Chapter 1 Why you should care about design

Answers to additional self-test questions

Q1.1 (Nothing to do with experimental design really): Humans have tremendous variation in the patterning of grooves on our fingers, allowing us to be individually identified by our fingerprints. Why do you think there is such variation?

Natural selection tends to reduce variation since more beneficial traits flourish at the expense of less beneficial ones. It is hard to see how the exact patterning on our fingers would have any effect on the probability of our genes being passed on to future generations. Indeed, a lack of correlation in fingerprint patterns within closely related individuals suggests that this patterning is not under tight genetic control. Hence, we have a lot of variation in this trait because it is not under strong selection pressure.

Q1.2 Imagine the research task that you want to address is to estimate the fraction of the electorate who plan to vote in the next elections for the Scottish Parliament. You plan to do this by surveying a sample of the appropriate statistical population. Define this population carefully in your own words.

The population we are interested in is all those people who will be eligible to vote in the next set of elections for the Scottish Parliament. Notice, this is not all the people of Scotland, since not everyone has the vote. It is not even all the adults in Scotland, since not everyone is registered to vote and people in prison (for example) are not eligible to vote. Strictly speaking, it's all the people on the electoral roll at the time of the next election, but the current electoral roll may be a satisfactory approximation to this. It may not be, however, because there may be a surge of people registering just before the elections because of government campaigns and the generally high profile of the elections in the media. Although these late-registering people may make up a small fraction of the electorate, they may have a disproportionate effect on the survey because, having taken the trouble to get registered, they are more likely to use their vote. However, by and large, we'd say the current electoral roll is a good approximation to the population that we are interested in. This approximation is unlikely to influence our results by more than a percentage point or two, so is probably accurate enough for the likely use that our research will be put to. *It is vital that you define your study population carefully; if you are not crystal clear on what the population is it would be very easy to sample in a biased way.*

Q1.3 In the example above, how might you choose a representative sample for the survey?

Let us assume that the population is the current electoral roll. This is publicly available data. We think we could load all of the approximately four million names into a database and assign each a number. We then get the computer to generate a sequence of random numbers from 1 up to the maximum number until we have the desired sample size. We must now contact each of these people to ask them the question about whether they intend to vote. We might initially do this by telephone. There are several possible outcomes. Firstly, they may answer our question or decline to answer our question. If so, we have finished trying to sample them. Alternatively, we may be unable to contact them this way (perhaps they are ex-directory, or have no phone, or are never in when we call). We could then follow this up with sending a letter or 'door-stepping' them. The latter must be a matter of last resort as this will be expensive and time consuming. We think we need such an active approach, as simply writing to the individuals may not be the best way of gathering the data. You might argue that people who do not reply to the letter are generally apathetic (or busy) people who are less likely than the average person to use their vote. Notice that you could simply give up on people if you can't reach them by telephone. However, this could lead to the introduction of unintended bias in your sample. For example, retired people are more likely to be at home to answer the phone than people who work, and so could be over-represented in your study. This would matter if retired people are more likely to vote than working people. *It is very easy to sample in a biased way.*

Q1.4 Imagine that you personally are bidding to survey likelihood of voting for a national newspaper. What number of people would you aim to gather data on?

We think it is unlikely to make much difference to the newspaper commissioning the survey whether the answer is 45% or 46%. So we think sample sizes like 10 000 would be overkill (despite being less than 1% of the population). We think 1000 would still be on the high side. We can see that there is significant effort required to find a phone number and even more to door-step. We think that how many people you approach depends on the method you use to approach them. If you are simply mailing them and asking them to fill in a freepost form and post it back (and, as discussed above, we don't think this is a good method) then you might go for 500, expecting at least 100 (and more likely 200–300) to actually post a response back to you. If you are going for the 'telephone call, then letter, then door-stepping' approach then the effort required for each person sampled increases substantially, but we think the fraction of people that actually give a response will increase from perhaps 40% to 80%. This suggests that a number like 200 or 250 would be reasonable. We still think this would be a considerable amount of work, and our temptation would be to

think about whether 150 or even 100 might be enough. We think less than 100 would be hard to justify. *The sample size you should aim for will be influenced by the accuracy of answer required, the likely variation between individual sampling units, and practical concerns related to ease of sampling, costs, and ethics.*

Q1.5 If you wanted to explore if there was a correlation between the entrance charge for UK public zoos and how far north the zoo was, then how would you go about this?

Firstly, you need a list of all UK zoos. This can probably be obtained from the government (because zoos need a licence) or from a professional organization like the British and Irish Association of Zoos and Aquariums (BIAZA). Some care may be needed here if not all zoos are members of BIAZA. Membership of BIAZA probably costs money, and small zoos may not be members and may also have lower entrance charges. Fortunately it seems unlikely that membership would be influenced by geographical location. You could sample a number of zoos from the list on the BIAZA website, and for each of these the latitude should be easy to find since the zoo is likely to have a website with information on how to get there and this can be converted to a latitude-reading using an online map. The website is also likely to give you details of entrance charges too. But which entrance charge should you pick? The question was not specific. Should you use the cost for adult entrance at the time of your study? Or should you use the cost for a family of two adults and two children in summer? *You must take care when asking a scientific question that the question is exactly defined.*

Q1.6 A student project involves comparing the size of slugs on organic and other farms. The student asks how many slugs they should measure on each farm, and the supervisor replies 'as many as you can'. Was this an appropriate response?

No. Whilst bigger sample sizes give you more statistical power (a more accurate measure of slug size on a given farm), there is an effect of diminishing returns from larger and larger sample sizes. There are ethical implications of sampling more slugs than is necessary, and also the question of whether the student would not be better to take their time to get careful measurements of a small number of slugs than rushing to find as many slugs as they can. The supervisor, on the basis of their experience of previous similar experiments, should be able to suggest a target range of slugs on each farm.

Q1.7 Imagine you are given the project of watching a grassy area at your local university in winter. When birds land on the grass to forage, you record for how long they stay before they fly off. Do you have any ethical concerns?

It might be that your presence scares birds away or causes them to eat more slowly or for less time. This might have a welfare impact on the birds, but there are many similar alternative feeding sites available to these birds and they are probably used to people anyway.

Q1.8 Imagine the project is the same as the above, but now you are recording how long students sit on the grass in summer. Are your ethical concerns different?

Yes; it is unlikely that starvation risk will be a factor now. However, there might be an invasion of privacy issue, perhaps if you saw someone there who had explained that they couldn't help with the project because they were out of town that day. It might be best if the surveyor was someone unconnected to anyone at the university. Even then, having someone nearby with a clipboard might make people uncomfortable, so you should gather the data as inconspicuously as possible and be prepared to explain your actions to anyone that asks. You might say it's OK because CCTV cameras record people going about the university, but people are warned about this with signage; people are not warned in your survey.

Q1.9 An early draft of the book contained the following real example, but the authors were persuaded that it was both a flawed way of collecting data and ethically objectionable.

A social scientist wanted to find out what newspapers people in a given street read. The problem is that people can be expected to lie when you ask them, saying that they read a broadsheet when they actually read a tabloid or no newspaper at all. The social scientist got around this by saying that he was piloting a paper recycling scheme, providing people with sacks, and asking them to deposit all their waste paper in the sack which he collected at the end of the week. This allowed him to evaluate which papers were read by looking at the papers placed in the sacks. Having obtained this information, he took the contents of all the sacks to a paper bank.

Why is this unethical and scientifically flawed?

The scientist is collecting information by deception. We hope you can see that this is only justified in very unusual circumstances. Information on people could now be stored without the people's knowledge that this data about them had been collected. It may seem like a

harmless deception, but that argument feels like the thin end of a wedge. It is poor data because it only collects papers that end up at home; it misses papers that are read on the bus or train to work and then discarded. Also, because a paper ends up at home does not mean that all the members of that household have read that paper.

Q1.10 The book states that the sheep in a flock will not all be the same weight. Can you explain this in terms of the underlying biology of sheep?

The sheep will potentially differ in age and sex, both of which potentially affect weight. They are different genetically, which can influence weight. Previous history (e.g. where they were raised and their previous history of illness) can also affect weight. They may vary in parasite load, which could affect weight.

Q1.11 Explain why confounding factors can be a problem in biological studies, using an example.

Imagine that we want to know whether there is an effect of age on reproductive success in Arctic terns. A very obvious confounding factor here is previous experience (how many previous occasions the individual has bred). Age and experience are very closely linked because young birds on average have less breeding experience than older birds. However, the correlation is not exact; it is not true that all five-year-old birds will have bred twice. Whilst most will have bred twice, some will have bred once or even never before. Thus, it should be possible to separate the effects of age and experience in your statistical analysis, but if you do not consider experience at all and report a correlation between age and reproductive output as an effect of age, you could be open to criticism, because it may be experience rather than age which has the dominant effect.