CORNWALL COLLEGE

Exam– Academic Year 2015-2016

BSc Environmental Resource Management

ERM304

Research Methods

Time Allowed: Three Hours

Permitted Materials: Non-programmable Calculators

Instructions

You must answer TWO out of Questions 1, 2 and 3.

You MUST answer Question 4.

All Questions carry equal weight.

Answer any TWO of Questions 1, 2, and 3

Question 1

With reference to relevant examples, identify and illustrate the main features of a convincing scientific argument.

Question 2

Describe a current or recent research programme related to environmental science and comment on the extent to which the ideas of Kuhn, Popper, Lakatos or Feyerabend provide an adequate account of the conduct of individuals involved and the development of the programme.

Question 3

With reference to examples, assess the role, impact and limitations of the process of peer review within scientific practice.

You MUST answer Question 4

Question 4

A healthy systolic blood pressure in adults is about 120 mmHg, with a standard deviation among the adult population of about 12 mmHg.

A pharmaceutical company has devised a drug which it hopes will reduce blood pressure by 3 mmHg. This is deemed the minimum reduction that would merit the risks of taking the drug. A research group is asked to test whether this reduction in pressure actually happens and plan to report that the drug does reduce blood pressure if they find a reduction for which the p-value is 0.05 or less. In a first attempt, the investigators make measurements of blood pressure on a treatment group of 100 randomly chosen individuals who have had the drug, and on a control group of another 100 randomly chosen individuals who have taken a placebo drug instead. The mean blood pressures for each group are then calculated.

The pooled standard error of the difference $\bar{x}_{\text{trmt}} - \bar{x}_{\text{ctrl}}$ between the mean pressures of the two samples is 1.7 mmHg.

a) i) In this investigation, double blinding was used. What is this and why is it used here?

ii) What is the standard error of the mean blood pressures $\bar{x}_{\text{trmt}}$ and $\bar{x}_{\text{ctrl}}$ of each group?

iii) Write down suitable hypotheses for a two sided hypothesis test in this context.

iv) Under the null hypothesis, what would be the mean difference between the mean values of blood pressure from each sample $\bar{x}_{\text{trmt}} - \bar{x}_{\text{ctrl}}$

b) Study Figure 1 below which shows probability distributions of measured differences of the means under the null hypothesis and under the alternate hypothesis in which there is a reduction in blood pressure of 3 mmHg. The dashed vertical lines indicate the limits of the regions of rejection of the null hypothesis, at the 5% significance level.

i) Explain why the dashed lines are positioned at about ± 3.4 mmHg.

ii) Comment on whether this investigation has been well designed for its purpose of detecting an an effect of at least -3 mmhg

iii) Supposing that a real effect does *not* exist, give with justification an example of a measured value for the mean pressure difference that would give rise to a Type 1 error

iv) Supposing that a real effect of -3 mmHg *does* exist, give with justification an example of a measured value for the mean pressure difference that would give rise to a Type 2 error

c) A Research Council requires that any experimental investigation it funds should be designed in such a way as to ensure 80% power.

i) Explain the meaning of the term 'power' in this context.

ii) Estimate the approximate power of the investigation and give your reasoning.

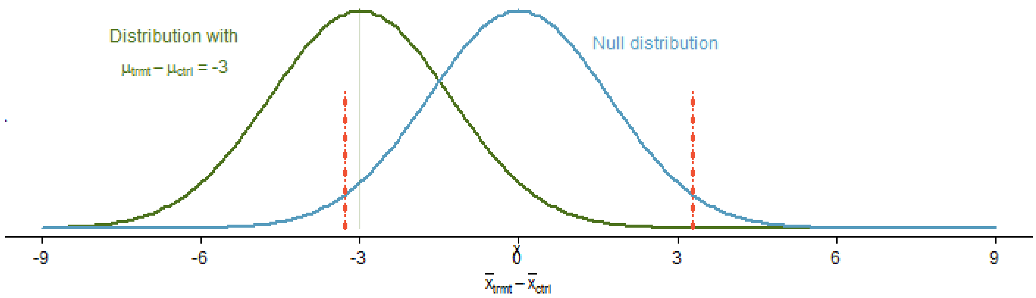

Figure 1: Probability distribuitions for the alternate hypothesis (left) and null hypothesis (right). The dashed lines indicate the limits of the regions of rejection of the null hypothesis at the 5% significance level.

iii) What could the investigators do to improve the power of their investigation?

Suppose the investigators find that the mean blood pressure of the treatment group is 3.7 mmhg lower than that of the control group. The p-value for this result is 0.015 and hence the investigators claim to have evidence sufficient to reject the null hypothesis.

i) Explain in English what this p-value means.

ii) A peer-reviewer states, correctly, that investigators cannot infer with 98.5% probability that the null hypothesis must be false. Explain why the peer-reviewer is correct.

iii) Explain from a Bayesian perspective what additional information would be needed in order to assess the odds for the truth or otherwise of the null hypothesis.

——— *End of Exam* ———

Solution

Solution to Question 1

A good answer will include many of the following points:

- Rationale,context provided
- Relevant and credible literature cited
- Scope, aims, objectives presented
- Exclusions described, with rationale
- Terms, concepts defined
- Relevance of terms, concepts explained
- Methodology cited, used clearly presented and transparent
- Methodology appropriate
- Evidence presented
- Sufficient evidence
- Appropriate comment on the evidence
- Relevance of evidence explained
- Appropriate analysis of evidence
- Comment on limitations, omissions, inconsistencies
- Conclusions justified by evidence
- Discussion of scope of conclusions
- Uncertainties, errors etc discussed and quantified where possible
- Impact of methodology on results, reliability of conclusions explained
- Next steps outlined
- Language, level of detail etc, appropriate for audience
- Clear, structured presentation

Solution to Question 2

Good answers to provide evidence of understanding of ideas of K, P, L and F and of their relevance to chosen research programme. Answers might include the following:

a) Kuhn

   i) Paradigm explained

   ii) Response of actors to anomalies

   iii) Consequence of profusion of anomalies

   iv) Daily reality of practising scientists

   v) Examples

b) Popper

   i) Idea of falsifiability explanatory power as filter for science / non science. Confirmations rather than proof

   ii) Identifiable progress within the field as a consequence of falsification of hypotheses.

   iii) Lack of progress a consequence of untestable ideas?

   iv) Examples

c) Lakatos

   i) Consistency, commensurability the key issue

   ii) Limitations of simplistic falsifiability

   iii) Complex issues, lack of smoking gun experiments

   iv) Actual response of actors to experimental results

   v) Research programmes rather than individual theories

   vi) Examples

d) Feyerabend

   i) Do actors agree on an objective reality and on primacy of evidence?

   ii) Is there a diversity of approaches (eg alternative/mainstream)?

iii) Strengths / dangers of mulitiplicity of approaches discussed.
iv) Professionalisation/centralisation of science dangers/strengths
v) Relativist attacks on science
vi) Perceptions of balance
vii) Examples

Solution to Question 3

Credit

- Journals / editors/referees/iterative process between submission and decision
- Criteria for decision : appropriate for journal; meets house rules of journal; context; methodology, analysis, conclusions justified by analysis; priority
- Role of anonymity : advantages, disadvantages
- Function as filter; quality assurance of published scientific record; role within career and funding decisions
- Limitations : inherently conservative? Makes science too slow to respond rapidly when required?
- Safeguards : against unfair stealing of ideas (submission dates, multiple referees)
- Examples : distinction between peer review journals and the rest, inc grey literature; consequences of reliance upon grey literature alone
- Awareness of different models of peer review currently in use, and a balanced discussion of their relative pros and cons.
- Discussion of role of peer review in light of emergence of pre-print sites

Solution to Question 4

a) i) To avoid bias on the part of the subjects or the researchers.
ii) $\text{SE} = \dfrac{\text{SD}}{\sqrt{N}} = \dfrac{12}{\sqrt{100}} = 1.2$

iii) Null Hypothesis: the drug has no effect on blood pressure so that $\mu_{\text{trmt}} = \mu_{\text{ctrl}}$; Alternate: The drug changes blood pressure so that $\mu_{\text{trmt}} \neq \mu_{\text{ctrl}}$

iv) 0

b) i) They are 2 (1.96) SE's away from the null mean, and so there is a 5% probability that the data will lie beyond the, if the null mean is true.

ii) Not really The effect to be detected has size -3 mmHg, but if this were the detected difference made by the drug, the combination of effect size and significance level mean that the null would not be rejected.

iii) False positive. An effect greater than ± 3.4 mmHg eg - 3.7 mmHg

iv) False negative. An effect less than 3.4 mmHg eg -2.7 mmHg

c) i) The likelihood that a real effect wil lbe detected.

ii) Accept $\approx 45\%$

iii) Cannot change effect size or SD of population, so can increase sample size to reduce SE.

d) i) The probability that data as or more extreme than that actually measured would have been obtained *given* that the null hypothesis is true.

ii) If measuring an effect of greater than -3 mmHg, at 5% significance level is denoted "+", and if the null hypothesis is denoted H_0, then the p-value is $P(+|H_0) = 0.015$. The probability that the null hypothesis is false, and thus that the alternative hypothesis H_A is true, given the positive result, iS $P(H_A|+) = 1 - P(H_0|+)$, but it is not generally the case that $P(H_0|+) = P(+|H_0)$

iii) Prior odds required - assessment of odds that effect exists, prior to doing doing the measurements.