Chapter 10 Within-subject designs

Additional self-test questions

Q10.1 Explain the advantages and disadvantages of a within-subject design.

In a between-subject design, the greater the within-treatment variation is the less powerful the test. Such between-sample variation is not a problem in within-subject designs, since you make comparisons between the responses of the same individual to different treatments.

The disadvantage is that the treatments applied to an individual must be done at different times, and so care must be taken to avoid inadvertently introducing time of application as a confounding factor. The response you are measuring must be reversible; that is, once an individual has one treatment applied to them and the consequences measured, that individual must revert back to the same state it was in before the first treatment was applied before the second treatment can be applied. This can be called the problem of irreversibility or (if less severe) carry-over effects.

Q10.2 The book says 'the longer the experiment goes on, inevitably, the greater the problem drop-outs will be'. Explain this in your own words, and explain its relevance to consideration of within-subject designs.

A drop-out is a situation where you had intended to take a number of measurements on a subject but this becomes impossible through some extraneous effect. For example, one of the lab rats in your study dies, or one of your human volunteers falls out with you and refuses to participate any further. Clearly the greater the length of time for which an individual is involved in your study, the greater the chance that at some time before the end they will drop out. This is a problem for within-subject designs because treatments are applied sequentially to the same individual, so they are inevitably involved in the experiment for longer than between-subject designs.

Q10.3 In the book, it suggests that there are 24 different orderings of four distinct treatments. Can you demonstrate this?

Imagine drawing four numbered balls from a bag. There are four alternatives for the first number to be drawn. No matter which ball is drawn first, there are three remaining, and so three possibilities for the number of the second ball. So, there are 4 x 3 different

alternatives for the combination of first and second balls to be drawn. There are now two balls remaining and so two different alternative third balls for each of the 12 combinations of the first two balls, so 24 combinations of the first three balls. Now there is only one ball left, and so if the identity of the first three balls is known then there is no need to draw the last one, we can deduce what it is. Thus, the last ball added no further information and there are 24 different orderings of the four balls, and thus 24 orderings of the four treatments.

The number of orderings of N treatments is N! (called N factorial) and calculated as N*(N-1)*(N-2)*…*1.

Q10.4 How would you select a random permutation of 1 to 6?

You could use numbered pieces of paper in a hat. You could use a die, and simply disregard numbers that have previously been recorded. You could do it on a computer, but can you explain exactly how?

Q10.5 We wish to test for differences in fear reaction of mice to avian and mammalian predators. We intend to do this by monitoring the heart rates of wild-caught field mice following exposure to taxidermic mounts of a weasel and an owl. Consider the ethical and practical advantages and disadvantages of a within-subject design for this experiment (where the same individual is exposed to both stimuli) compared to a conventional fully randomized experiment. The mice would be returned to the wild after the experiment.

The attraction of a within-subject design is (because we are comparing within rather than between individuals) that we can use smaller numbers of mice. Our guess is that instead of two groups of 15 mice, we could get away with two groups of 8 mice. Practically, this would make a small but significant impact on both our trapping and housing demands. Ethically, it is also a good thing as we are taking fewer animals from the wild. But, there are ethical drawbacks to the within-subject design. Being exposed to the predators is stressful, and in the within-subject design we are actually using slightly more of these stressful events (if our numbers above are about right). That said, the numbers are so similar, this makes little difference. We are also exposing individuals to repeated stressful events; this would be very concerning for us ethically if there was a cumulative effect whereby the second stressful event was even more stressful because of memories or physiological carry-over from the first event. For example, the first time the mouse enters the test chamber it could be mildly stressed by the new environment, but the second time it enters the test chamber it could be very stressed because it remembers that this was the place where something bad happened

to it before. We think we can circumvent this by testing animals in their home cages, and by having the heart rate monitors permanently attached, so that the mouse has no cues forewarning it of the second stimulus. Hence, in this case, we think multiple exposures should not be a great concern arguing against a within-subject design. However, there is no doubt that we will need to keep individual mice in captivity for longer in the within-subject trial, about twice as long since we will need to leave the mice for some time to settle (perhaps a day) before exposing them to an experimental stimulus and an equivalent amount of time between stimuli in the within-subject design. If we expected the mice to deteriorate rapidly with time in captivity then the within-subject trial would become less attractive. However, we think that good husbandry would prevent this being a concern. Our feeling is that it's a pretty close call in this case which design is best, but we'd plump for the within-subject trial because fewer mice are taken from the wild and because it is possible that between-individual variation could be really quite high.