

Eton   96, 85, 112, 90, 95, 99
Comprehensive   110, 106, 103, 98, 100,101,102, 104

Has the demonstration been effective?

Problem W-2

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?

Problem W-3

A sport psychologist finds that a number of her clients report temporary improvements in visual acuity (quality of eyesight) following strenuous exercise. To her knowledge, no one has investigated this issue before, and she has no theoretical basis for explanation of these anecdotes. She decides to administer a standard eye-sight test to a number of her clients immediately before, and then again immediately after, 20 mins on an exercise bicycle. The number of letters correctly read from a distance of one metre are:

Before   18, 12, 9, 15, 22, 6, 9, 17
After   22, 22, 21, 15, 22, 11, 11, 15

Does exercise affect visual acuity?

Problem W-4

A representative of a large drugs company believes, from earlier preliminary trials, that their new drug *Recall* enhances exam performance. An unscrupulous hall of residence decides to make a little money by running a clinical trial. They lace the evening meals of sixteen second-year psychology undergraduates with the drug and then ask by how many percent their examination marks rose (or fell) compared to the previous year. Here are their results:

-20, -10, +5, +8, +7, -30, 0, -12, +9, -14, +1, 0, -50, -8, -22, +3

Does *Recall* improve exam performance?

Reality check: Problem 4 does not represent a real experiment – it breaks the British Psychological Society's code of ethics. The other three problems are based on real or allowable studies.

Variance test problems

Problem V-1

A large company has developed cash flow problems. A management consultant suspects this is due to the sales teams' performance becoming more variable. The company has many sales teams but sales figures are only available to the consultant for one of the teams. Here are the bi-monthly sales figures for the last two years for that team (in £10,000 units)

This year	32	24	9	58	12	19
Last year	98	12	98	25	3	99

Has the variability of the company's sales teams changed? Is there any other information the management consultant should draw to the attention of the managing director?

Problem V-2

An educational psychologist has noticed that many of the parents of ADHD children believe that *Ritalin* (a drug) encourages more regular sleep patterns. He decides to investigate, and measures the number of hours a particular child sleeps on each of 6 nights before taking the drug, and each of 5 nights once on the drug. The data are below:

Before drug	8.5	0.4	12.9	5.2	4.2	9.1
With drug	7	7.2	8.2	6.9	5.4	

The educational psychologist concludes that *Ritalin* does indeed promote more regular sleeping patterns. Is he right to do so?

Z-test problems

Problem Z-1

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?

Problem Z-2

A machine in a factory produces washers. When it is working normally the diameter of these washers has a mean of 7 mm, and a variance of 0.1mm. An engineer picks up a washer and finds that it has a diameter of 7.6 mm. Is the machine working normally (assuming conventional levels of significance)?

t-test problems

N.B.: The data sets for some of these problems are very small or non-normal. If you're looking at these problems as revision and thinking they might be better done as Wilcoxon tests, you may well be right.

Problem t-1

A cognitive psychologist is interested in whether top-down processing from a word level plays a part in the perception of individual letters. She hypothesises that if this is the case then the central letter of a string of letters should be identified more quickly if the string is a valid word than if it is not. She asks a number of people to identify letters in word and non-word strings, and takes average response time from each person. The results are below (in milliseconds):

Non-word	450	580	320	510	300	290
Word	420	560	240	470	270	295

A within-subject methodology was employed. Does the nature of the letter string affect identification time?

Problem t-2

A psychophysicist knows that the properties of retinal ganglion cells mean that the best way to make your whites look "whiter than white" is to hold them up against a dark background. Decades of psychophysics research make us entirely sure about the direction of the effect. What our psychophysicist wants to know is whether he can make some money out of this in advertising. He shows people two towels, one on a

dark piece of card and one against a light piece of card. He asks each person to rate the brightness of each towel on a scale of 0 to 10. Here are the results:

Against a dark background	7	8	7	8	5	5	8	8	7	8
Against a light background	6	7	6	7	5	5	6	9	7	7

Does a dark background make towels look whiter?

Problem t-3

A social psychologist hypothesises that groups are more likely to make risky decisions than individuals. She designs a series of twenty written scenarios, at the end of each of which two options are presented 1) An alternative that results in a small but certain gain, 2) An alternative that may either result in a very large gain or a large loss. She gives the scenarios to groups of three and also to a separate group of individuals. Here are the number of risky decisions made

Group of three	20	18	15	17	8	3		
Individual	10	8	9	6	10	13	9	20

Does being in a group affect the level of risk you are prepared to accept?

Problem t-4

A drugs company wishes to know whether its new product *Abstain* is effective in reducing alcohol consumption in alcoholics. Alcoholics are asked to record their consumption the week before taking the drug, and the week after. The company is wary of the fact that _any_ intervention may have an effect – an effect that may having nothing to do with the drug *per se* but with the attention received. Therefore, half the alcoholics are given a placebo (a non-active drug) and half the real drug. No one knows who gets what until after the experiment is complete. Here are the data (consumption in units):

Pre placebo	65	89	74	66	72	113	58	51	98	79
Post placebo	55	84	77	51	68	125	18	39	83	61
Pre *Abstain*	83	97	55	62	110	66	79	66	72	61
Post *Abstain*	37	67	15	42	113	42	39	0	32	41

Does the drug help? Were the company right to be concerned about a placebo effect?

Probability, Combination & Binomial test problems

Problem PCB-1

A teacher sets a four-choice multi-choice test with 5 questions. What is the probability of scoring 100% by pure guessing?

Problem PCB-2

A psychologist devises a rather dubious personality test that involves the client picking their 3 favourite colours in the rainbow. The choice is red, orange, yellow, green, blue, indigo, violet. The choice determines your personality type. How many personality types are defined by this frankly laughable test?

Problem PCB-3

In clinical trials of a drug for hypertension, use of the drug is found to increase blood pressure in 2 patients but reduce it in 7. Previous studies suggest the drug is effective. Assuming blood pressure is equally likely to increase or drop from the first to the second readings in the absence of any medication, would you conclude that the drug significantly reduces blood pressure?

Problem PCB-4

An animal learning theorist sets up a Y-shaped maze. Each of his six rats starts at the base of the Y and is free to go down either the left or right arm. However, a situation is set up such that if they go down the left arm they receive food whilst if they go down the right arm they receive a mild electric shock. After some initial training trials, the psychologist puts each rat at the base of the Y. Five rats go down the left arm and one goes down the right. Should the psychologist conclude that the rats have learned from experience? Assume there is no preference for the left or right arm prior to training.

Chi-square problems

Problem C-1

In a special promotion, a supermarket offers four different brands of tomato ketchup for sale, all at the same price. Here are the sales figures over the course of one hour – Heinz, 20; Daddy's, 12; Own brand, 9; Value brand, 3. Are people sensitive to product brand?

Problem C-2

A student of animal learning suggests that rodents will travel farther to food stores if they contain high energy food than if they contain low energy food. The number of different rodents arriving at feeders placed either 100m or 800m from the burrow are as shown below. Do these data provide support for her hypothesis?

	High-energy	Low-energy
Feeder near to burrow	67	31
Feeder far from burrow	12	2

Problem C-3

A market researcher shows 34 people a picture of Prince Phillip, and 24 different people a picture of Ricki Lake. 50% of people correctly identify Phillip, but 75% of people correctly identify Ricki. Is Ricki significantly more famous than Phillip?

Correlation and linear regression problems

Problem CLR-1

A student of clinical psychology believes that an introverted personality type may cause people to be anxious. To this end, she gives a random sample of students two standard questionnaires (see data below). One questionnaire provides an index of introversion (on a scale of 1-20), the other provides an index of generalised anxiety (on a scale of 1-10). Are the two measures significantly correlated? Is there evidence for the student's hypothesis?

Introversion	2	4	12	11	10	9	12	18	20
Anxiety	1	6	2	5	5	6	5	10	9

Problem CLR-2

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 same 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? What is the best-fitting straight-line function?

Exploratory Data Analysis problems

Problem E-1

Assess the following data sets for normality using EDA techniques:

Proportion correct   0.20, 0.28, 0.60, 1.00, 1.00, 1.00, 0.52, 0.47, 0.70, 0.82, 0.95, 0.88

IQ 89, 115, 100, 104, 105 ,102 ,109 ,94, 99, 98, 91, 109, 87, 104, 103, 102, 94, 92, 97, 99, 98, 97 ,97,104

Problem E-2

Are there any outliers in the following within-subjects data set?

Pre-test	9	11	12	7	15	6	0	80
Post-test	15	12	10	15	10	1	30	78

Further problems

Here are some questions that are as hard as any you are likely to find in an exam. Take care in selecting the correct test, and make sure you have done the necessary exploratory data analysis. After these questions, you may wish to attempt last year's paper.

Question F-1

Some drivers report that they're more likely to be stopped by police for speeding if they are on a motorcycle than if they are in a car. Police agree that they stop motorcycles more often than cars, but argue that this is because people tend to drive faster on motorcycles. Below are two sets of radar-measured speeds for seven bikes and seven cars driving in an urban area. Is their any evidence for the police argument?

Motorcycles	50	49	25	27	29	45	52
Cars	28	30	31	30	31	29	29

Question F-2

Caffeine is a stimulant and, as such, might affect performance in exams. To investigate this question, a psychologist takes three groups of twenty students and sets each group the same exam. Immediately prior to entering the examination hall, one group is asked to drink either a) one cup of coffee, b) six cups of coffee, c) no coffee. 70% of the "no coffee" group get a 2:1 and 30% get a 2:2. In the "one cup" group, 10% get a 1st, 70% get a 2:1 and 20% get a 2:2. In the "six cups" group, 10% get a first, 20% get a 2:1 and 70% get a 2:2. Is level of caffeine consumption related to exam performance? What is the nature of the relationship?

Question F-3

A cognitive psychologist wishes to investigate whether people can effectively suppress thoughts. To his knowledge, this has not been investigated before. His experiment has a control group and an experimental group. Each subject in the control group sits in a room and is simply asked to press a button each time they think of an elephant. Subjects in the experimental group are instructed "not to think of an elephant" but to press the button if they do have that thought. Summary statistics are given below. Can people suppress their own thoughts?

	Control	Experimental
N	12	10
Mean number of button presses	10	16.7
Variance	28.9	46.9

Question F-4

A number of people believe that an important factor in determining IQ is the overall efficiency of a person's neural pathways. To investigate this claim, a psychologist collects simple two-choice reaction times from a group of 18 year olds and then administers a standard IQ test. Is there a reliable relationship between RT and IQ? In the equation $IQ = m\,RT + c$, what do you estimate m and c to be?

RT(ms)   185, 190, 213, 220, 222, 237, 241, 260, 265, 268, 276, 298
IQ   112, 120,101,110,105,100,92,95,98,91,85,80